

chemistry

June 2017

in Australia



Banknote security: from paper to polymer and beyond

chemaust.raci.org.au



- Chemistry and transport proteins
- Celebrating the RACI years
- Research performance in Australian universities

RACI2017 Centenary Congress

The oldest scientific or technical professional society in **Australia**, the Royal Australian Chemical Institute celebrates their centenary, at **RACI2017** in Melbourne at the Melbourne Convention & Exhibition Centre 23-28 July 2017.

RACI Must Dos



Be social. Mingle in amongst old friends and make new ones. Celebrate the Centenary and enjoy yourself.

This novel congress concept involves all of the partner conferences running concurrently during the week allowing delegates to access sessions across a wide variety of chemistry disciplines.



CHEMISTRY – ADDRESSING



2 Nobel laureates
9 Congress plenary speakers
334 Keynote/Invited speakers
62 participating countries
2979 abstract submissions
1575 oral submissions
1404 poster submissions

Melbourne | 23-28 July 2017

Download the App from the Congress website.



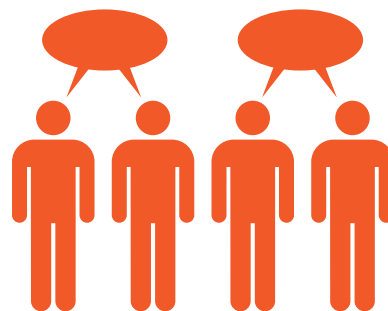
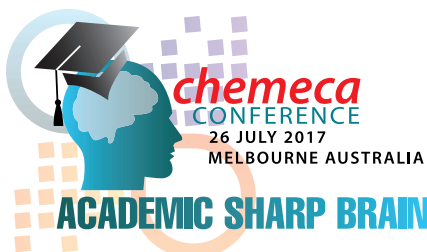
Attend the Academic Sharp Brain

- 10 intelligent minds will pitch their ideas
- Panel of experts vote for the idea
- Knowledge investors will compete by offering bigger dollars
- Intelligent minds and knowledge investors will bring the idea to the marketplace

Join the conversation
#RACI100



Plan ahead, create your own itinerary and make contacts with other attendees.



Consult with your colleagues and make valuable connections. Speakers, sponsors and exhibitors and attendees alike are experts in their field.

SUSTAINABLE DEVELOPMENT AND OTHER CHALLENGES OF THE 2020s



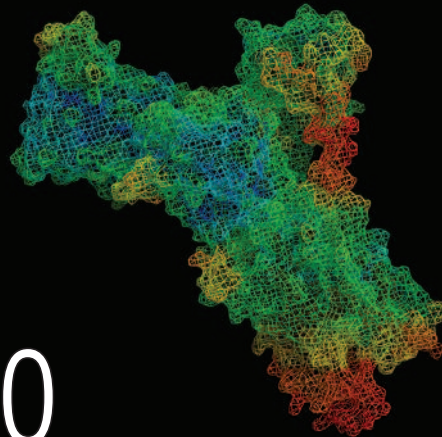
23-28 July 2017 | Melbourne



Centenary Congress

REGISTER NOW
www.racicongress.com





cover story

Banknote security: keeping our currency current

We are in the midst of Australian banknote anniversaries, and last year the UK released their first polymer note. Tom Spurling and David Solomon reflect on the security of banknote technology and look to its future.

16

20 Pumps, channels and transporters: how chemists can help

Sixty years ago, a Danish doctor was the first to isolate an ion-transporting membrane protein. Much has been learned about the crystal structures and amino acid sequences of such proteins since then, and the scope for work in chemical synthesis is increasing.

24 Celebrating the RACI years 1917–2017

Helmut Hgel looks back at the RACI's beginnings and the changes over the past 100 years.

news & research

- 7 News
- 12 Research
- 42 Cryptic chemistry
- 42 Events

members

- 32 Obituary

views & reviews

- 5 Guest editorial
- 6 Your say
- 28 Books
- 33 Environment
- 34 Plants & soils
- 36 Science for fun
- 38 Education
- 40 Grapevine
- 41 Letter from Melbourne





March for Science in Brisbane. Mattias Björnmalm

Marching for science

On Earth Day, 22 April, chemists across Australia and the world joined a global movement celebrating science by engaging with other scientists and the general public in meet-ups, marches, public talks and festivities. I was in Brisbane that day, having just visited a collaborator at the University of Queensland the day before, and therefore joined the activities in the River City. Across all of Australia, thousands of scientists and researchers from all disciplines and their friends, kids, relatives and other supporters came together. But what were we trying to support? The March for Science international website (marchforscience.com) says:

The March for Science champions robustly funded and publicly communicated science as a pillar of human freedom and prosperity. We unite as a diverse, nonpartisan group to call for science that upholds the common good and for political leaders and policy makers to enact evidence based policies in the public interest. The March for Science is a celebration of science.

While influential voices globally (such as *Nature*, *Science* and the American Chemical Society) and locally (including the *Sydney Morning Herald* and Nobel Laureate Peter Doherty) expressed strong support for this movement, others expressed concerns. A prominent example in Australia is the Australian Academy of Science, which was called ‘spineless’ by Professor Simon Chapman for not endorsing the March for Science (*Sydney Morning Herald*, 17 April 2017).

During discussions with colleagues, friends and attendees before, during and after the event, two concerns kept coming up. One was the notion that ‘Scientists should not march; they should not be involved in politics’. But science and chemistry – and indeed the pursuit of knowledge and understanding in general – does not happen in a vacuum. If we want these to help shape our world and the direction we are moving in, then we must engage with the broader community. Dispassionate presentation of discoveries and facts only marginally informs

and influences behaviour. Instead, norms, values and narratives are what drive decisions, both for individuals and for communities. These are areas that have been called ‘blind spots’ for scientists (*Nature* 2017, vol. 543, p. 623) and are something we as a community should work to improve on. Something like the March for Science is only a small part towards increasing broad engagement with the general public, but it is a step in the right direction that also complements emerging concepts in the scientific community towards open and transparent science, as we have recently discussed (*J. Am. Chem. Soc.* 2016, vol. 138, p. 13 449).

The second concern centred on ‘What difference is this going to make?’, which can be difficult to answer. Reporting from marches all over the world showed people of all ages and backgrounds enjoying themselves and having a great time with some funny signs and outfits. But after the event very few immediate effects or changes were obvious, which can then raise the question ‘What was the point?’. Here it is important to remember that the key idea is to show, share and spread passion about science, that it is valuable and worthy of support, and to raise awareness of the challenges that the scientific endeavour is facing. A march is only one of many ways to do this, and many supporters have helped – and continue to help – by spreading these messages through TV, radio, newspapers, social media, and just by talking with colleagues and friends. Having the support of a global movement helps provide weight and momentum to these efforts.

To effect change is never easy and requires sustained efforts. At its core it is about trying to share what we as chemists and scientists are passionate about, what we value, and why we think chemistry and science are important for our future.

Dr Mattias Björnmalm is at the ARC Centre of Excellence in Convergent Bio-Nano Science and Technology, and the Department of Chemical and Biomolecular Engineering, the University of Melbourne.

Centenary of death of chemistry laureates

It was interesting to read in Sally Woollett's editorial in the March issue (p. 4) of the several Nobel laureates in chemistry who were born in 1917, the centenary year of the RACI. To that might be added the fact that 1917 is the year of the deaths of two of the early Nobel Prize winners in chemistry.

One is Adolf von Baeyer, who died in August that year at age 81. He received the prize in 1905 'in recognition of his services in the advancement of organic chemistry and the chemical industry, through his work on organic dyes and hydroaromatic compounds'.

The other is Eduard Buchner, who received a Nobel Prize in 1907 'for his biochemical researches and his discovery of cell-free fermentation'. At the beginning of World War I, Buchner entered the German Army, and he died in action in August 1917 at age 57.

