WESTERN SYDNEY
UNIVERSITY

Nanoscale Organisation
and Dynamics Group

NANOSCALE RESEARCH NEWSLETTER

The BMRF Brief (since March Nanonews):

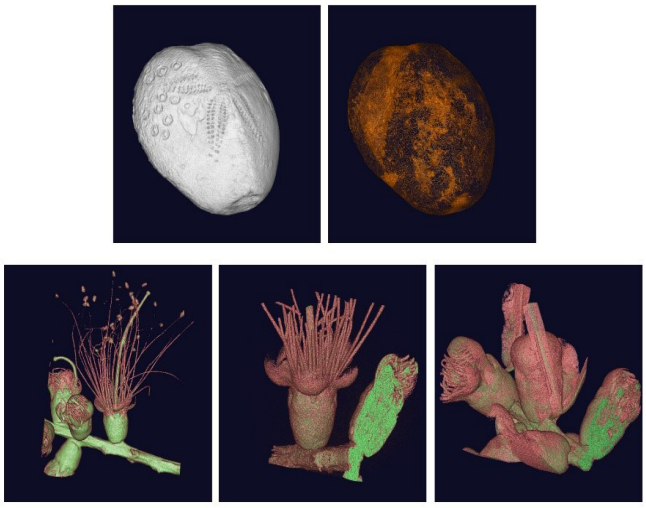
Dr Scott A. Willis

Biomedical Magnetic Resonance Facility Manager

The Biomedical Magnetic Resonance Facility (BMRF) has a specialised suite of equipment suited to anything from routine NMR spectroscopy to diffusion measurements and imaging (MRI and MicroCT). The newest set of equipment in the BMRF is the Stelar Spinmaster FFC2000 1 T Fast Field Cycling Relaxometer and the HTS-110 3 T Field Cycling Relaxometer. These were installed since our last newsletter and are well suited to measure the field dependence of relaxation rates – very important for contrast agent development among other applications. There has been some downtime and teething problems with the instruments and room utilities but these are getting finalised and the research with them is gaining momentum. The BMRF has also suffered during the last year with some equipment breakages and need for repairs but they are slowly getting corrected.

The Nanoscale Organisation and Dynamics Group held three seminars this year showcasing some of the applications of NMR/MRI and MicroCT – the BMRF at Campbelltown is well equipped with these instruments which are available for use. The first seminar was given by Prof. Yves De Deene from Macquarie University who presented 'From Safeguarding to Image Guiding of Radiotherapy Challenges and Opportunities for quantitative MRI', the second was given by Assoc. Prof. Jeffrey Harmer from the University of Queensland and Prof. Marcel Maeder from the University of Newcastle who presented on 'Extracting Information from NMR Spectra of Coal', and the third by Adjunct Prof. – Dr Suzy Rogiers from the NSW Department of Primary Industries who presented 'The application of MRI and micro-CT to understanding Plant Structure and Function'.

Some general housekeeping: Users of the 300 MHz spectrometer (or any other instrument for that matter) in the BMR Facility are reminded that it is necessary to fill in the log book next to the instrument and also book time using the online booking timetable – book the time you want beforehand both so other users know, and you know it is free for use, and so we can get usage statistics for the instrument(s). If you would like to use the facility or are keen to find out more about our capabilities please email the facility manager: Dr Scott A. Willis, Scott.Willis@westernsydney.edu.au and we can arrange a time to discuss this. If you are a current user who requires help with some experimental parameters or training for a different set of experiments, also contact Scott via the email above or find him in Building 17 (either in the BMR Facility or his office 17.G.06) – this is particularly important given the equipment issues over the past year (if you don't know what a parameter does or want to try some new expe riments just ask Scott or one of the other friendly facility personnel (e.g., Allan, Tim, Gang, Abhishek, Robyn or Bill)).



MicroCT images acquired on the Perkin Elmer Quantum GX MicroCT in the BMRF by Dr Scott A. Willis. Upper: 23-Million-Year-Old fossil of a Lovenia forbesi. (Sea Urchin Echinoid) from Mannum, South Australia. The white 3D rendering shows the outer surface and the orange 3D rendering shows some features inside the fossil. Lower: 3D rendered images obtained of a Red BottleBrush.

SPECIAL POINTS OF INTEREST

HAPPY MOVEMBER!

