WESTERN SYDNEY
UNIVERSITY

Nanoscale Organisation
and Dynamics Group

NANOSCALE RESEARCH NEWSLETTER

ISSUE 10 – AUGUST 2019

Flow Measurement in Grape Vines

Dr Tim Stait-Gardner

NIF Facility Fellow

The images in the last Nano Newsletter showed the initial stages and preparation for the imaging of a live grape vine in the 14.1 T (600 MHz) MRI in the BMRF.

This project is a collaboration with the National Wine and Grape Industry Centre (NWGIC) at Charles Sturt University and the NSW Department of Primary Industries. Of interest is the vascular transport within the grapevine. Xylem vessels transport water and nutrients from the roots to the shoots, whereas the phloem vessels transport photosynthates (mainly sucrose) from the sources (leaves) to the sinks (mainly the roots, fruit and growing tissues) of the grapevine. The flow rate within these conduits could reveal how the flow of water to various parts of the plant behave at different times during the day and the season and under different abiotic stress conditions. We hope the new knowledge will help us better understand fruit growth and provide leads in finding ways in better controlling yield and berry quality in the vineyard. This is the initial stage of the project where we are investigating and calibrating the methods for flow measurement. In summer, when the grapevine is fruiting we will examine diurnal and developmental changes in vascular flow in the grapevine subjected to abiotic stresses.

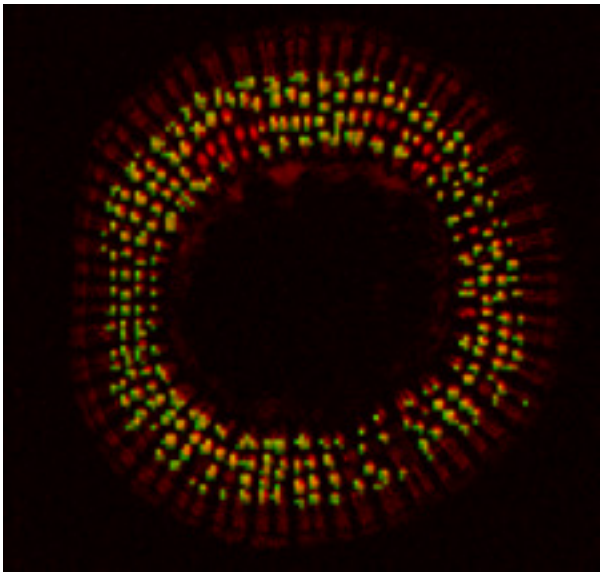

Figure 1 *The image is a composite of two scans, (red) sensitive to the morphology (FLASH with 400 × 400 pixels) and (green) sensitive to flow (FLOWMAP with 200 × 200 pixels scaled to 400 × 400 pixels). The more intense the green component of the voxel, the higher the flow rate.*

MRI is a very versatile imaging modality allowing for many different forms of contrast, including dynamic contrast such as diffusion and flow. The appropriate MRI flow measurement technique depends on the expected range of flow rates. The xylem vessels in a grapevine are approximately 50 to 100 µm in diameter and the phloem vessels are below 50 µm in diameter. The expected flow rates in the xylem vessels are between 1 mm/s and 6 mm/s (volume flow of 1 to 15 mm^3/s), and in the phloem vessels of between 0.2 and 0.5 mm/s (volume flow of 0.1 to 0.5 mm^3/s).

We use a flow mapping technique (the FLOWMAP sequence) that looks for changes in the phase of the nuclear spins due to coherent motion. To measure flow along a particular direction, first we apply a magnetic field gradient along that direction. This causes the magnetisation in the specimen to wind into a helix along that direction. If flow is present, then the helix will move along the direction of flow and there will be a phase shift along this

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SPECIAL POINTS OF INTEREST

Dr Scott A. Willis

Facility Manager

The BMRF in Brief

Since January this year there have been ten NANO guest lectures from: Prof. Sergey Traytak (Semenov Institute of Chemical Physics of the Russian Academy of Sciences, Russia), Dr Sean J. Blamires (UNSW), Dr David Waddington (USyd), Dr Rong Liu (WSU), Dr Jeffrey C. Hoch (UConn Health, USA), Prof. Pall Thordarson (School of Chemistry, UNSW), Dr Yingyan Zhang (School of Computing, Engineering and Mathematics, WSU), and Prof. Danuta Kruk (University of Warmia and Mazury in Olsztyn) – with research topics ranging from spider silk to NMR relaxometry. This month sees two new visiting researchers in the NANO group: Noriko Kanai from Japan and Prof. Danuta Kruk from Poland.