In spite of taking an interest in such matters for very many years, I was unaware until I read Sally's piece that the organic chemists J.W. Cornforth and R.B. Woodward had been born in the same year. The latter predeceased the former by 34 years.

Clifford Jones FRACI CChem

RACI and overseas membership

The following may sound like a provocative question, but is meant as an honest question: as a chemist permanently based in Europe, is there any point maintaining my membership of the RACI?

I should stress that I have no intention of leaving the RACI, but the question occurred to me here over Christmas. Let me explain my background. I obtained my BSc(Hons) and PhD (organic chemistry) at the University of Sydney. After five years in postdoctoral positions at the Centre for Drug Discovery and Development (now part of the IMB) at the University of Queensland, I obtained a three-year postdoctoral position at the University of Cambridge. Since then, I have held positions within the pharmaceutical industry in Denmark (largely as a

process chemist). With that as my background, I believe it is relevant to consider both (a) the relevance of the RACI to me at present, and (b) my relevance to the RACI.

The relevance of the RACI to me for the last 20 years is essentially negligible. There is no similar institution in Denmark, and the title Chartered Chemist has no weight whatsoever in Denmark. Yes, I appreciate that chemistry (and science in general) needs a voice in Australia, and that the RACI helps to supply such a voice, but I have not been able to vote in Australia for many years, and (and this hurts when I say it) it is unlikely that I will be permanently based in Australia in the future (for many different reasons).

What is my relevance for the RACI? Pretty similar, I feel, i.e. negligible. Yes, one more person in the statistics, but no other relevance. I am not part of any local group (since I am not 'local'), so I am not able to contribute in any meaningful manner. Taking part in working groups and such like is similarly more or less excluded, in part because I lack 'local knowledge', and partly because I cannot physically be there. I have always felt it very important to encourage and help the next generation of chemists, but I cannot do this for Australian chemists, since I am geographically remote (as an example, the University of Sydney's mentoring program requires, reasonably enough, that the mentors live in Australia).

To summarise, I have difficulty seeing how I am relevant to the RACI, and, similarly, I see very little relevance of the RACI in my professional life. So therefore the question: is there any point maintaining my membership of the RACI? I would be very happy to discover that there are important points that I have overlooked.

Robert Dancer MRACI CChem

Editor's note: A copy of this letter has been forwarded separately to the RACI Board. The Board recently embarked on a strategic planning exercise in an effort to turn around declining membership. They have identified five key areas that need to be addressed and are asking for member assistance. Suggestions about how the RACI can improve interactions with international members are welcome. See www.raci.org.au/raci-news/plan.

chemistry
in Australia
chemaust.raci.org.au

EDITOR

Sally Woollett
Ph (03) 5623 3971
wools@westnet.com.au

PRODUCTION EDITOR

Catherine Greenwood
catherine.greenwood@bigpond.com

PRODUCTION

Control Publications Pty Ltd
science@control.com.au
www.control.com.au

BOOK REVIEWS

Damien Blackwell
damo34@internode.on.net

RESEARCH HIGHLIGHTS

David Huang
david.huang@adelaide.edu.au

GENERAL ENQUIRIES

Robyn Taylor
Ph/fax (03) 9328 2033/2670
chemaust@raci.org.au

PRESIDENT

Peter Junk FRACI CChem

MANAGEMENT COMMITTEE

Sam Adelejo (Chair) Sam.Adelejo@monash.edu.au, Amanda Ellis, Michael Gardiner, Helmut Hügel, Colin Scholes, Madeleine Schultz, Richard Thwaites

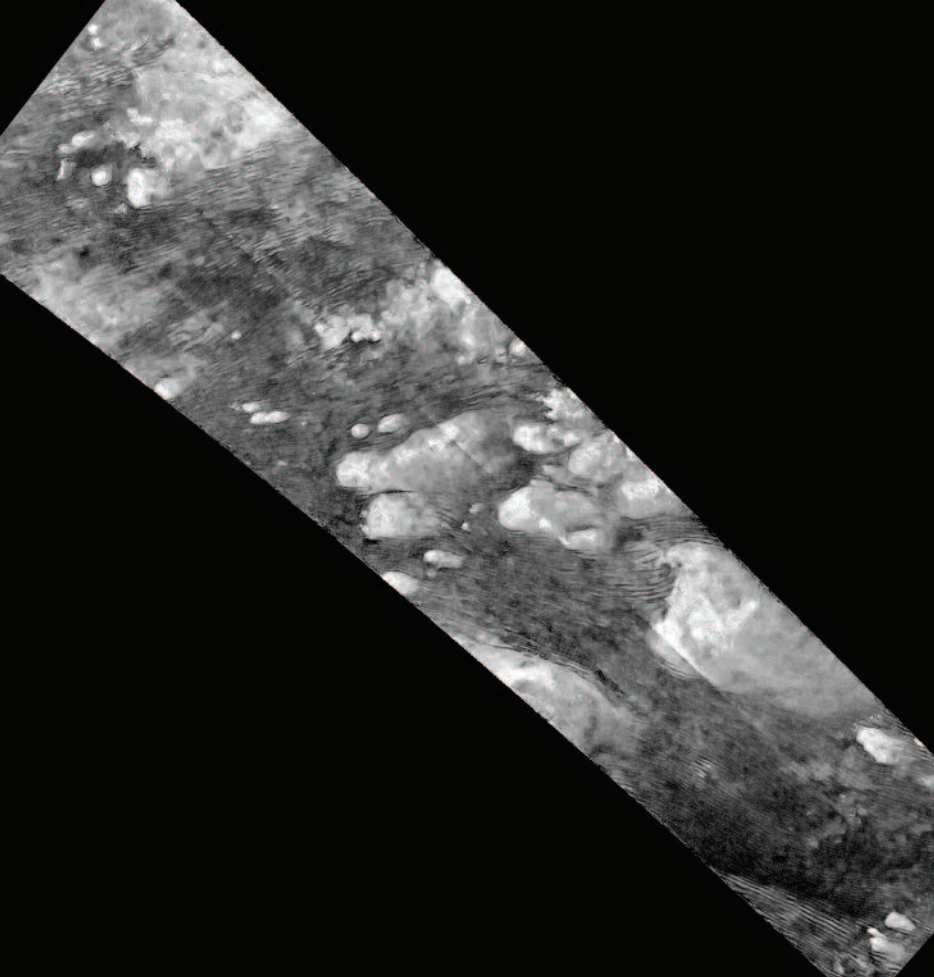
CONTRIBUTIONS

Contributors' views are not necessarily endorsed by the RACI, and no responsibility is accepted for accuracy of contributions. Visit the website's resource centre at chemaust.raci.org.au for information about submissions.

© 2017 The Royal Australian Chemical Institute Inc. unless otherwise attributed. Content must not be reproduced wholly or in part without written permission. Further details on the website (chemaust.raci.org.au).

ISSN 0314-4240 e-ISSN 1839-2539





Radar image of the Shangri-La Sand Sea on Titan, taken from NASA's Cassini spacecraft. Hundreds of sand dunes are visible as dark lines across the surface. NASA

There are no boundaries, no walls, between the doing of science and the communicating of it ... Communicating is the doing of science. Publication and public speaking are how scientific work gains a presence, a shared reality in the world.

Scott Montgomery, author of *The Chicago guide to communicating science*

Saturn's moon Titan may have electric sand

On Titan, the sand doesn't act the way it does here. Of course, it also has methane seas and ice volcanoes, but the sand dunes face the wrong way, which researchers in the US think could be because the sand's physical and chemical properties and friction are causing it to be electrified. The authors say the electrostatic charges between the sand particles are strong enough to get the sand to bunch together, changing how it moves across the land, even changing the landscape of the strange, planet-like moon.

Georgia Institute of Technology

Unlike Earth, Titan hosts granular reservoirs whose physical and chemical properties possibly enhance the effects of charging on particle motion.