Support Your Local Moustache

60 seconds with Janice Aldrich-Wright

Professor Janice Aldrich-Wright

ACCORDING TO BBC HORIZON, THE UK SPENDS MORE ON RING TONES THAN THE WORLD SPENDS ON FUSION RESEARCH.

How would you describe the research of your group in a few words?

Multifaceted! Our research is focused upon the design, synthesis, characterisation and biological applications of a wide variety of transition metal complexes. Our studies include, but are not limited to: development of platinum complexes with excellent in vitro cytotoxicity against several cancerous cell lines, the synthesis of ruthenium polypyridyl complexes with potential use as fluorescent sensors, and the synthesis of novel metal complexes for antimicrobial studies. We enjoy designing molecules that interact differently, challenging inorganic chemistry synthesis, and yet also indulge in other fields such as biophysical chemistry and medicinal chemistry. It is one thing to be able to synthesise a compound, but it's a whole other challenge to study its structural and electronic properties, as well as elucidating the mechanisms behind its biological activity.

What prompted you to investigate this topic?

Our research team has synthesised platinum complexes incorporating 1,10-phenanthroline and its derivatives with great success. However, in order to truly investigate the structure–activity relationships of our complexes, we needed to study compounds that were vastly different from those in our current library. We recently developed complexes of dipyridoquinoxaline with high anticancer activity, and the trend has continued here with the study of bipyridine and 2-(2-pyridyl) quinoxaline (2pq). Ligand 2pq in particular has fascinated us, as its geometry distortion when coordinated to a metal centre has resulted in some really unique structural and electronic properties.

How did the collaboration for this work arise?

Continuing from above, our research team obviously required further expertise to investigate the structure and anticancer activity of our complexes. So we enlisted the help of the talented X-ray crystallographers Dr Feng Li and Dr Yingjie Zhang, who really helped us investigate the unique structures of our 2pq complex. To explore the cytotoxicity of our complexes in a variety of cancerous cell lines, we have begun a collaboration with Calvary

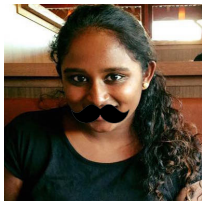
Mater Newcastle, particularly with Dr Jennette Sakoff and Dr Jayne Gilbert, whose cell line work has been incredibly helpful both in this study and others. Collaboration is an integral part of scientific research today; there will always be someone out there who can help with aspects of your project, you just have to know where to look (and how to ask nicely!).

What does the future hold?

The future is looking bright, as we are discovering more about the biological activity of our complexes, which in turn leads to design modifications and the development of new complexes. The study of the extracellular in vitro activity of our compounds and the development of targeted drug delivery are high on the list!

Masters Student Profiles

Aleen Khoury



Adeline Rajamanickam

Aleen Khoury

Aleen Khoury completed her B.Med.Sc. in 2015 at Western Sydney University. She recently completed her Master of Research degree (2017) at WSU under the supervision of Prof. Janice Aldrich-Wright and Dr Christopher Gordon, submitting her thesis titled 'The Synthesis and Characterisation of Novel Platinum(II) and Platinum(IV) Complexes with Anticancer Activity'. Her research interests include the development of novel inorganic anticancer agents as well as the characterisation of complexes with NMR, MS, HPLC, UV and CD. She hopes to continue the development of platinum(IV) complexes that are able to selectively bind to cancer cells.

Adeline Rajamanickam

Adeline Rajamanickam completed her B.Med.Sci.(Advanced) in 2016 at Western Sydney University. She is currently in the final year of her Masters of Reseach degree at Western Sydney University, under the supervision of Prof. Janice Aldrich-Wright and Dr. Ming Wu. Her research interest is the synthesis and antimicrobial activity of N4-tetradentate ligands and their complexes. Adeline has undertaken research projects throughout her undergraduate degree synthesising platinum(II) anti-cancer agents with the group and is currently investigating the biological activity of copper(II) Schiff base N4-tetradentates. She is due to submit her thesis in April 2018 and aims to publish these findings soon after.