The 600 MHz NMR was down for most of April after the slow quench on 21/02/19, but was successfully recharged at the end of April – start of May. After some post recharge stabilisation time the 600 MHz has been seeing more use through NIF, NANO and SOM, including imaging of flow in a grape vine by visiting postdoctoral researcher Dr Zeyu Xiao (Charles Sturt University) for his research.

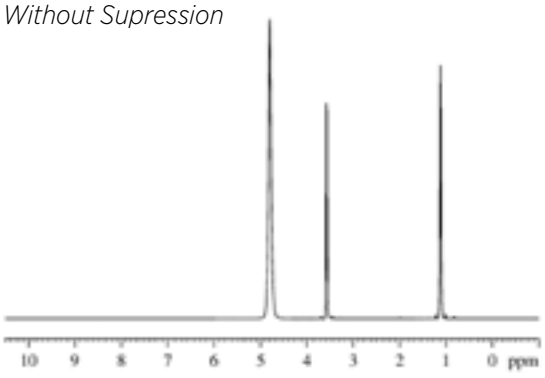
Dr Abhishek Gupta (postdoctoral researcher in the NANO group) visited Harvard/MGH and Johns Hopkins University, USA in June/July. He also attended and presented at a conference (The Future of Molecular MR, Canada; this conference was focused on MRI contrast agents) where he was awarded the Young Investigator Award.

In July, a group of HSC physics students (~30-40 students) were taken on a tour of the BMRF during the HSC Study Sessions – Academic Enrichment Sessions with Prof. William S. Price, Dr Tim Stait-Gardner and Dr Scott A. Willis.

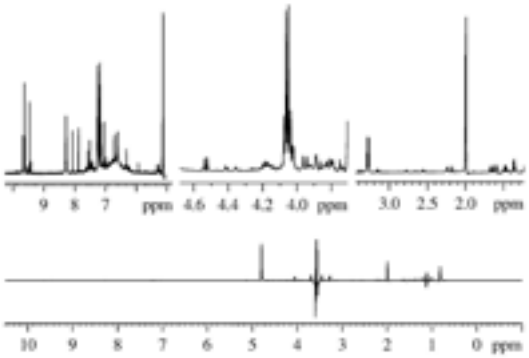
Members from the NANO group took part in an event for the 2019 Sydney Science Festival on the 09/08/19 which included a talk from Dr Abhishek Gupta on 'Detecting Cancer with Magnets' followed by a meet-and-greet session with demonstration using the Earth's Field NMR/MRI from Dr Abhishek Gupta, Dr Gang Zheng, Dr Scott A. Willis, Dr Timothy Stait-Gardner, Dr Allan Torres and Prof. William S. Price.

WHAT DO YOU CALL A NUMBER THAT CAN'T KEEP STILL? A ROAMIN' NUMERAL

Without Supression



With Supression



Research Snapshot: *Shown here are the 1_H NMR spectra acquired by Dr Scott A. Willis on the Bruker Avance III HD 600 MHz NMR of Miyagikyo Whisky (straight from the bottle) with and without suppression of the water/ethanol signals. NB: All spectra have different scaling factors in this image (i.e., left and right spectra were acquired with different receiver gains and number of scans and the insets for the suppressed spectrum are scaled to best show most of the 'non-alcohol' regions).*

SAFETY, INDUCTIONS and TRAINING: If you are a new or existing researcher that wants to use the BMR Facility at Campbelltown send me an email (Scott.Willis@westernsydney.edu.au) or come and see me for a tour or to organise the training.

THE PROBLEM WITH MATHS PUNS IS THAT

CALCULUS JOKES ARE DERIVATIVE,

TRIG JOKES ARE TOO GRAPHIC, AND

ALGEBRA JOKES ARE FORMULAIC.

BUT THESE JOKES ARE GUARANTEED TO MULTIPLY YOUR ENJOYMENT.

Can MRI help us to hit the right target?

Can MRI help us to hit the right target? (part one).

Behrouz Rasuli

PhD student

In radiation therapy, accurate treatment planning requires actual delineation (contouring) of the target volume currently obtained using CT scans (Fig. 1).