J.S. Méndez Harper, et al. *Nature Geoscience*,
<http://dx.doi.org/10.1038/ngeo2921>

'Poor writing makes for poor science'

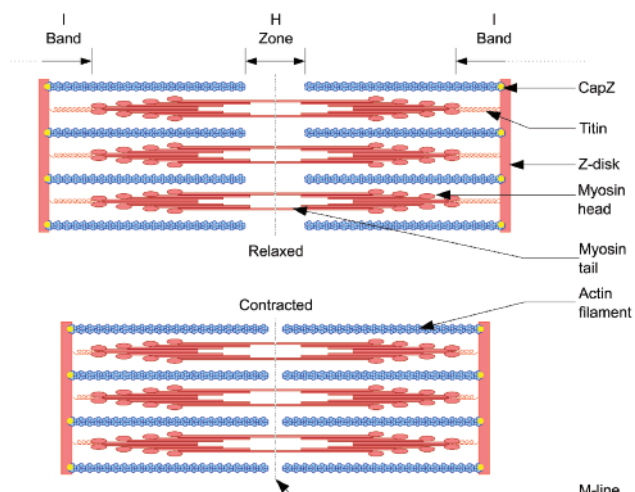
Scientific research that doesn't get communicated well to the public may as well never have happened at all, says Scott Montgomery of the University of Washington in Seattle, US.

Montgomery, a geologist and faculty member in the university's Henry M. Jackson School of International Studies, is the author of *The Chicago guide to communicating science*, an expanded second edition of which was published in February by the University of Chicago Press.

New to the book's second edition are chapters addressing plagiarism and author misconduct, translating scientific material, advice for researchers with English as a second language, communicating with the public and being a responsible source to the media.

University of Washington

Atomic resolution of muscle contraction



Sliding filament model of muscle contraction. David Richfield/CC BY-SA 3.0

At the molecular level, muscle contraction is defined by myosin molecules pulling actin filaments. New electron cryomicroscopy images with unprecedented resolution taken by researchers at Osaka University, Japan, reveal unexpectedly large conformational changes in the myosin molecule during the pull. These findings, which can be seen in *Nature Communications* (doi: 10.1038/ncomms13969), provide new insights into how myosin generates force and a paradigm for the construction of nanomachines.

To biophysicists like Keiichi Namba, professor at Osaka University, the ability of tiny molecules to generate large amounts of force seen in muscle make myosin an engineering marvel.

‘Myosin and actin are nanomachines that convert the chemical energy of ATP hydrolysis into mechanical work’, he said.

Myosin converts this energy by hydrolysing ATP molecules into movement along an actin filament. The hydrolysis involves a number of conformational changes in myosin. These changes

have been imaged by electron microscopy, but, notes Takashii Fujii, specially appointed assistant professor, ‘there were no atomic images of ATP hydrolysis when myosin is interacting with actin’, which would more accurately represent the changes myosin takes during muscle contraction.

Indeed, Fujii and Namba used electron cryomicroscopy to acquire images at 5.2 Å resolution to show a previously unobserved conformational change in the myosin molecule when it interacts with actin. The two scientists hypothesised that this conformation could explain why muscle myosin has much faster kinetics than other myosin in the body.


The images also give clues into how myosin moves along actin. The binding of ATP forces a rotation within the myosin molecule that reduces the number of bonds between it and actin. This weakly bound structure with a highly asymmetric bond distribution allows myosin to detach from actin and rebind preferentially in one direction, thus pulling the actin filament. Detachment towards the opposite direction would require a larger number of bonds to be broken at once, preventing detachment. This picture provides a new perspective on how myosin functions.

‘This is a very unique image, because the weak binding state is unstable and its lifetime is short’, noted Namba. He believes that this conformational state could be the reason why experiments on ATP hydrolysis by myosin without actin do not explain muscle contraction well.

‘There is a structural asymmetry in the system’, he said. ‘This could explain why myosin moves over much longer distance per ATP hydrolysis than expected.’

Besides providing new molecular details on muscle contraction, Namba expects the structural information gained by this work could be used to make artificial nanomachines. ‘We are studying nature’s nanomachines to build human-made ones’, he said.

Osaka University



Rowe Scientific
www.rowe.com.au

Suppliers of:

CERTIFIED REFERENCE MATERIALS

Reference materials from all major worldwide sources including:

- NIST (USA), CANMET (Canada), SABS (South Africa), BAS (UK), Standards Australia, BGS (UK), BCR (Belgium), NWR (Canada), NRCC (Canada), Brammer (USA), Alpha (USA), Seishin (Japan)

ADELAIDE
08 8186 0523
rowesa@rowe.com.au

BRISBANE
07 3376 9411
roweqld@rowe.com.au

HOBART
03 6272 0661
rowetas@rowe.com.au

MELBOURNE
03 9701 7077
rowevic@rowe.com.au

PERTH
08 9302 1911
rowewa@rowe.com.au

SYDNEY
02 9603 1205
rowensw@rowe.com.au



Call to phase out lead bullets at shooting ranges

Lead released when people fire weapons at shooting ranges creates such a health risk that lead bullets should be phased out, according to new research.

Every time someone fires their weapon, lead fragments and fumes are discharged at high pressure. Shooters then breathe in the metal, while other particles stick to their hands and are swallowed through smoking and eating.

Women of child-bearing age are at particular risk, as the lead is stored in their bones where it substitutes for calcium. When a woman becomes pregnant, the foetus takes in lead along with the calcium it needs from its mother's bones, which can cause serious neurodevelopmental damage. Female shooters can also pass on lead exposure through breast milk.

Dr Mark Laidlaw, a researcher in RMIT's Centre for Environmental Sustainability and Remediation in the School of Science, said the dangers of long-term exposure to lead were well known, but the risks for people using shooting ranges had not previously been fully explored.

'While there is no safe level of lead exposure, US health bodies regard 5 micrograms per decilitre of blood as the level that's cause for concern.

'What this research found is that people using shooting ranges can record blood-lead levels as high as 40 micrograms, with women and children at particular risk.

'The kind of blood-lead levels found among shooters can lead to essential tremor, hypertension, cardiovascular-related mortality, electrocardiography abnormalities, decreased kidney function, psychiatric effects, decreased hearing, decreased cognitive function, decreased fertility, incidence of amyotrophic lateral sclerosis, adverse sperm parameters, increased spontaneous abortion, and reduced foetal growth in children.'

In the US, about one million law enforcement officers train using guns, 20 million citizens practise target shooting, and there are 16 000–18 000 indoor firing ranges. In Australia, the Sporting Shooters Association of Australia claims 180 000 members.

Co-researcher Professor Gabriel Filippelli from Indiana University–Purdue University Indianapolis said he was concerned about children being exposed to lead at the range or from their parents' clothes and skin.

Laidlaw said lead-free bullets and primers (involved in combusting the cartridge) already existed but also needed are better ventilation systems, protective clothing that is changed after shooting and a ban on smoking and eating at firing ranges.

'But the real solution is a transition to copper bullets and lead-free primers. That may seem like a big ask, but Australia phased out lead in petrol between 2000 and 2002 even though it was a challenge to the automotive and fuel industries.'

The results have been published in *Environmental Health* (doi: 10.1186/s12940-017-0246-0).

RMIT University

Analysis yields clues to chemical composition, natural ageing of 100-year-old beer



Recently discovered World War I era beer could help scientists better understand the ageing processes involved in brewing.

Brewing Institute, Prague

Stashed away and long forgotten, a trio of century-old bottled beers recently discovered in the Czech Republic could help scientists better understand early 20th-century brewing practices, as well as the chemical changes that occur in beer over long periods of time. A report on the well-preserved lagers appears in *Journal of Agricultural and Food Chemistry* (doi: 10.1021/acs.jafc.6b05706).