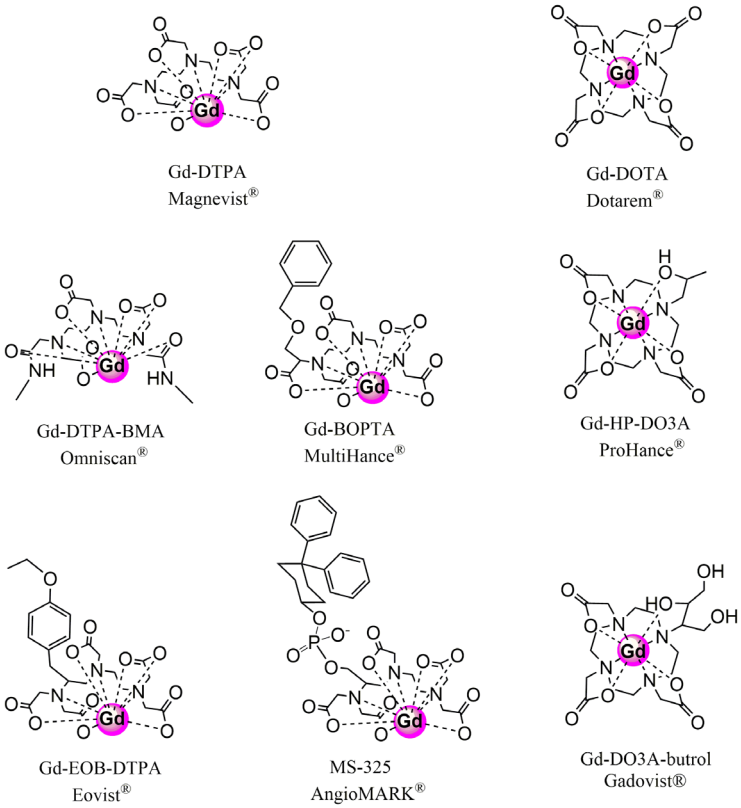
Magnets in our body: MRI contrast agents

Dr Abhishek Gupta

Magnetic resonance imaging (MRI) is one of the most prominent imaging modalities in clinical medicine. It is a non-invasive imaging technique which offers excellent spatial resolution without using any harmful radiation. As with any imaging technique, it is important to be able to differentiate between a diseased tissue from the neighbouring normal tissue. This requires the two tissue types to possess different properties that will result in different signals being detected by the imaging method. This difference in the signals from the two tissues of interest is called 'contrast'. In MRI, there are various sources of contrast, many of which are dependent on the magnetic field experienced by the water molecules. Recall that the primary sources of signals in clinical MRI are the magnetic moments of the nuclei of the hydrogen atoms of the water molecules (hereafter referred to as 'water protons'). That is, for the purposes of MRI, a human body contains numerous miniscule bar magnets (water protons), all spinning about their own axis. When placed inside a large magnet (of the MRI scanner), the total magnetic field experienced by the water protons is the sum of the magnetic field of the MRI magnet and the various 'local' magnetic fields, such as the magnetic fields of the neighbouring water protons (miniscule compared to the magnetic field strength of the MRI magnet).

Clinically, if the naturally occurring contrast between the tissues is insufficient in an MRI image, which is often the case, especially in complicated cases such as for detection of primary tumours, it becomes important to somehow modulate the 'local' magnetic fields experienced by the water protons in the region of interest. The easiest way to achieve this would be to inject magnets (much stronger than water protons) inside the body, ideally specifically to the tissue of interest. The chemical equivalent of injecting strong magnets is injecting a metal ion with unpaired electrons in its valence shell. The metal ion with the most number of unpaired electrons in its valence shell is Gadolinium (Gd3+) with seven unpaired electrons. However, Gadolinium is very toxic and thus needs to be encapsulated within a chemical 'cage' to suppress its toxicity. It was found that by using an octadentate ligand (i.e., by using a ligand which blocks 8 out of 9 coordination sites of Gd3+), in-vivo use of Gd3+ is possible. As a result, most of the current commercially available and clinically used MRI contrast agents are Gd-complexes.

In this way, clinicians are able to detect abnormalities, such as tumours, by essentially injecting magnets in our body.



Figure; Chemical structures of some of the commercially available MRI contrast agents. In general, all contrast agents have a Gd^{3+} metal ion encapsulated within a chemical 'cage', an octadentate ligand, to suppress its toxicity."

HOW MANY SPECTROSCOPISTS DOES IT TAKE TO PREPARE A SAMPLE? NONE. THAT'S WHAT CHEMISTS ARE FOR.