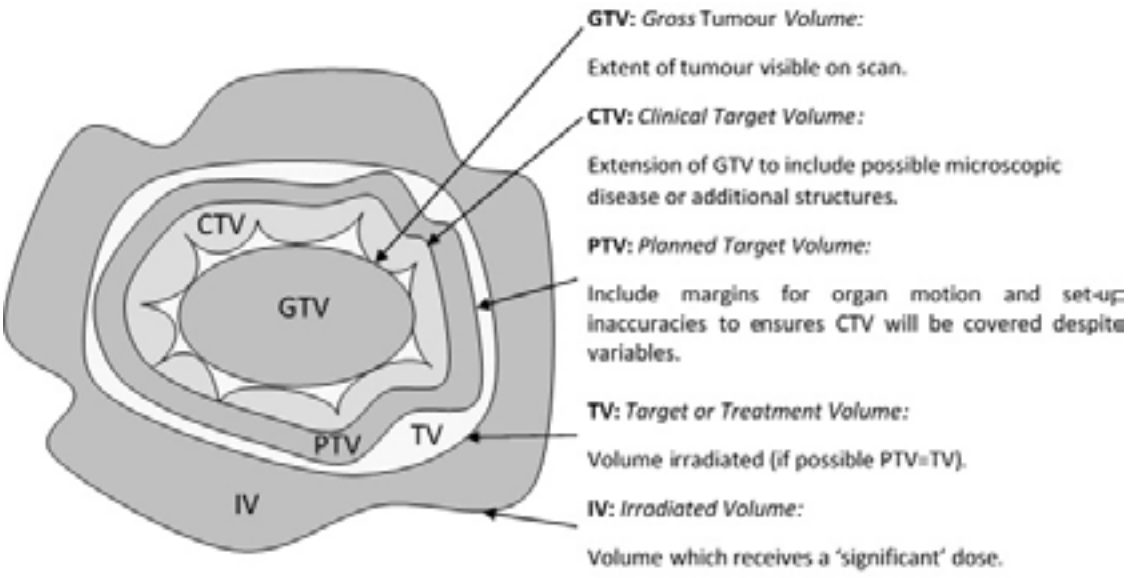


Fig 1: Target volumes in radiotherapy treatment planning

Errors in target delineation leads to treatment-related uncertainties that no level of in-room image guidance can compensate. Correct contouring of the target volume improves accuracy (reduces systematic errors) whereas image guidance improves precision (reduces random errors). In other words, you can continuously hit a wrong target (high precision but low accuracy), but what is required is to continuously hit the right target (planned target/tumour volume) during the radiation therapy (high precision and high accuracy) (Fig. 2).

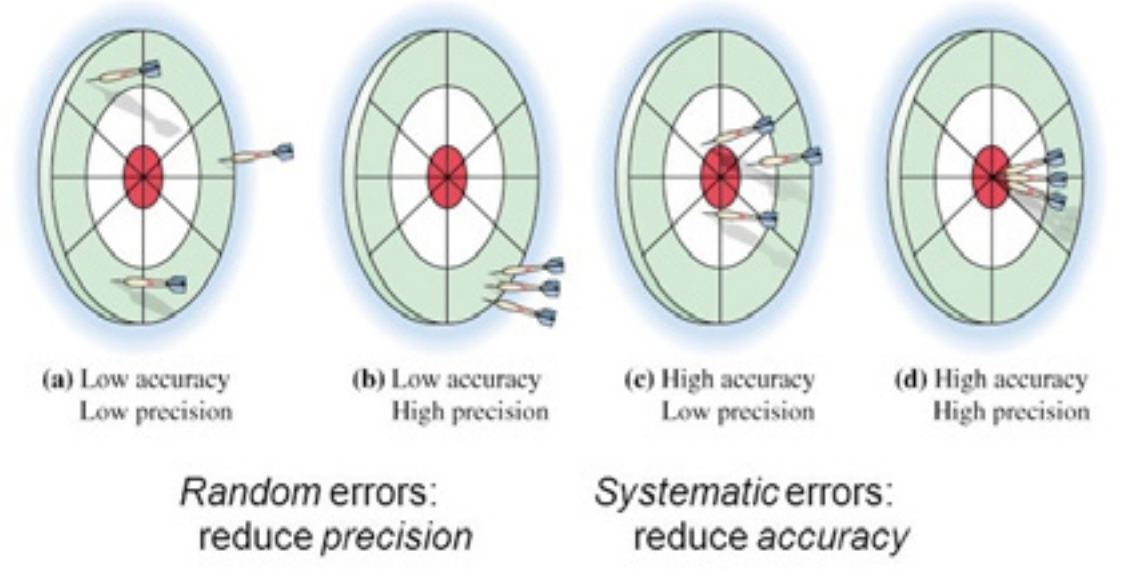


Fig. 2: Comparison of accuracy and precision in measurements

MRI scans provide multi-planar imaging capability, and excellent soft tissue contrast that is far superior to CT images (and without using ionising radiation). MRI can play a vital role in target contouring in radiotherapy treatment planning. In part two of this essay in the next issue of Nanonews, find out how we (Prof. Price, Dr. Stait-Gardner, Dr. Stephen Bosi and I) will use the dance styles of whirling protons in MRI signals to improve radiotherapy treatment planning.