Uncovered in 2015 during the reconstruction of an old brewery, the three lager beers apparently were produced during the World War I era and stored in a large cold cellar at the brewery where they remained to gather dust. The beers were bottled in dark glass and well sealed. Taking advantage of this unique discovery, Jana Olšovská and colleagues sought to produce detailed chemical profiles of these 100-year-old beers and determine the long-term effects of lager beer ageing.

Initial sensory analyses found that the beers ranged from intensely sulfuric to sour, and had off-flavours that ranged from faecal to fruity. Using HPLC and other techniques, the researchers compared the beers' features to those of modern-day brews. For example, the century-old beers had higher alcohol content and were less bitter. They also contained more iron, copper, manganese and zinc. There was also evidence of the particular yeasts used to make each of the beers, along with bacterial and fungal contaminants. The researchers conclude that chemical changes to two of the beers were likely caused by microbial contaminants, while the third beer, which was better preserved, offered the best insights into the older brews' natural ageing processes.

American Chemical Society

Chemists can rapidly purify wastewater with sunlight



Professor Yun Liu (left) and PhD student Qingbo Sun.

Chemists have found a way to use sunlight to purify wastewater rapidly and cheaply, and to make self-cleaning materials for buildings. The technology uses modified titanium dioxide as a photocatalyst that works with sunlight, unlike other leading water purification products on the market that need ultraviolet light.

Research group leader Professor Yun Liu from the Australian National University (ANU) said the team's invention was 15 times more efficient than leading commercialised products.

'With innovative chemistry design, we can use our photocatalyst to purify water with natural sunlight instead of UV light and dramatically reduce costs for operators,' said Liu.

'Our photocatalyst can completely decompose organic pollutants in wastewater in 20 minutes, compared with the leading commercialised products which take one hour to decompose only 26% of the same pollutants.'

The new technology could be useful for treating water for human consumption and has potential applications in making self-cleaning building materials, including glass, and splitting water to make hydrogen fuel.

Photocatalysts can also be used to speed up chemical reactions used in industrial processes in automotive, construction, environmental, medical and other sectors.

The team added nitrogen and niobium ions in pairs into the titanium dioxide to improve its performance as a photocatalyst.

'It's an important breakthrough for science and industry,' Liu said.

'With four years of work done in this area, we now understand the science and can rationally design catalysts.'

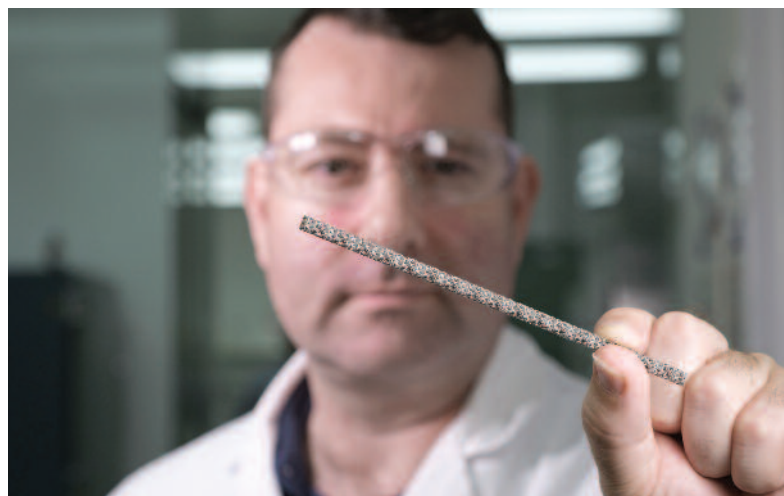
ANU conducted the research in collaboration with the Chinese Academy of Sciences, the University of New South Wales, Western Sydney University and the Australian Nuclear Science and Technology Organisation.

ANU has filed a provisional patent covering the discovery, which involved the design strategy, chemical composition and manufacturing approach.

The research is published in *Advanced Materials* (doi: 10.1002/adma.201605123).

Australian National University

Catalyst for efficient drug and chemical production



Dr James Gardiner inspects a catalytic static mixer.

CSIRO scientists have made a breakthrough that could result in faster and cheaper production for the pharmaceutical, food and bulk chemistry industries.

The team has developed a more efficient and simpler process that – when combined with flow chemistry – does away with the need to filter out catalysts.

Dr James Gardiner, from CSIRO's FloWorks Centre for Industrial Flow Chemistry, used the technique to create a key ingredient in the manufacture of the antibacterial pharmaceutical Linezolid.

It was the first successful example of a combined catalyst and flow reactor technology that could make the leap from the laboratory to industry.

'Before now, making catalytic chemical reactions faster and more scalable has been a challenge, but this smarter process, that gives a better result in a short period, lends itself to more efficient scale up,' Gardiner said.

Normally in chemical processing, a powdered metal catalyst is added to a mixture to ensure a chemical reaction takes place.

The catalyst is then removed at the end – an often tedious, time-consuming and costly task.

CSIRO's new method involved 3D printing specially designed rods known as static mixers at Lab 22, then using its Cold Spray technology to coat and immobilise the catalyst onto the rods.

They were then placed inside the flow reactor, allowing reactions to occur without the catalyst leaching into the product.

'This breakthrough means that any industry doing complex catalyst processes can now use a process that is smarter, faster and more efficient', CSIRO Research Director for Advanced Fibres and Chemicals Dr John Tsanaktsidis said.

'We've developed a method for chemical processing that combines all the benefits of flow chemistry with a much simpler way of using metal catalysts in them, reducing the number of steps that need to be taken.'

CSIRO

New chemical composition of ‘poppers’ linked to retinal damage

The new chemical composition of the legal high ‘poppers’ is linked to retinal damage at the back of the eye, finds a small study published online in the *British Journal of Ophthalmology*.

The findings prompt the researchers to call for a reassessment of the harms associated with these recreational drugs.

Poppers are colourless liquids with strong odours that are inhaled for their psychoactive effects, feelings of euphoria, and sexual arousal.

The Psychoactive Substances Act 2016 aimed to ban the production and sale of all ‘legal highs’ in the UK from April 2016. But poppers were exempt as they don’t directly affect the central nervous system.

However, the principal chemical ingredient of poppers, isopropyl nitrite, replaced isobutyl nitrite after the latter was reclassified as a cancer-causing agent in 2006. And eye problems have emerged as a less-well-known side effect since the chemical composition of poppers was changed.

The researchers analysed visual disturbances subsequently associated with the use of poppers in twelve 31–59-year-old men treated at one specialist eye hospital in southern England between 2013 and 2016.

The men were assessed by a retinal specialist; photographs of their retinas were taken; and their eyes were scanned by optical coherence tomography, a technique that is similar to ultrasound, but which uses light rather than sound waves to achieve higher resolution pictures of the structural layers of the back of the eye (retina).

The most frequently reported symptom was impaired central vision, such as blurriness, or blind spots (scotoma), with symptoms starting within hours or days of inhaling poppers.

Eight of the products the men used were chemically analysed: Platinum, Hard-on, Rush, Berlin XXX Hardcore, Liquid Gold, Jungle Juice (yellow label), and two Jungle Juice Plus varieties.

Six of the brands linked to visual symptoms contained isopropyl nitrite, while Jungle Juice Plus varieties, used without visual side effects in one case, contained other forms of nitrites and related compounds.

Three patients had used poppers for 20 years or more, only noticing symptoms after switching to a new brand.

One of these men developed a progressive central scotoma after using Jungle Juice, containing isopropyl nitrite. Previous use of Jungle Juice Plus, without isopropyl nitrite, wasn’t associated with any visual disturbances.

The second patient noticed symptoms after using Berlin XXX containing isopropyl nitrite, for the first time, having previously suffered no ill effects when using other brands.

The third patient had frequently used isobutyl nitrites in the 1980s with no visual side effects, but after heavy use for the first time in years developed scotoma.



Fundus photograph showing the blood vessels in a normal human retina. Mikael Häggström/CCO

Individual susceptibility to visual disturbances associated with poppers is likely to vary, say the researchers, although several users gave a clear history of visual disturbance after changing brands.