Introducing Adam Stait-Gardner

Analysing the vasculature of plants

"Visualization of vascular structure and function in grapevines using MRI and Micro-CT"

Partnership Grant

Department of Primary Industries

Dr Suzy Rogiers

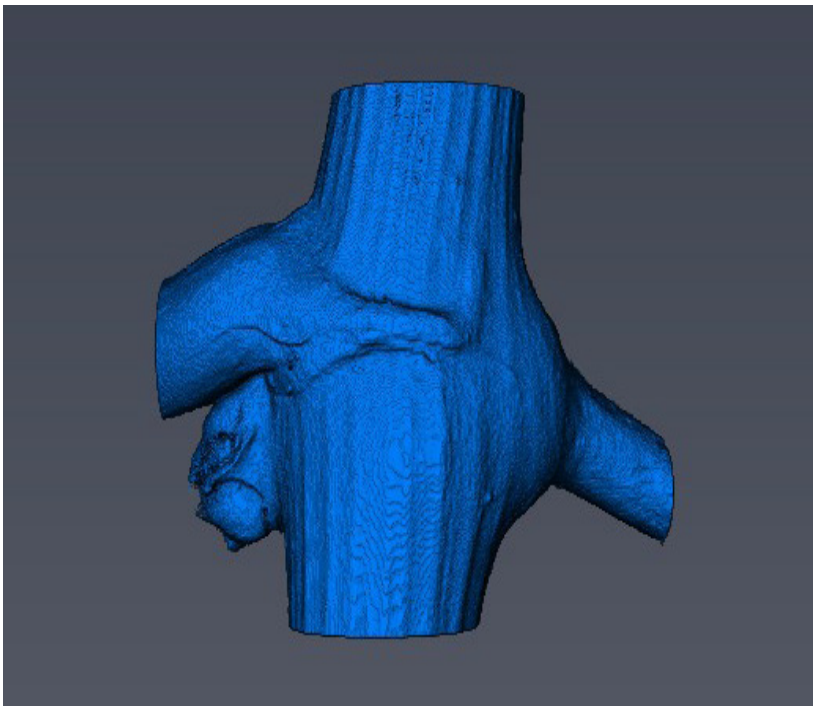
School of Science and Health

Prof. Bill Price

Dr Tim Stait-Gardner

Dr Leah Stroud, is employed under the School of Science and Health / Department of Primary Industries Partnership Grant 2017-18. Scanning was done by Dr Suzy Rogiers, analysis was done by Leah with assistance by National Imaging Facility Fellow, Dr TIm Stait-Gardner.

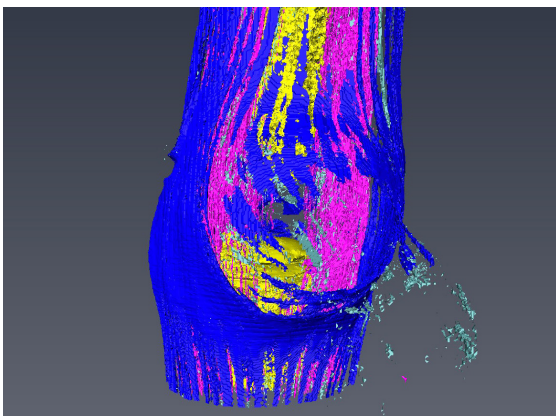
Just like humans, plants have an intricate vascular network that transports nutrients and materials to various locations within the plant. Analysis of this network is made possible using a workflow that integrates Micro Computed Tomography (micro-CT) and specialised analysis software. Once the images are obtained, a semi-automated workflow is designed to segment the plant into meaningful regions or structures of interest. In doing this, valuable insight into the spatial relationships of internal structures is possible. In combination with other functional analyses this process can be used to identify the relationship of complex vascular networks on the size and composition of the fruit and ultimately the yield.

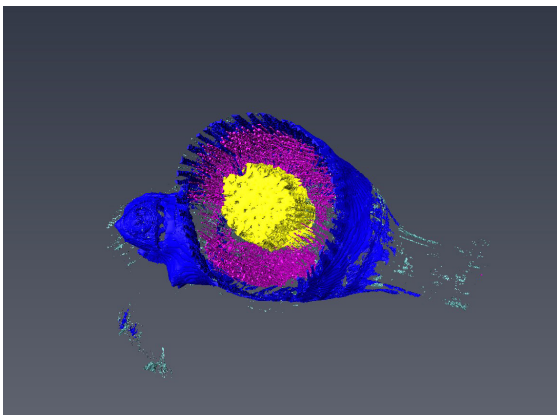


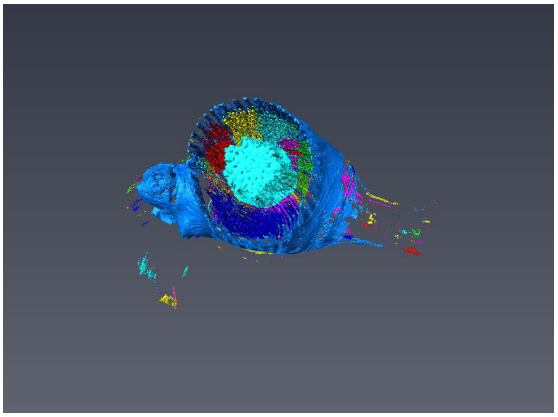
Stem and Nodes from a Grapevine.