Dr Abhishek Gupta's Visit to USA and Canada

Dr Abhishek Gupta

Post Doctoral Fellow

Dr Abhishek Gupta recently visited leading research laboratories in USA and also attended 'the Future of Molecular MR' conference in Canada as part of a WSU Early Career Researcher Development award. Here, he shared his experience of the trip:

What was the purpose of your trip?

I have been working on developing advanced MRI contrast agents for most of my academic career. Recently, it was found that a majority of the current clinically approved and commercially available MRI contrast agents were cumulatively getting retained in the brains of the patients following contrast enhanced MRI examinations. These serious safety concerns even led to the ban on three of the eight commercially available MRI contrast agents in Europe in 2017. In Australia, although no contrast agents were banned, strict warnings and cautions were issued over their use. Following these regulatory actions, there is a lot of interest in exploring potential alternatives to the current batch of MRI contrast agents, which are all small complexes of the Gadolinium metal ions.

As part of my career development, I wanted to visit some of the leading contrast agent laboratories in the world to discuss potential solutions to the safety concerns of gadolinium based contrast agents, learn about the current research in their laboratories, and initiate collaborations. Last year, I received a WSU Early Career Researcher Development Award, which made this visit possible. Using this award, I spent 4 weeks at Harvard University/MGH, 1 week at a conference with world leaders in contrast agents in Canada, and 1 week at Johns Hopkins University.

How was your experience?

Excellent! I learnt a lot during this visit and made some very useful contacts both at Harvard/MGH and Johns Hopkins. I have also initiated a collaboration with Harvard/MGH and am currently writing a paper with the contrast agents group there.

In addition, I presented my work at the 'Future of Molecular MR' conference in Canada. This conference aimed to identify new opportunities and existing barriers in molecular MRI, and discuss how these may be addressed. There were sessions dedicated to discuss alternatives to Gd-based MRI contrast agents, how to probe tissue microenvironment (like pH and pO2) using MRI and potential endogenous sources of MRI contrast. Speakers/organisers at this conference included almost every renowned name in the field of MRI contrast agents. At the end of this conference, I was awarded the 'young investigators award' for researchers within 6 years of completing their PhD.

This visit has truly helped, in my career development.

How was Boston? Did you visit any other cities as part of this trip?

I absolutely loved Boston! It has many historic buildings and I loved that the city is open till late every day. I also visited New York and Washington D.C. over the weekends and got to see many tourist attractions including the White House, the US Capitol, the Empire State Building and the Statue of Liberty.

In Canada, I enjoyed my stay in St John's (Newfoundland and Labrador). It is the eastern most city in North America and has many picturesque sceneries. It also has the famous 'jelly bean houses' (houses painted in bright colours) spread throughout downtown.

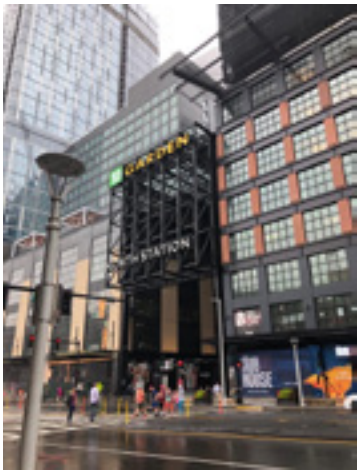
What's next?

Academically, this is a very exciting time for me. I am initiating a couple of new projects in the pursuit of safe and target-efficient contrast agents for MRI. As such, I am looking to build a collaborative team with a range of laboratories including chemistry, tissue-culture and animal facilities. I have also applied for an early career fellowship which, if successful, will provide funding for a PhD student.

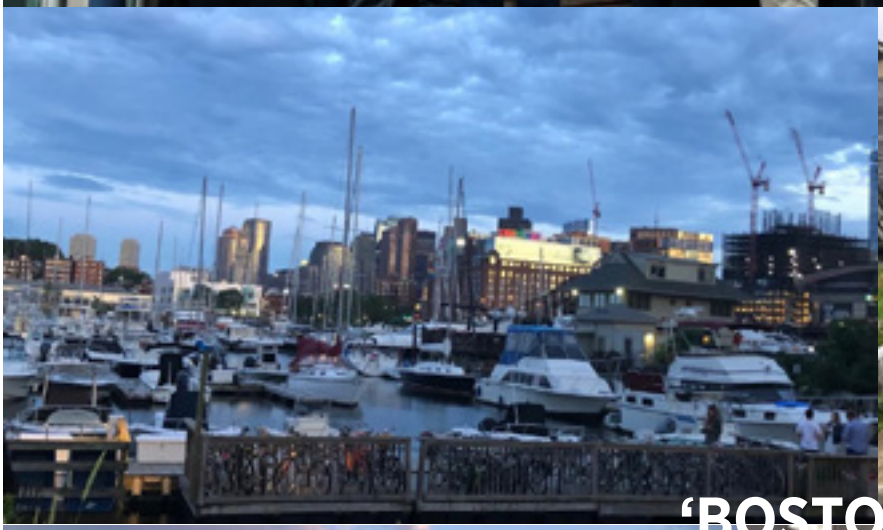
These projects will specifically benefit our (the Nanoscale group's) collaboration with the MRI-Linac (integrated MRI and linear accelerator) team at Ingham Institute, Liverpool Hospital, where we continue our efforts to improve and implement MRI-guided radiotherapy treatment of tumours.

