**Nanjing University**

* **A/Prof Ronald. J. Clarke**

**Electrostatic Switch Mechanism of Membrane Protein Trafficking and Regulation**

Lipids are asymmetrically distributed across the membranes of all cellular life forms. In bacteria and mammalian cancer cells negatively charged lipids are predominantly localized in the extracellular leaflet of the membrane, whereas in healthy mammalian cells negatively charged lipids are localized in the cytoplasmic leaflet. In fact, exposure of negatively charged phosphatidylserine molecules on the extracellular face of membranes is a signal for apoptosis. This lipid asymmetry is utilized to advantage in the design of positively charged anti-microbial and anti-cancer peptides to selectively target bacteria and cancer cells. However, Nature cannot have incorporated lipid asymmetry into cell membranes in order to provide medicinal chemists with a druggable target; it must have a physiological purpose. The aim of our project is to discover this purpose.

In preliminary experiments1-4 we have discovered that ion pumps such as the Na+,K+-ATPase and the H+,K+-ATPase possess positively-charged lysine-rich extramembrane N-terminal extensions which project out into the cytoplasm and, depending on the protein conformation, can interact with negatively charged phospholipids in the surrounding membrane. The charge on the proteins’ N-terminus could also be modulated by the action of protein kinase C, which is known to have conserved serine residue targets in the N-terminus sequence. This is termed an “electrostatic switch” mechanism. By controlling protein conformation, N-terminal-membrane interaction thus provides a mechanism for ion pump regulation.

Many peripheral membrane proteins, which are only bound transiently to the membrane surface, have also been found to possess lysine-rich termini together with serine residues. In their case the electrostatic switch mechanism could provide a way of controlling their trafficking around the cell, e.g. their movement between the plasma membrane and the nucleus.

Thus, the electrostatic switch mechanism could be a widespread phenomenon, which depends on animal cell membrane asymmetry and thus provides a physiological reason for asymmetry.

References

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* **Prof Meredith Jordan**

**New Mechanisms in Atmospheric Chemistry**

The predictive value of atmospheric models improves with our knowledge of atmospheric chemistry. As models become more and more accurate, it becomes more difficult to challenge their overall qualitative findings. There are many outstanding challenges in atmospheric modelling, however. Research projects could address one or more of the following using techniques such as computational chemistry, kinetic theories and master equation modelling.

In both polluted and pristine environments there is a significant shortfall (by over an order of magnitude) in predicted concentrations of the OH radical, the single most important radical in the atmosphere - it effectively acts as an atmospheric ‘detergent’. We have recently postulated an entirely novel atmospheric mechanism that can lead to OH formation and initial results from experimental collaborators are consistent with this mechanism. The mechanism we have proposed is likely to be general and ubiquitous but we are yet to demonstrate this for a range of atmospherically important molecules.

Only about half the observed molecular hydrogen in the atmosphere can be accounted for by current atmospheric models. Given the increasing use of hydrogen as a fuel, this is a significant shortcoming that needs to be urgently addressed if we are to be able to model any unintended increase in hydrogen released to the atmosphere. We have recently demonstrated a new photochemical source of molecular hydrogen (Physical Chemistry Chemical Physics, 21, 14284, 2019) although the mechanism and its ubiquity are yet to be determined.

We have recently shown (Nature Communications, 9, 2584, 2018) that photochemically-induced keto-enol isomerisation of acetaldehyde is a significant source of atmospheric formic acid – indeed it is the dominant source in the marine boundary layer. We are yet to determine how important this mechanism is in other atmospheric carbonyls.

The competition between the reaction and collisional stabilisation of very internally “hot” atmospheric molecules, for example, those formed after absorption of near ultra violet solar radiation, is completely unknown. In this project classical mechanics trajectory models will be used to investigate collisional energy transfer in the atmosphere.

All of these projects are part of a wider research effort in atmospheric chemistry which involves researchers at the University of NSW, the University of Wollongong, Leeds University, CNRS in Lille and the University of Minnesota. As such, you will also have the opportunity to be exposed to a range of different experimental and modelling techniques.

