WESTERN SYDNEY
UNIVERSITY

Nanoscale Organisation
and Dynamics Group

NANOSCALE RESEARCH NEWSLETTER

ISSUE 3 – MAY 2016

Biomedical Magnetic Resonance Facility

Dr Mikhail Zubkov Biomedical Magnetic Resonance Facility Manager

In early May, after some initial teething problems, the 600 MHz Bruker spectrometer has been bought back into operation in the Biomedical Magnetic Resonance Facility. The machine is now available for both imaging and spectroscopic experiments. Imaging can be performed using the dedicated Micro 2.5 gradient probe (30 mm or 10 mm samples) or the shared (500 MHz spectrometer) Mini 0.75 (40 mm samples) and Micro 5 (5 mm, 8 mm and 10 mm samples). Also the Micro 2.5 probe can be used for temperature controlled imaging (-20 to +60°C).

Dr Mikhail Zubkov presented the BMRF capabilities to a small gathering of students and academics in April. The meeting was chaired by Prof. James Arvanitakis, (Dean of Postgraduate Studies) and other facility managers under the WSU Centralised Facilities, presented information on their own facilities. The meeting was organised to encourage greater student awareness and usage of the facilities and their capabilities. Informal discussion after the meeting gave the students the opportunity for further discussion on past, current and ongoing research and encouragement to become involved.

The 2015 BMR Facility Operational Report was submitted but was hindered by the lack of data on the usage of the 300 MHz spectrometer. Despite having an online timetable available for the machine it is rarely being used for booking. Therefore we ask for users to either book their usage on the 300 MHz spectrometer beforehand or log their usage, in the same timetable, after their experiments have been finished.

WSU - National Imaging Facility Node

National Imaging Facility

I DON'T LIKE ELECTRONS;

THEY'VE ALWAYS HAD A NEGATIVE INFLUENCE ON SOCIETY.

— CHRIS LIPE.

NIF case study: Grape berry split using DWI

Dr Ryan Dean, Dr Gabriele Bobek, Dr Suzy Rogiers, Dr Simon Clarke, Dr Timothy Stait-Gardner and Prof. William S. Price

Berry split is a condition in which the grape epidermis splits. It often occurs during periods of high rainfall and is a significant cause of grape crop loss. In damp conditions there is increased uptake of water via osmosis and decreased water loss from transpiration. The pre-dawn turgor pressure of table grape cultivars lies in the vicinity of 5-38 kPa but prior to berry split can be as high as 1.5-3.7 MPa. The conditions causing berry split in Australia are projected to worsen due to climate change.
This study investigated the physical changes within the grape berry both before and after splitting using diffusion magnetic resonance imaging. Thirty-six table grapes of the Thompson Seedless variety were involved in the study and assigned to three groups: a control group (12 berries), a group in which they were wrapped in damp tissue (12 berries), and a total immersion group (12 berries). Five axial images (including diffusion tensor images) spaced evenly apart along the length of each berry were acquired simultaneously every hour to create a time-course study of each grape.

For each grape that split within the MRI during the study it was observed that there was an immediate change in the diffusion coefficient in the region of the wound. This region increased in volume over the course of the subsequent scans and correlated with regions of non-vital cells (as determined by fluorescence microscopy). It was determined from the study that grape berries left exposed to standing water after splitting exhibit greater cell death within the vicinity of the split. Therefore, the surface of split berries should be kept dry if possible to reduce further damage. Further information can be found in [1].

[1] Dean, R.J., Bobek, G., Stait-Gardner, T., Clarke, S.J., Rogiers, S.Y. and Price, W.S. (2015), Time-course study of grape berry split using diffusion magnetic resonance imaging. Australian Journal of Grape and Wine Research. doi: 10.1111/ajgw.12184

SPECIAL POINTS OF INTEREST

Magnetic Resonance Imaging Explained

WHAT IS THE MEANING OF THE ABBREVIATION SPIN?

SOCIETY FOR THE PROTECTION OF INNOCENT NUCLEI

Magnetic Resonance Imaging (MRI)

is commonly considered a medical imaging technique alternative or complementary to Computed Tomography (CT). The physical and mathematical principles behind the two are however distinctly different. While CT is based on acquiring a large number of X-ray absorption profiles (projections) and using the Radon transform to build an image, MRI looks at the frequencies the nuclear magnetization rotates (or precesses) at and uses the Fourier transform to produce an image from the raw data.