OLD CHEMISTS NEVER DIE, THEY JUST STOP REACTING

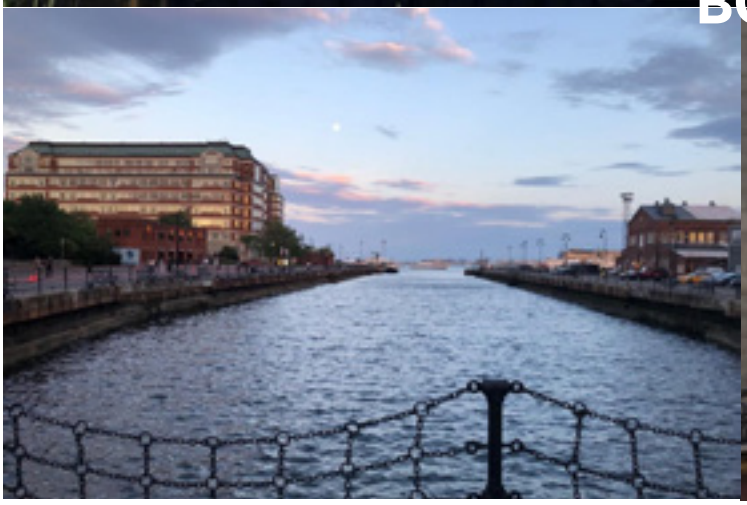
OLD MATHEMATICIANS NEVER DIE. THEY JUST LOSE SOME OF THEIR FUNCTIONS.

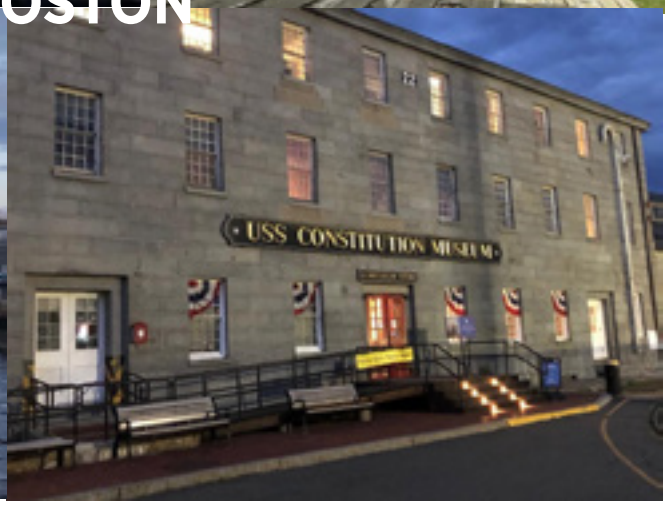


‘The Future of Molecular MR’ conference



‘BOSTON





continued from page 1 -

direction. This phase shift can be measured enabling the determination of the flow rate.
Our initial scans revealed a relatively low rate of xylem flow in a potted Shiraz grapevine. A large number of scans reveal a reasonably stable flow pattern, although the large dataset collected will take some time to process. Figure 1 (on page 1) shows a colour-coded image produced from a composite of a morphology scan and a flow sensitive scan. With a few more preliminary scans we will be ready to undertake the larger proposed study

NIF Central

NIF Central have moved from a print-only Quarterly Newsletter, to a limited print run. This is an electronically distributed 16-page Newsletter which is accessible to all devices and distributed monthly. Subscription to the "NIF Central Newsletter" is through this link - https://anif.org.au/nif-email-updates-subscribe/

NIF highlights from the past year. In 2018, NIF secured a $53.5 million investment over five years through the National Collaborative Research Infrastructure Strategy. Thanks to this investment, NIF plans to grow its network by including 21 more NIF/NCRIS funded or contributed instruments and 15 new Fellows, starting with 1 Fellow already welcomed in 2018.

The Global Bioimaging Project, funded through Horizon 2020, ended in late 2018. However, through the support of NIF, Microscopy Australia, and the project partners, we're pleased to let you know that the networks will continue to facilitate access to a global network of imaging infrastructure, exchange experience, and standardise data protocols.