Most patients fully or mostly recovered several months after stopping drug use, although symptoms didn’t clear up in all of them.

Most of the tested products were not the exact samples used by patients, and the composition of the poppers might be different from those inhaled, caution the researchers. Popper products should be subject to further analysis as different versions may have differing strengths and contaminants, they add.

But on the basis of their findings, the researchers conclude that isopropyl nitrite is harmful to the fovea—the small depression in the retina at the back of the eye where visual acuity is greatest.

The high rate of popper use is ‘of increasing concern, both because of the mounting body of evidence suggesting that poppers can have serious effects on central vision, but also because users and healthcare professionals may be unaware of the risk’, explained the researchers.

Poppers’ exclusion from the legislation banning legal highs may have reinforced the impression that they are largely harmless, suggested the researchers.

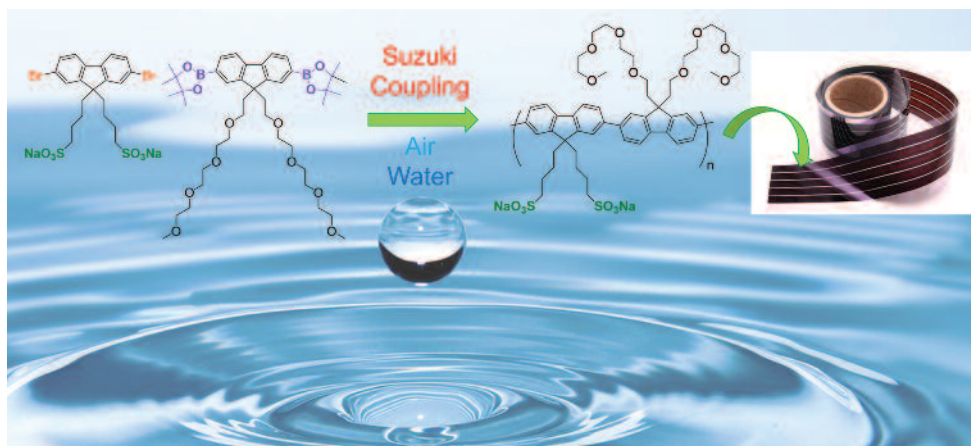
‘While retinal damage can often resolve on cessation of use, symptoms can be prolonged and the visual effects of chronic use of the newer brands of poppers are unknown. For these reasons, it seems appropriate that the level of harm associated with poppers should be reassessed’, they concluded.

Sussex Eye Hospital, UK

Organic solar cell materials made in water

One of the barriers to commercialisation of organic solar cells is the synthesis and processability of the required materials in a large-scale industrial setting. The vast majority of organic solar cell materials are currently synthesised, purified and processed into devices using organic solvents, in particular toxic chlorinated solvents. Avoiding hazardous solvents would be beneficial for industrial applicability as well as for reducing environmental impact. Dr Wallace Wong and Dr David Jones at

the University of Melbourne have recently reported a green route for synthesising conjugated polyelectrolyte materials, key components in high-performance thin-film solar cells (Subbiah J., Mitchell V.D., Hui N.K.C., Jones D.J., Wong W.W.H. *Angew. Chem. Int. Ed.* 2017, doi: 10.1002/anie.201612021). Making use of Suzuki–Miyaura coupling chemistry in aqueous media originally developed for bioconjugation, the team synthesised conjugated polyelectrolytes in water and in air. The



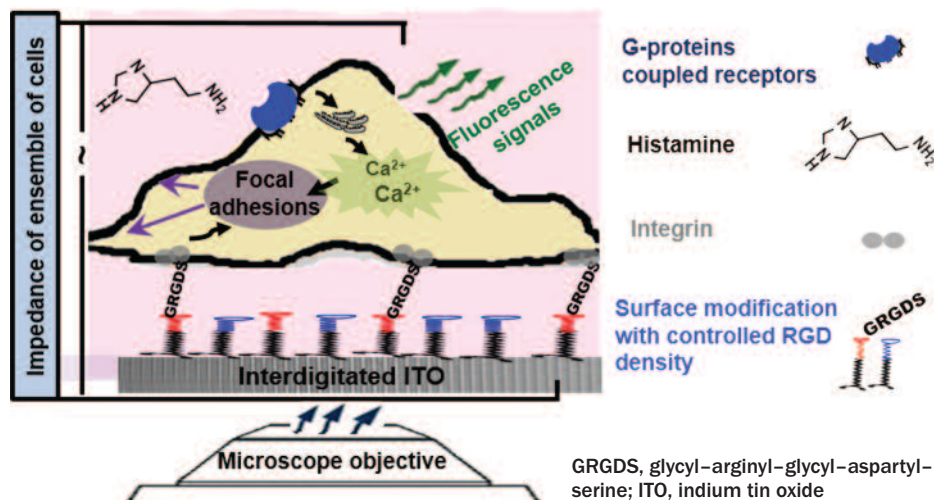
resulting polymeric materials were easily purified by dialysis, and thin films were deposited from alcohol solution. The performance of the materials was examined in both polymer solar cells and perovskite solar cells, giving power conversion efficiencies comparable to those of devices containing materials synthesised using organic solvents.

Real-time tracking of cellular drug response

To understand how cells respond to drugs and other chemical cues, the two most common methods are fluorescence microscopy, which is excellent for short-time scale measurements down to single cells, and impedance spectroscopy, which permits label-free monitoring of many cells over a long time period. In both types of measurement, the cells adhere to a surface. Professors Justin Gooding and Katharina Gaus and Maryam Parviz at the University of New South Wales have combined these two techniques with well-defined surface adhesive cues to investigate how cell–surface interactions influence the cellular responses to drugs (Parviz M., Gaus K., Gooding J.J. *Chem. Sci.* 2017, 8, 1831–40). The coupling of the fluorescence and impedance methods is particularly relevant for tracking interconnected events that have significantly

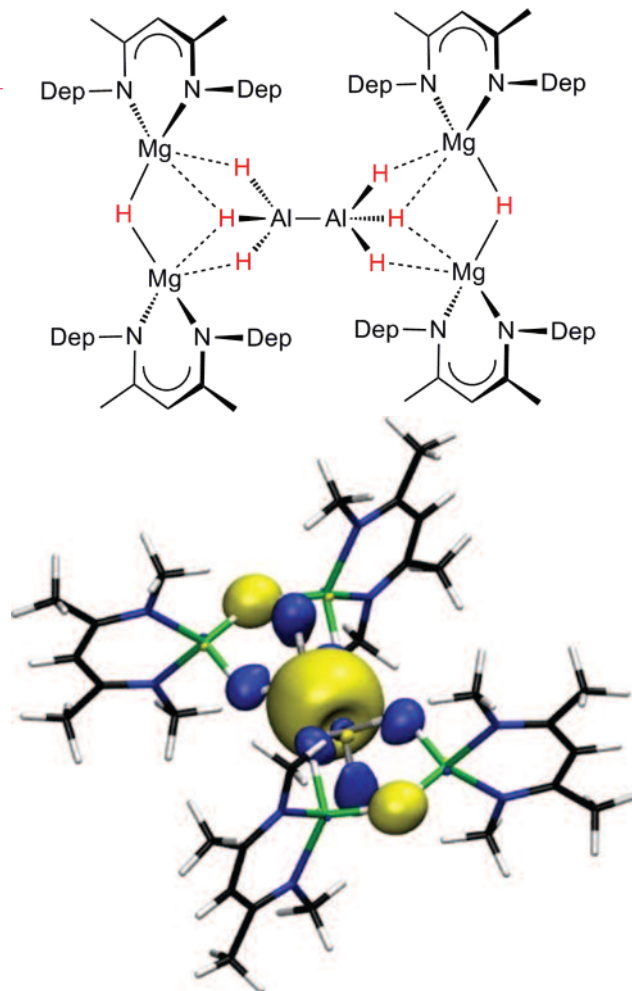
different timescales, which would not be possible using a single detection method. The team used the combined cell-based system to track transient Ca^{2+} release and changes in the dynamics of cell adhesion as a function of the spacing of RGD (arginyl–glycyl–aspartic acid) adhesive ligands in response to histamine, a model drug. The simultaneous measurements

revealed the correlation of timescales of histamine-induced Ca^{2+} mobilisation and the change in cell–cell adhesions and how they depend on RGD spacing. Furthermore, the application of the new technique can be extended to investigate the potential effects of surface designs on cellular signalling events in response to soluble cues.