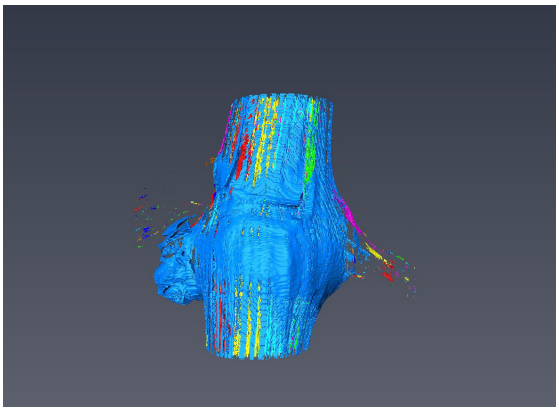
Scanned using the PerkinElmer Quantum GX Micro CT

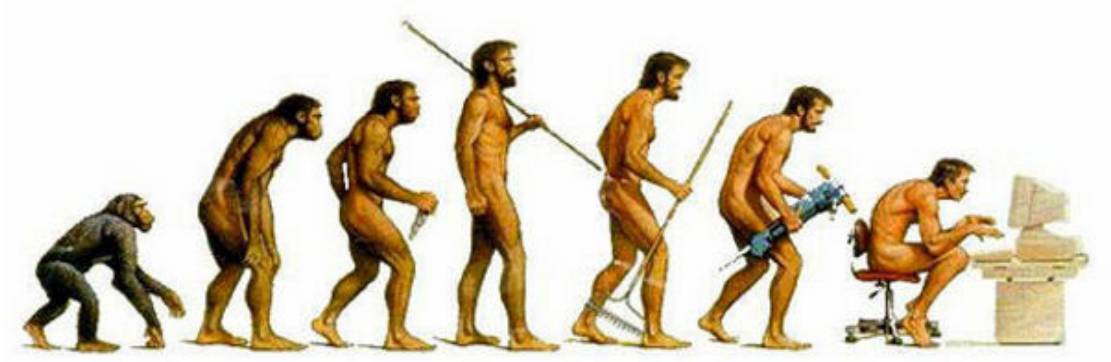
Analysis by Dr Leah Stroud using AMIRA (Software platform for 3D and 4D data visualization, processing, and analysis)