Australia's research community is increasingly reporting the impact they have on the economy, society, and the environment. The NIF e-newsletters will highlight some example projects, showcasing the collaborative efforts of NIF scientists. It will also bring you news about NIF-related activities and keep you informed on current events.

Congratulations

Congratulations Dr Abhishek Gupta on winning the "Young Investigator Award for researchers within 6 years of completing PhD" at the "Future of Molecular MR" conference in July in St. John's, Newfoundland, Canada.

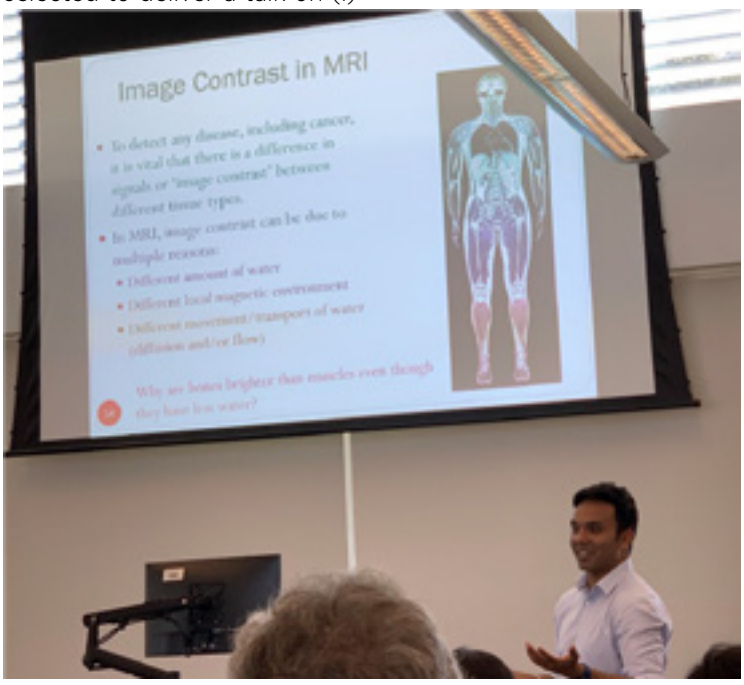
Abhishek recently travelled to Canada and the USA on the WSU 2019 Early Career Researcher Development Award.

He visited some of the leading laboratories in MRI contrast agent development (Prof. Peter Caravan, Harvard U/MGH; Prof. Peter van Zijl and Dr Michael McMahon, Johns Hopkins Univ.) in the US. Contrast agents are used in MRI for purposes such as better delineation of cancers and for probing the effectiveness of cancer treatment.

The conference was looking to the "Future of molecular MR imaging" by identifying new opportunities, existing barriers, and how these may be addressed, with sessions dedicated to:

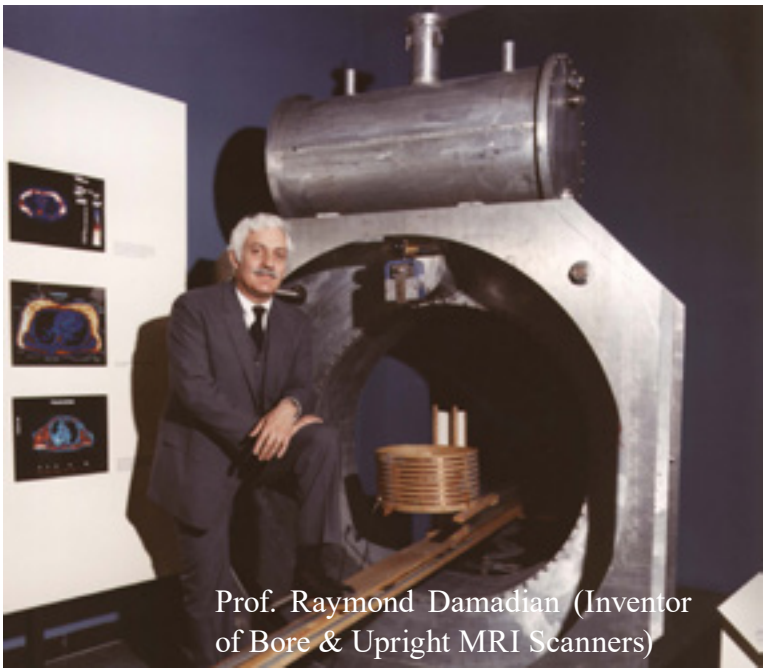
- Alternatives to Gd-based MRI contrast agents
- How to probe microenvironment (like pH and pO_2) in MRI
- Endogenous sources of MRI contrast

All the big names in MRI contrast agents were there (including Abhishek!) Abhishek had been selected to deliver a talk on (i) supramolecular nanoparticles, including the hypoxia-specific liposomes, and (ii) on optimal strategies for hypoxia detection including designing hypoxia-specific contrast agents. At the conference he was awarded the "Young Investigator Award for researchers within 6 years of completing PhD" acknowledging his international eminence in the field of MRI contrast agent development.