HAIAI certified

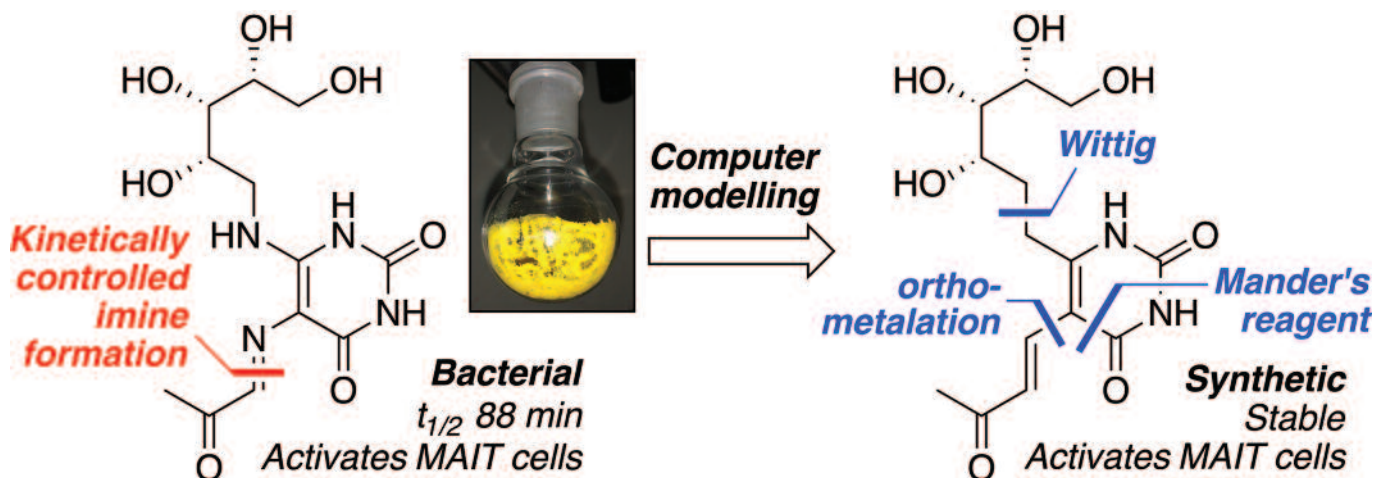
The chemistry of neutral and anionic binary borane fragments, such as $[B_6H_6]^{2-}$, is of undoubted importance to inorganic chemistry, and numerous examples of such B–B-bonded species have been described. In contrast, binary aluminium hydride moieties had only been known to be stable in cryogenic matrices (at <10 K) until the team of Professor Cameron Jones at Monash University recently reported the synthesis of the dialanate dianion, $[H_3Al-AlH_3]^{2-}$, which possesses aluminium centres in the +2 oxidation state (Bonyhady S.J., Holzmann N., Frenking G., Stasch A., Jones C. *Angew. Chem. Int. Ed.* 2017, doi: 10.1002/anie.201610601). This species was prepared by the reduction of a magnesium salt of the alanate anion, $[AlH_4]^-$, using one of Jones's β -diketiminate-stabilised magnesium(I) dimers as the reducing agent. The dianion possesses an Al–Al covalent bond and is a valence isoelectronic analogue of ethane. Computational studies revealed that its remarkable thermal stability (decomposition at >230°C) stems from the weak interactions it has with two dimagnesium hydride counter-cations. Jones's team is currently exploring the extension of this work to the synthesis of higher nuclearity polyhedral alanes, such as $[Al_nH_n]^{m-}$ ($m = 0, 2$, etc.), that are stable under ambient conditions.



Molecular insight into immunity

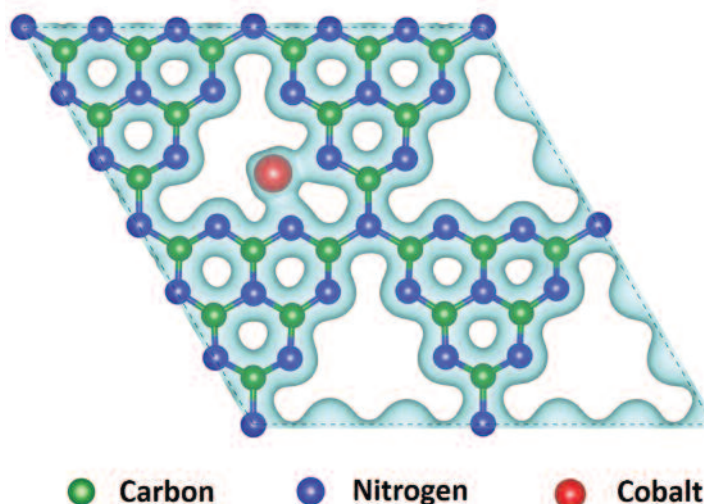
Mucosal-associated invariant T (MAIT) cells are important T lymphocytes in the body's defence against bacteria. Previously, researchers from the University of Queensland, the University of Melbourne and Monash University had discovered that these T cells are unusually activated by unstable heterocyclic ligands that act as antigens. The antigens are produced from an intermediate of riboflavin biosynthesis, which occurs in bacteria but not in humans. Now, a University of Queensland team led by Professor David Fairlie, Dr Jeffrey Mak and Dr Ligong Liu have shown how to stabilise these remarkably potent chemical signatures of bacterial activity (Mak J.Y.W., Xu W., Reid R.C., Corbett A.J., Meehan B.S., Wang H., Chen Z., Rossjohn J., McCluskey J., Liu L., Fairlie D.P. *Nat. Commun.* 2017, **8**, 14599).

These compounds are prone to imine hydrolysis and cyclisation in water (half-life = 88 min at 37°C and pH 7.4), but were successfully synthesised as kinetically stable products in aprotic and highly polar DMSO. The researchers used computer modelling to identify mechanistic and structural requirements for chemical stability and MAIT cell activation potency, leading to the synthesis of a thermodynamically stable analogue. Researchers from the University of Melbourne found that the analogue was functionally equivalent to the natural product in cell and mouse models. Conducted in the ARC Centre of Excellence in Advanced Molecular Imaging, this study exemplifies how chemistry can contribute to a molecular understanding of immunity.