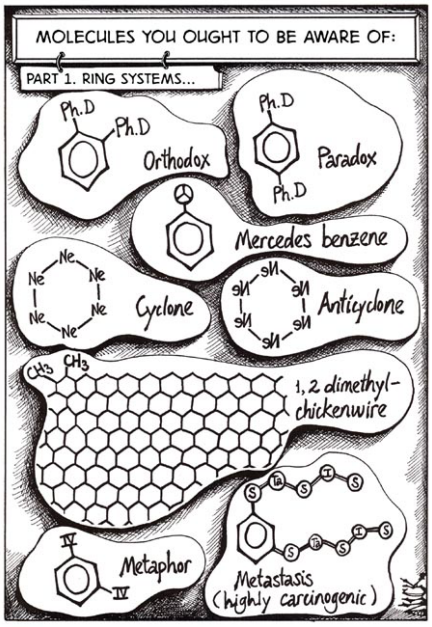


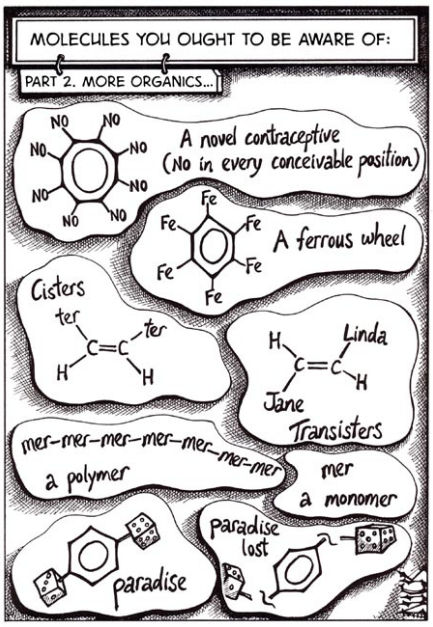


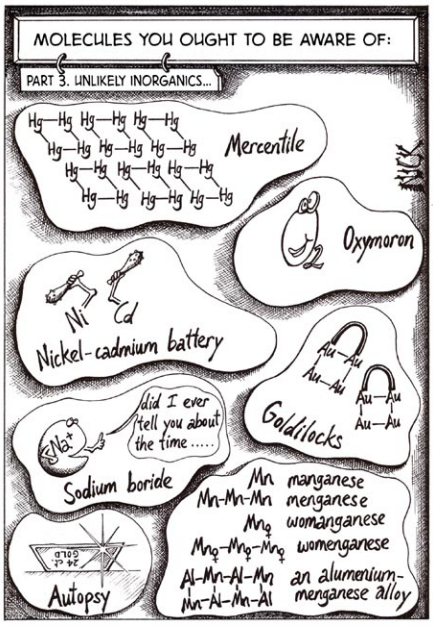


EVERYTHING IS THEORETICALLY IMPOSSIBLE, UNTIL IT IS DONE -

ROBERT A. HEINLEIN







* Why do spins tend to relax?
* Work makes them tensor.

* What is the Fourier transform of noisy data?
* A varyin' baseline.

* What happens when spectroscopists are idle?
* They turn from nutating nuclear spins to notating unclear puns.

* Why is a NOESY like a milk shake?
* You have to use the right mixing time to get a good one.

* How are spin echos so useful?
* Many Hahn's make light work.

* Who writes novels with a Western spin?
* Louie Larmor.

* Why are spectroscopists never satisfied with their magnets?
* The gauss is greater on the other side of the fence.

* What do you call obsolete pulse sequences?
* ANACHRONYMS.

* Are peaks inverted in the Southern Hemisphere?
* If they are, no one is phased.

* Why are supercons such empty bores?
* They've no irony core.

* What happens to old spectroscopists?
* They never really retire, they just change fields.

* How do spin students relax?
* The teacher lets them out for precess.

* Why did the spectroscopist throw the clock out the window?
* To see the time-domain transform.

* Why do magnets drift around?
* They're such shifty characters. (a sine of the times, some observe)

DID YOU HEAR ABOUT THE MAN WHO GOT COOLED TO ABSOLUTE ZERO?

HE'S OK NOW

MÉNAGE A TROIS! LIGAND SEEKS TWO RECEPTORS INTO BINDING AND MUTUAL PHOSPHORYLATION.

LET'S GET TOGETHER AND TRANSDUCE SOME SIGNALS.

NANOSCALE ORGANISATION AND DYNAMICS

Professor William S. Price
Group Leader
- Medical Physics, MRI, NMR and diffusion

Professor Janice Aldrich-Wright
Lecturer
- Potent in-vivo cytotoxic agents, Antibacterial Agents, Quadruplex binders

Professor Annemarie Hennessy
Dean of Medicine
- Preeclampsia

Assoc. Prof. Gary Dennis
Director Research School of Science and Health
- Polymer and surface chemistry

Dr Abhishek Gupta
Post Doctoral Fellow
- MRI contrast agent development and NMR relaxometry, Self assembled nanoparticles

Dr Tim Stait-Gardner
National Imaging Facility Fellow
- MRI and quantum physics

Dr Allan Torres
Senior Lecturer
- NMR and MRI

Dr Scott Willis
BMRF Manager & Researcher
- NMR diffusion measurements, Pulse sequence developement, polymer materials

Dr Gang Zheng
Lecturer
- NMR pulse sequence development, Chemical exchange studied by NMR

WHY DONT' CALCULUS STUDENTS THROW PARTIES?

BECAUSE YOU SHOULD NEVER DRINK AND DERIVE

Group Meetings

NANOSCALE RESEARCH / GRANT MEETINGS

PROFESSOR WILLIAM PRICE'S LAB GROUP

Meet every Friday at 09:30 am in CA 21.1.65

PROFESSOR JANICE ALDRICH-WRIGHT'S LAB GROUP

Group meet every Friday at 10:00 am in 21.G.23

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