Acquisition of the raw data (referred to as the k-space) is slightly more complicated in MRI than in CT, where a simple analogy of shining a light onto a semi-transparent body and looking how much light passes through can suffice. The k-space on the other hand consists in the simplest case of the digitized nuclear magnetic resonance signals (usually spin-echo or gradient echo) of water recorded in the presence of a magnetic field gradient. The presence of the gradients is central to MRI. In the absence of the gradients the water NMR signal from the whole body contains radio waves of only a single certain frequency. When gradients are applied the frequency of the NMR signal becomes dependent on where the water is located in the body. The magnitude of the signal at each frequency then becomes dependent on how much water is present at the particular location in the body corresponding to that frequency. Thus after application of the gradients the NMR signal carries the information about the quantity of water in the body and where it is located, i.e. these values are encoded in the frequency of the signal. This process is called frequency encoding.

Fourier transform allows the decoding of this information encoded in the signal and provides a distribution of water content within the body, which is what the simplest MRI images represent (although actual imaging techniques usually involve more than just frequency encoding, usually employing magnetic field gradients to perform phase encoding and slice selection). While water content (or proton density) can be sufficient, for some diagnostic purposes MRI usually relies on relaxation to provide better contrast between the tissues (as a lot of biological tissues have roughly similar water content, thus they might be hardly distinguishable on proton density MRI images). Varying the timing of the MRI experiment, particularly how fast the MRI pulse sequence is repeated (TR) and how fast the NMR signal is acquired after the pulse sequence begins (TE) allows one to stress either the difference in longitudinal (T1) or transverse (T2) nuclear relaxation times. These differ a lot more than the proton density from tissue to tissue and from healthy tissue to damaged body regions, thus they appear either as significantly darker or brighter areas on MRI images.

By increasing the complexity of an MRI experiment MRI images can be made to represent various other properties, e.g. diffusion, flow, lipid content, motion, elasticity, temperature, neural activity etc. Each of the parameters mapped by MRI can then be used to further clarify the processes in the body without the need to interfere with its integrity.

Images of a Quail Egg (left to right); MRI Image; Quail Egg; MicroCT image

Student Profile - Dale Ang

Dale Ang

Dale Ang completed his B.Sc. (Adv anced Science) (Honours) in 2014 at Western Sydney University and was awarded the University Medal.

Dale L. Ang is currently undertaking a PhD titled "Structural requirements for selective QDNA binding". He is the recipient of the Dean's medal, the Ellice Swinbourne Prize for Excellence in Chemistry and an Honours scholarship in 2014. In 2015 Dale was awarded the University Medal and an Australian Postgraduate Award and offered an Endeavour Scholarship. In 2013 Dale participated in the ANSTO Winter School and a summer studentship at CSIRO. He has presented research at two international conferences and conducted experiments at several international facilities. Dale is currently in his second year of PhD and during 2016 is participating in a Marie Curie Early Stage Researcher fellowship at the University of Warwick, Coventry, UK, where he is focussing on molecular dynamics simulations of various biomolecules. His research interests include G-quadruplex binding platinum complexes, circular and linear dichroism, and computational techniques such as molecular dynamics and docking simulations. He currently has two first author publications.

Dale is supervised by Prof. Janice Aldrich-Wright and Dr Christopher Gordon.

Scientist Find-a-Word

Y	G	A	L	I	L	E	I	N	S	T	E	I	N	Y
D	B	G	E	R	U	T	H	E	R	F	O	R	D	R
L	N	A	L	M	E	N	D	E	L	E	E	V	H	R
O	I	U	B	L	L	E	B	N	G	C	N	O	R	U
G	L	S	B	V	M	F	C	N	O	X	B	N	H	W
N	K	S	U	I	O	F	I	U	E	T	G	E	A	A
I	N	A	H	G	A	L	L	A	C	V	W	M	R	T
K	A	C	R	R	E	O	T	S	B	D	V	E	B	S
W	R	C	A	E	M	R	U	A	L	Y	L	S	N	O
A	F	D	K	B	U	E	R	A	U	G	A	J	P	N
H	A	T	H	E	A	Z	W	N	I	W	R	A	D	U
Y	L	X	T	N	Y	T	U	E	D	I	S	O	N	D
T	E	S	N	K	S	S	Z	H	K	C	N	A	L	P
F	A	I	I	O	O	R	V	C	A	C	U	R	I	E
P	L	N	X	V	X	S	E	L	U	O	J	V	I	A