Mini Symposium to Launch New Imaging Courses

Thursday 24th October 2019 @ 1:00 pm


Prof. Raymond Damadian (Inventor of Bore & Upright MRI Scanners)

Guest speaker, Professor Raymond Damadian (American physician, medical practitioner, and inventor of the first MR Scanning Machine) will head the list of speakers at the launch of the new courses.

Talks will be followed by an evening networking event at Rydges Hotel Campbelltown starting at 6:00 pm. The evening will give attendees the opportunity to socialise with Prof. Damadian and other people in the field of Medical imaging.

Attendance at the talks will be free and they will be held in CA.04.G.015 (Lecture Theatre 1).

Attendance in the evening (Canapes and Dinner) will cost $35 per person (Drinks not included).

Please register for both events at;

www.westernsydney.edu.au/MRIsymposium

Masters of Medical Imaging (MRI)

The Master of Advanced Imaging MRI, is available for students who would like to further their knowledge and skills in clinical MRI. This course is structured to cater for eligible Graduate Medical Practitioners, Medical Radiation Practitioners (MRP) and Allied Health and other Health Professionals including Dentists and Veterinary practitioners. The Master course provides in depth learning in MRI including basic physics as well as advanced clinical imaging techniques. Students will learn the skills to conduct an independent research project in MRI to address theoretical and/or practical issues and problems in relation to Advanced Imaging/MRI. There will be face-to-face or video-conferencing intensive workshops and interactions with specialists from different medical disciplines.

The course provides two weeks clinical training in a WSU endorsed MRI clinical site for each of the clinical units offered.

Graduates will be offered optional eight weeks additional clinical training, especially for those who do not have an opportunity for ongoing MRI practical experience.

Graduate Diploma in Advanced Imaging (MRI)

The Graduate Diploma in Advanced Imaging aims to evaluate regional human anatomy and pathological findings to distinguish normal and pathological MR images; to analyse the principles, techniques, procedures and aspects of MR imaging practices and image formation. Graduates will become equipped with the skills to design MR protocols relevant to patients' clinical needs and employ the technology to provide quality imaging with high diagnostic confidence. There will be face-to-face or video-conferencing intensive workshops and interactions with specialists from different medical disciplines

The course provides two weeks clinical training in a WSU endorsed MRI clinical site for each of the clinical units.

Graduates will be offered optional eight weeks additional clinical training, especially for those who do not have an opportunity for ongoing MRI practical experience.

Graduate Certificate in Advanced Imaging (MRI)

The Graduate Certificate of Advanced Imaging MRI examines the radiobiological effects of ionisation and excitation on human cell biology for both small and large doses and their Stochastic, Deterministic, and Genetic effects on Humans. It explores the different designs of MRI units and the associated accessories as well as the physical structure and safety requirements in MRI. Course content employs an evidence-based approach to examine different diagnostic imaging pathways for the different organs and human body parts. The Graduate certificate is designed to also accommodate Nursing, and Medical professionals who will be relying on MRI for clinical assessments or working in MRI as well as to non-health related professional anticipating work with or within the health industry.

There will be face-to-face or video-conferencing intensive workshops and interactions with specialists from different medical disciplines.

Puzzle Page

WHAT KIND OF ROOM HAS NO DOORS OR WINDOWS?

A MUSHROOM

A PLANE CRASHES ON THE BORDER OF N.S.W. AND QUEENSLAND. WHERE DO THEY BURY THE SURVIVORS?

YOU DON'T BURY SURVIVORS!

WHAT CAN TRAVEL AROUND THE WORLD WHILE STAYING IN A CORNER?