* **Prof Brendan Kennedy**

**Energy, pyrochlores and perovskites**

Energy security is one of the major challenges of the 21st century with both fuel cells and nuclear power being promoted. The binary oxide Gd2Zr2O7 is currently of interest in both areas, being studied for use as an electrolyte solid oxide fuel cells which requires high ionic conductivity and as a host for immobilisation of radioactive waste which required no diffusion of cations. This project aims at understanding this apparent contradiction in properties. Our proposal is that anion disorder occurs independently cation disorder and we are now keen to fully understand this process and to extend our observations to other pyrochlore type oxides such as Ln2TiO5. A third aspect of this work is to examine the structural stability of the key component of perovskite solar cells, the layered halide perovskites APbI3. This project aims to establish the role the Pb2+ lone pair electrons play in their exceptional photovoltaic response.  
Structural and electronic properties of 4d and 5d oxides: This project will build on our discovery of an unexpected high magnetic phase transition temperature in SrTcO3 and CaTcO3. The work will explore the solid state chemistry of 4d and 5d metals isostructural with Tc(IV), especially Ru(V) and Os(V) to establish the role this has in the unusual magnetic properties of SrTcO3. We aim to prepare a number of double perovskites of the type A2MLnO6 M = Ru or Os, Ln = La or Y. We have developed world leading expertise in the analysis of L-edge X-ray absorption spectra of such oxides and a unique feature of this project will be to exploit this to understand the unique properties of these oxides. A second part of this project focuses on the importance of spin-orbit coupling in Ir containing oxides. This aims to build on the observation of unusual magnetostriction in Ba3BiIr2O9 and will explore both the role of spin-orbit coupling of the Ir cations and the potential for electron transfer between the Bi and Ir cation.

* **A/Prof Christopher McErlean**

A short research project is available for an outstanding student to work in the McErlean Research Group at the University of Sydney. The successful applicant will apply a novel photoredox-catalysed strategy to construct biologically important oxazole-containing compounds. The key step in this innovative approach involves a metal-free cyclization of an *in situ* generated enamide.

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For key references see: *Chem. Rev*. 2016, *116*, 10075−10166; *Synlett* 2014, *25*, 665–670.

* **A/Prof Alice Motion**

**Breaking good – Citizen science and drug discovery**

Drug discovery is traditionally a highly secretive process. Open source drug discovery aims to find new medicines more efficiently by sharing data and ideas. Removing secrecy from this process has enabled us to engage high school and undergraduate students in drug discovery. The Breaking Good Project works with junior students on the synthesis of medicines that aren’t accessible to patients; either because the market incentive is insufficient to motivate their discovery or because existing medicines are unaffordable. This project will involve expanding Breaking Good to more schools. You will develop process-style chemical synthesis that is suitable and safe for high school laboratories and research the best way to teach synthetic organic chemistry to citizen scientists.

* **A/Prof Liz New**

**New fluorophores for biological sensing**

The field of fluorescent sensing has provided biological researchers with tools to visualise organelles, proteins, and chemical processes taking place within the cell. The development of new fluorescent sensors is hampered by the limited number of suitable fluorescent scaffolds, particularly those that emit in the red or infrared. Projects in this area will involve identifying how new fluorophores can be made or existing fluorophores modified to improve the photophysical and biological properties. These projects will suite with an interest in synthesis and photophysical studies (UV-vis, fluorescence), and could also include theoretical calculations and/or biological studies.

* **Dr Stephen George-Williams, Dr Reyne Pullen and A/Prof Siegbert Schmid**

**Using Virtual Reality to aid in the teaching and learning of chemistry**

Virtual Reality (VR) has become a much more common household commodity thanks to the proliferation of more affordable VR devices. It is highly likely that you have encountered a VR device as a gaming tool either at home, at a shopping centre or during a gaming convention. We are particularly interested in using this equipment to aid in the teaching and learning of chemistry, and we need your help with that. As an undergraduate student, you are best placed to consider the value of the technology from the perspective of your peers.

This project seeks to generate a range of VR materials designed to support 1st year students learning organic chemistry. Additionally, we are interested to create virtual laboratory environments to better prepare students for experiments they will conduct in our newly refurbished state-of-the-art 1st year laboratories from 2020.

You will research best practice and help develop the learning materials in consultation with your mentors in the School of Chemistry. These materials will then be pilot tested with both students and teaching staff, with all sessions being video and audio recorded. Follow up interviews will also be conducted with all participants. Student understanding will then be tested with theoretical questions or physical laboratory tasks.

You may choose either the creation of pre-laboratory or tutorial activities