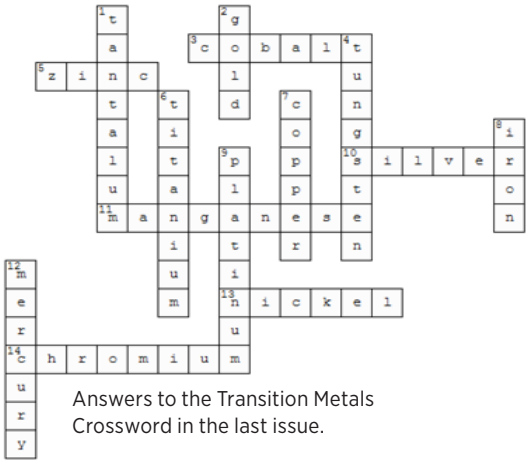
ARCHIMEDES	CURIE	GALILEI	JOULE	PASCAL	URRY
BARZYKIN	DARWIN	GAUSS	KEELING	PASTEUR	VOLTA
BELL	EDISON	GREBENKOV	LINNAEUS	PLANCK	WATSON
BOHR	EINSTEIN	HAWKING	MENDELEEV	RUTHERFORD	XIE
CALLAGHAN	FARADAY	HUBBLE	NEWTON	SEMENOV	YUNUSOV
COULOMB	FRANKLIN	INGOLD	OSTWALD	TANNER	ZEIGLER

IF IT'S GREEN OR WRIGGLES, IT'S BIOLOGY.

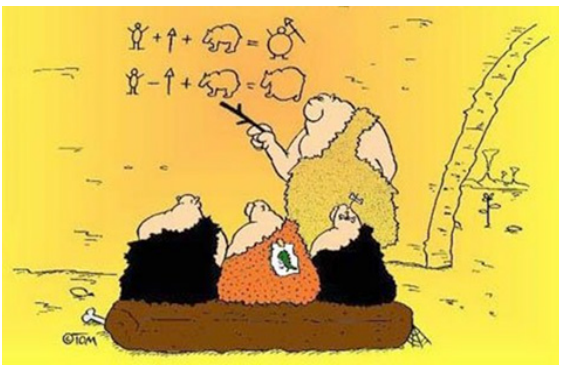
IF IT STINKS, IT'S CHEMISTRY.

IF IT DOESN'T WORK, IT'S PHYSICS...

RADIOACTIVE CATS HAVE 18 HALF-LIVES.



Answers to the Transition Metals Crossword in the last issue.



筑波大学
University of Tsukuba

Associate Professor Yasuhiko Terada

Yasuhiko Terada is an Associate Professor at University of Tsukuba, Japan. He will be visiting WSU at Prof. William Price's invitation from the 23rd May - 15th July.

Associate Professor Yasuhiko Terada received his PhD in engineering from the University of Tokyo in 2001. After a few years working at Advanced Research Laboratory, Hitachi co. ltd., he moved to University of Tsukuba in 2005 as a postdoctoral researcher, and he and his team developed novel femtosecond time-resolved scanning tunnelling microscopy for nanoscale imaging of ultrafast phenomena.

In 2010, he started working with Professor Katsumi Kose in NMR imaging laboratory at the University of Tsukuba. His current research interests are development of novel NMR imaging systems and new applications in NMR imaging. More specifically, he enjoys developing open, compact MRI systems for specific uses, such as skeletal age assessment in children and microscopic imaging of sap flow in plants.

Australian Government

ansto

Dr Chris Garvey

Upcoming Lecture -

"Visual Analytics – Breaking the Complexity of Medical Data"

Dr Quang Vinh Nguyen - School of Computing, Engineering and Mathematics, and MARCS Institute

23rd June at 2:00 pm
Campbelltown21.G.03
Lecture Theatre 5

Christopher J. Garvey - Bragg Institute, Australian Nuclear Science and Technology Organization, Lucas Heights gave a lecture "Dynamic and Structural Heterogeneity in Red Blood Cells" at Campbelltown on the 18th May 2016.