A STAMP

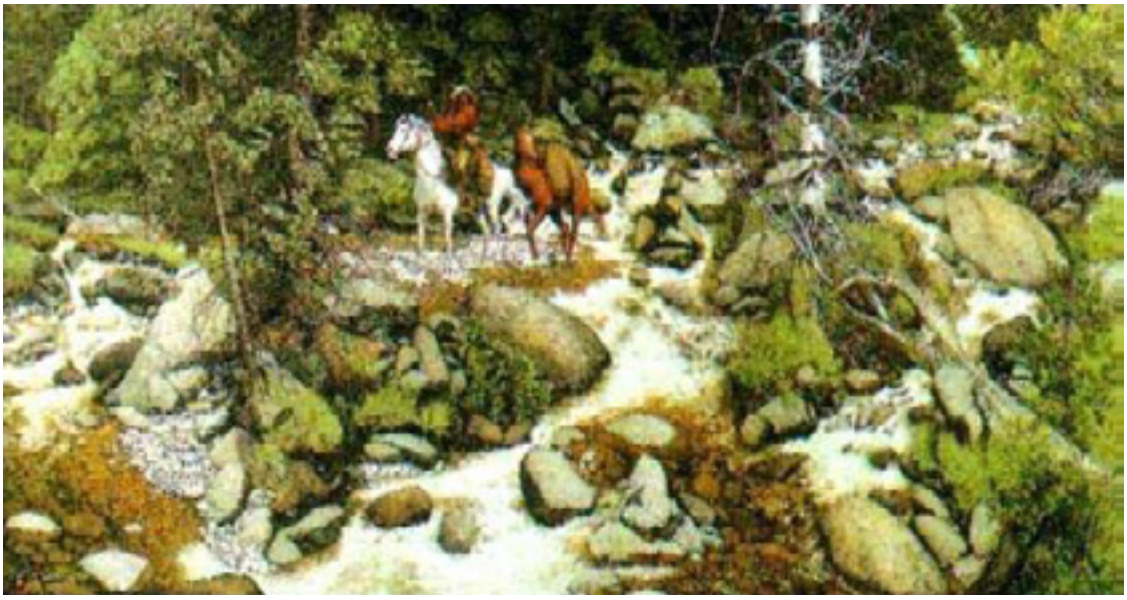
WHAT ARE THE NEXT 3 LETTERS IN THE FOLLOWING SEQUENCE?

J, F, M, A, M, J, J, A, __, __, __

S, O, N THE SEQUENCE IS FIRST LETTER OF THE MONTHS SEPT, OCT AND NOV

WHY ARE CHEMISTS GREAT FOR SOLVING PROBLEMS?

THEY HAVE ALL THE SOLUTIONS



There should be 11 faces on this picture. Average people see 4-6, sensible 8-10. The best see all 11, schizophrenics and paranoids 12 and more. And you? (don't take this one too seriously, I have even heard that there are 13 faces)

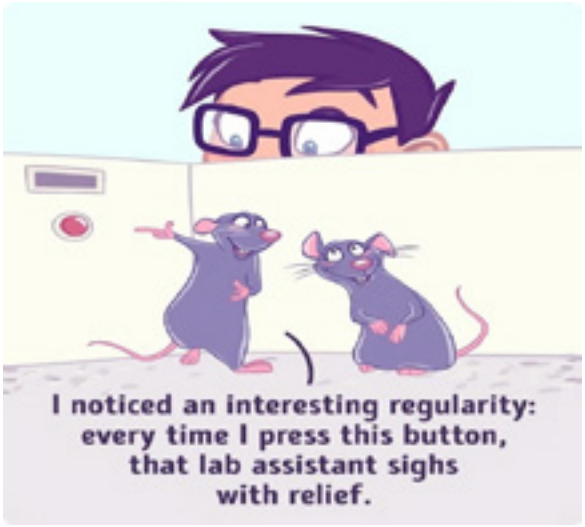
JIMMY'S MOTHER HAD 4 CHILDREN. SHE NAMED THE FIRST MONDAY. NAMED THE SECOND TUESDAY. THE THIRD IS NAMED WEDNESDAY. WHAT IS THE NAME OF THE FOURTH CHILD?

JIMMY. "JIMMY'S MOTHER HAD 4 CHILDREN"!

A photon checks into a hotel and is asked if he needs any help with his luggage. He says, "No, I'm travelling light.

An expert is a man who has made all the mistakes, which can be made, in a very narrow field - Niels Bohr

Don't trust atoms, they make up everything.



NANOSCALE ORGANISATION AND DYNAMICS

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

Professor Janice Aldrich-Wright
Director Research School of Science and Health
- Potent in-vivo cytotoxic agents

Professor Annemarie Hennessy
Dean of Medicine
- Preeclampsia

Assoc. Prof. Gary Dennis
Deputy Dean School of Science and Health
- Polymer and surface chemistry

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

Dr Allan Torres
Research Instrumentalist
Senior Lecturer
- NMR and MRI

Dr Gang Zheng
Lecturer
- NMR pulse sequence development

Dr Scott Willis
BMRF Manager & Researcher
- NMR and MRI diffusion measurements

Dr Abhishek Gupta
Post Doctoral Fellow
- MRI contrast agent development and NMR relaxation

I HAVE NOT FAILED.

I'VE JUST FOUND 10,000 WAYS THAT WON'T WORK

— THOMAS ALVA EDISON

Group 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

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