New platform for coordinating metals as efficient electrocatalysts

Organometallic complexes with metal–nitrogen/carbon coordination are among the most important alternatives to precious metal catalysts for the oxygen reduction and evolution reactions in energy-conversion devices. The preparation of these materials generally requires advanced synthetic approaches and precisely controlled chemical composition. Now, Professor Shizhang Qiao and Dr Yao Zheng at the University of Adelaide have found that graphitic carbon nitride ($g\text{-C}_3\text{N}_4$), which has a simple graphene-like framework and periodic heptazine units connected via tertiary amines, can efficiently coordinate a wide variety of transition metals, including Cr, Mn, Fe, Co, Ni and Cu, for the electrocatalysis of oxygen electrode reactions (Zheng Y., Jiao Y., Zhu Y., Cai Q., Vasileff A., Li L.H., Han Y., Chen Y., Qiao S.-Z. *J. Am. Chem. Soc.* 2017, **139**, 3336–9). As a first step, the team theoretically predicted and experimentally verified that the $\text{Co-C}_3\text{N}_4$ complex is an efficient electrocatalyst for



the oxygen reduction and evolution reactions in alkaline media, with comparable performance to benchmarked Pt- and Ir-based catalysts. A combination of electrochemical studies, spectroscopic characterisation and density functional theory computation confirmed that the high activity originates from the precise metal– N_2 coordination moiety in the

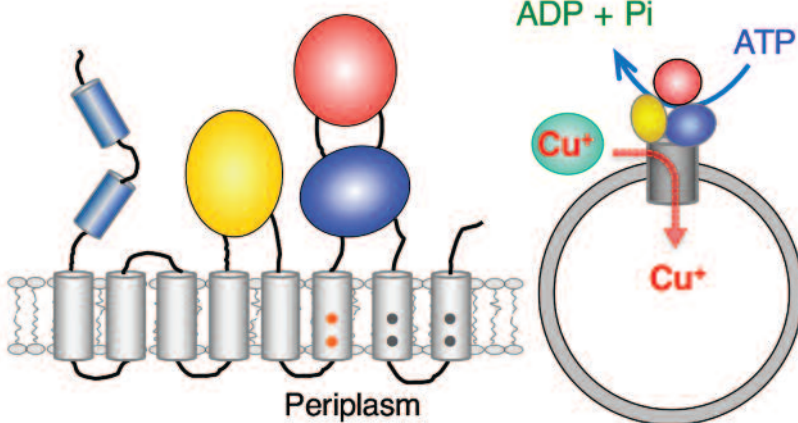
$g\text{-C}_3\text{N}_4$ matrix. Further experimental measurements and calculations indicated that $g\text{-C}_3\text{N}_4$ could serve as a platform to coordinate many different metals with desired electronic structures to replace traditional nitrogen-containing carbons as electrocatalysts for oxygen electrode reactions.

How membrane copper pumps work

Protein pumps play a central role in the metabolism of the nutrient metal copper by pumping copper(I) ions across cell membranes against the thermodynamic gradient using energy derived from ATP hydrolysis. Malfunctions of the human pumps ATP7A and ATP7B are directly

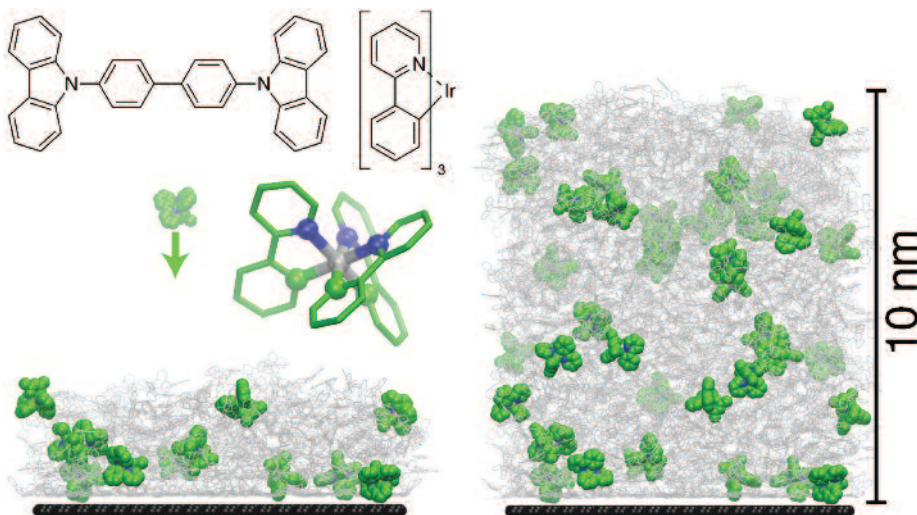
responsible for Menkes disease and Wilson disease, respectively, and for a spectrum of neuro-pathologies. Membrane proteins are notoriously difficult to isolate intact as they feature both hydrophilic and hydrophobic domains. The laboratory of Zhiguang Xiao

and Anthony Wedd at the University of Melbourne has isolated a bacterial analogue of the human pumps and characterised it in molecular detail (Wijekoon C.J.K., Udagedara S.R., Knorr R.L., Dimova R., Wedd A.G., Xiao Z. *J. Am. Chem. Soc.* 2017, **139**, 4266–9). The pump was embedded in a closed membrane system via a collaboration with Roland Knorr and Rumiana Dimova from the Max Planck Institute of Colloids and Interfaces, Germany, and shown to transfer one copper(I) ion per ATP molecule hydrolysed. This is the first quantitative correlation of ATPase activity and copper translocation. The stoichiometry contrasts with the two Ca^{2+} ions pumped in the calcium ATPase pumps. Extension to the human copper pumps is now possible.



Emitter arrangement in OLEDs

Organic light-emitting diode (OLED) displays are increasingly being found in smartphones and televisions. The emissive layer of the most efficient OLEDs generally comprises a molecular emitter blended into a host material at low concentration (e.g. 5 wt%), with the layer deposited by co-evaporation under vacuum. The purpose of the low emitter concentration in the emissive layer is to avoid intermolecular interactions that lead to quenching of the luminescence. Researchers in the Centre for Organic Photonics and Electronics and the Molecular Dynamics Group at the University of Queensland have mimicked the process of vacuum deposition of an archetypal phosphorescent blend found in OLEDs by using non-equilibrium molecular dynamics simulations (Tonnelé C., Stroet M., Caron B.,



Clulow A.J., Nagiri R.C.R., Malde A.K., Burn P.L., Gentle I.R., Mark A.E., Powell B.J. *Angew. Chem. Int. Ed.* 2017, doi: 10.1002/anie.201610727). Contrary to the popular view, even at a concentration of around 5 wt% of the racemic *tris*(2-phenylpyridine)iridium(III) emitter in 4,4'-bis(*N*-carbazolyl)biphenyl,

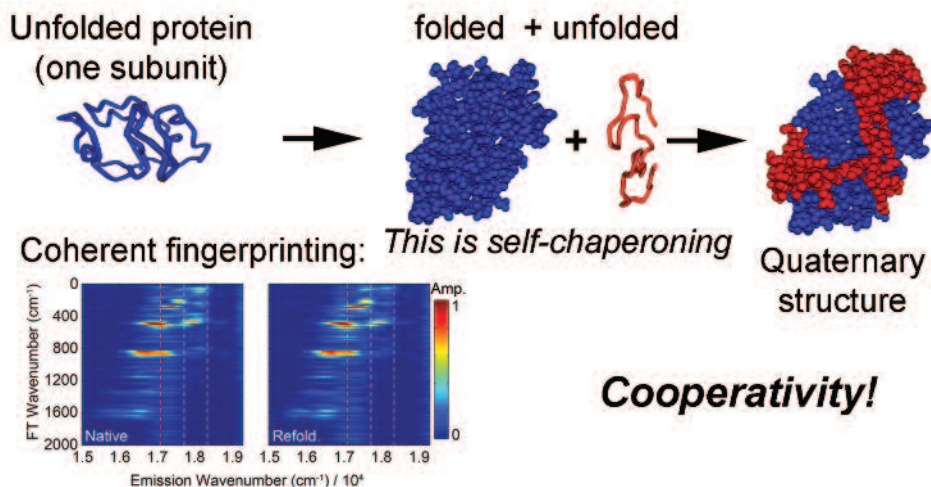
the emitter molecules were found not to be evenly distributed throughout film but instead form networks. While such networks would give rise to improved charge transport, they could also lead to increased non-radiative pathways for the emissive state and a resultant loss of efficiency.