Chris Garvey is an instrument scientist on the SANS instrument QUOKKA, and a physicist applying advanced physical characterisations at the interface between biology and materials science. He holds senior adjunct positions in the Departments of Chemical and Materials Engineering at Monash University; School of Molecular Biosciences at the University of Sydney; and Applied Physics at RMIT University. http://www.ansto.gov.au/ResearchHub/StaffProfiles/GARVEY-CHRIS

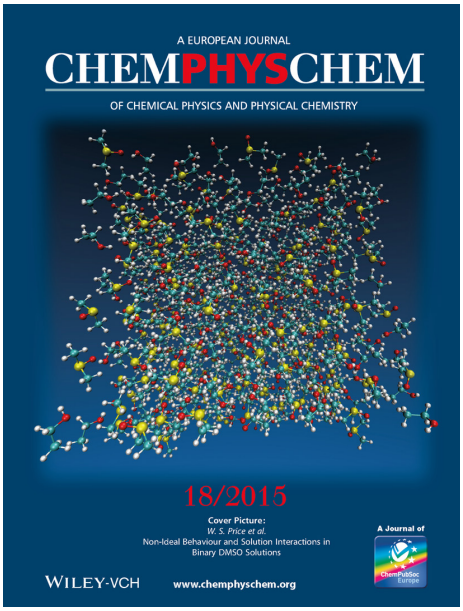
TOHOKU UNIVERSITY

Professor Masaya Ishikawa

Masaya Ishikawa is a Professor in the School of Applied Biological Science, Tokyo University, Japan. He will be visiting WSU for a short time this month.

Prof. Bill Price recently visited Japan for a series of meetings and lectures, one of which was at Tokyo University of Science. This visit is as a result of this and other meetings in Japan. Professor Masaya Ishikawa is a collaborator and co-author on a number of papers with Prof. Price. During this visit he will be using the 600 MHz spectrometer for low temperature imaging.

- Kishimoto, T., et al., High ice nucleation activity located in blueberry stem bark is linked to primary freeze initiation and adaptive freezing behaviour of the bark. AoB Plants, 2014. 6.
- Ishikawa, M., et al., Freezing Behaviours in Plant Tissues: Visualization using NMR Micro-imaging and Biochemical Regulatory Factors Involved, in Plant Cold Hardiness: From the Laboratory to the Field, L.V. Gusta, M.E. Wisniewski, and K.K. Tanino, Editors. 2009, Cabi Publishing-C a B Int: Wallingford. p. 19-28.
- Ide, H., et al., Freezing behaviors in leaf buds of cold-hardy conifers visualized by NMR microscopy. Tree Physiology, 1998. 18(7): p. 451-458.
- Price, W.S., et al., Visualisation of freezing behaviours in flower bud tissues of cold-hardy Rhododendron japonicum by nuclear magnetic resonance micro-imaging. Functional Plant Biology, 1997. 24(5): p. 599-605.
- Ishikawa, M., et al., Visualization of freezing behaviors in leaf and flower buds of full-moon maple by nuclear magnetic resonance microscopy. Plant Physiology, 1997. 115(4): p. 1515-1524.



Hydrogen-bonded associated structures in DMSO–MeOH and DMSO–EtOH mixtures were studied using nuclear magnetic resonance diffusion experiments and molecular dynamics simulations over the entire composition range at 298 K. A direct comparison of the simulated and experimental data gives a greater insight into the structural properties of binary mixtures.

CHEMICAL PHYSICS AND PHYSICAL CHEMISTRY Back Cover: Non-Ideal Behaviour and Solution Interactions in Binary DMSO Solutions (ChemPhysChem 18/2015)(page 3814)

Amninder S. Virk, Dale J. Codling, Timothy Stait-Gardner, William S.Price

DOI: 10.1002/cphc.201500670

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

Professor Annemarie Hennessy
Dean of Medicine
- Preeclampsia

Assoc. Prof. Gary Dennis
Director Research 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
Post Doctoral Fellow
- NMR and MRI diffusion measurements

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

Dr Mikhail Zubkov
Biomedical Magnetic Resonance Facility Manager
- Modified diffusion sequences

I HAVE NOT FAILED.

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

— THOMAS ALVA EDISON

Group Meetings

NANOSCALE RESEARCH / GRANT MEETINGS

Nanoscale Research/Grant Meetings are held monthly at Campbelltown.

PROFESSOR WILLIAM PRICE'S LAB GROUP

Meet every Friday at 09:30 am in CA 21.1.65

BMRF USERS MEETING

February / May / August / November

PROFESSOR JANICE ALDRICH-WRIGHT'S LAB GROUP

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

Contact information
02 4620 3336
nano@westernsydney.edu.au

Western Sydney University
Locked Bag 1797
Penrith NSW 2751 Australia

WESTERNSYDNEY.EDU.AU/NANOSCALE/NANOSCALE_ORGANISATION_AND_DYNAMICS