Self-help protein folding

There are four hierarchical structural levels in proteins: primary, secondary, tertiary and quaternary. At least 50% of proteins have quaternary structure, yet it is not known how these proteins fold and form. A collaborative effort between a University of New South Wales team led by Professors Pall Thordarson and Paul Curmi and the group of Professor Gregory Scholes at Princeton University, US, may fill this gap in understanding, suggesting that the subunits that make up quaternary complexes help each other to fold and chaperone themselves – a truly striking demonstration of the power of cooperativity in nature (Laos A.J., Dean J.C., Toa Z.S.D., Wilk K.E., Scholes G.D., Curmi P.M.G., Thordarson P. *Angew. Chem. Int. Ed.* 2017, doi: 10.1002/anie.201607921). For the first time, quantum coherences obtained by

2D femtosecond spectroscopy were used to fingerprint protein structure and thereby reveal the folding mechanism. Understanding how protein complexes

form is important, since how they (mis)fold plays a major role in diseases such as Alzheimer's.



Banknote security



Keeping our currency current

We are in the midst of Australian banknote anniversaries, and last year the UK released their first polymer note. **Tom Spurling** and **David Solomon** reflect on the security of banknote technology and look to its future.

On Christmas Eve of 1966, the Reserve Bank of Australia had an unwelcome surprise: forgeries of the new \$10 paper banknotes were discovered. The Bank was astonished that its state-of-the-art notes had been so easily forged, and within a year of their release. The Bank had imported from Europe the latest in banknote technology and expected the banknotes to be more secure than previous ones. They were not secure.

After the dust had settled, the Governor of the Reserve Bank, Dr H.C. (Nugget) Coombs, called a meeting to discuss ways of making more secure banknotes. In a characteristic bold move, Coombs called the April 1968 meeting with

some of the country's leading scientists. Included in the meeting were Dr Jerry Price and Dr Sefton Hamann from CSIRO. Coombs arranged to meet again in Thredbo in June of that year, a month before his retirement. Price had already contacted CSIRO's newly recruited polymer scientist, Dr David Solomon, about ideas on a more secure banknote.

Solomon had recently had a visitor, Professor Okamura from Kyoto, who was the first overseas visitor of the newly formed Polymer Division of the RACI. This was to be an important link in Solomon's involvement in the project. He showed Price Okamura's business card, which was printed on plastic paper. Solomon then arranged

for large samples of the plastic paper to be imported and sent to the Reserve Bank. Price suggested that the Bank invite Solomon to the meeting at Thredbo.

Coombs was convinced that science held the key to improving the security of banknotes. A more conventional reaction to the 1966 forgeries would have been to consult the Reserve Bank's overseas colleagues and technology suppliers.

In December 1968, the Reserve Bank agreed to support a CSIRO project suggested by Hamann on the use of natural fibres but this project was not successful. Solomon and Hamann decided to pursue their own research into clear film polymer substrates and optically variable devices respectively and reported their results to the Bank in June 1971.

Coombs was convinced that science held the key to improving the security of banknotes.

In February the following year, the Reserve Bank made the momentous decision to invest substantial resources in a long-term project to further develop Solomon's and Hamann's ideas. Solomon's team made a major proof-of-concept presentation in September 1974 and the Reserve Bank decided to proceed with the development of the polymer banknote. This development took a long time, largely because of understandable caution in introducing such a radical innovation but also because of the time needed to build the necessary capability.

Paper (and polymer) trail: a select timeline of Australian banknotes

1910–1966: Australia's currency is the **Australian pound**. National Numismatic Collection, National Museum of American History/CCA-SA4.0



14 February 1966: Australia's first decimal currency is issued, presided over by Reserve Bank Governor Coombs. Paper notes were initially of \$1, \$2, \$10 and \$20 denominations, and coins were also issued.



September 1976: CSIRO began producing millions of these 'birds in flight' prototype \$50 polymer banknotes as final 'test' notes. Some had a moiré pattern in the clear area and some a diffraction grating. They were never released and are not legal tender. CSIRO



25 November 1980: CSIRO and the Reserve Bank present the polymer substrate technology to the Four Nations Group (central banks of Australia, Canada, UK and USA).

26 January 1988: The Reserve Bank releases (in limited numbers) the \$10 commemorative banknote, made of polypropylene and featuring optically variable devices. Elizabeth Spurling



1 July 1992: The first full-circulation polymer banknote is introduced. The series began with a \$5 banknote and was completed on 15 May 1996 when the polymer \$100 banknote was released.



1 September 2016: The Reserve Bank releases the \$5 banknote of a new series of polymer banknotes into circulation. Reserve Bank of Australia

New polymer fiver for the UK

As the UK rolls out a new £5 note, we ask what are the advantages of ditching the old paper fiver?

The new £5 note went into circulation across the UK last September. The Bank of England has arranged for 440 million £5 notes to enter circulation with a value of £2.2 billion, with the old note being phased out by May 2017. The new note, which features a portrait of Winston Churchill, is part of a roll-out that will see the £10 note replaced in 2017 and the £20 note replaced by 2020. The note is being printed by De La Rue, which also produces currency for countries such as Fiji, Mauritius and Guyana, as well as the UK passport and Microsoft's certificate of authenticity.

Wait. We're in the digital age ... does paper currency have a future?

Absolutely. The banking industry estimates that around 162 billion new banknotes go into circulation every year. Reports of the 'death of cash' have been greatly exaggerated and the number of banknotes in circulation is still growing globally. Added to this, over a third of the world's population doesn't have a bank account – making digital transactions difficult.

So why the move to polymer notes?

Traditionally, the main material used in the manufacture of notes is cotton, and over 95% of the notes in worldwide circulation continue to be made from it today. The reason is a simple one; it possesses a longer fibre length than shorter wood equivalents, offering better durability. Currently, the Bank of England has to replace around 22 000 notes a year – including 10 761 torn notes, 5364 chewed or eaten notes, 1801 washed notes and almost 1000 destroyed by fire.

De La Rue's variant of the polymer banknote is made of polypropylene. Polypropylene starts out as a clear material, before base print layers are added

to the plastic for the purposes of durability, opacity and reducing static. Subsequent layers are then added to this foundation, which include the characteristic raised print or intaglio – one of the key things that make banknotes so secure. Using polymers also means that security can be further beefed up with a clear plastic see-through window, something not possible with paper notes. Finally, in addition to the magnetic materials added to allow banknotes to be read by cash machines, polymer notes have a hydrophobic polyurethane varnish, which prevents soiling and water damage.

All of this means polymer banknotes last up to 2.5 times longer than paper (depending on the specific geography, climate and culture of the country), as well as having more security features.

As with any emerging technology, countries have adopted polymer notes at different speeds: some have used it across the whole family of banknotes, while others have elected to target harder working denominations where durability is pivotal.

Are polymer banknotes the only option?

Not at all. The future of physical currency could also be hybrid substrates, which use paper between polymer layers (or the reverse).

What are the challenges when making polymer banknotes?

Naturally, more durable substrates mean that all the accompanying inks, coatings and applied features also have to last longer to meet the increased lifetimes of the notes. This includes inks that are visible under ultraviolet or infrared light, as well as those that are visible in normal circumstances. Typically, plastics are also vulnerable to static build-up in the manufacturing process, so any developments during the creation of notes



Polymer banknotes can show off clearer, more detailed holograms than cotton paper-based notes. © De La Rue

also require simultaneous improvements to overcome any static-related issues during their manufacture and use.

What about security?

As a result of their long and storied existence, banknotes are packed full of security features – although obviously we can't say too much about them. Helping to defeat counterfeiters by increasing the security of paper and polymer notes requires unrelenting attention to detail and constant innovation to prevent criminals from catching up with new technologies. Digital counterfeiting is just one new method by which forgers attempt to circumvent existing efforts, so new banknotes are designed with security features that cannot be credibly reproduced on a mass scale by established counterfeiting techniques.

What we can say is that polymer banknotes will increase the use of holograms on notes, and that new techniques are being used to make holograms clearer due to the smoother surface of the material. The new £5 note also includes features such as microscopic lettering under the Queen's portrait, the number five appearing under ultraviolet light and foil images of the Elizabeth Tower (in gold and silver) and the Blenheim Palace maze (in green).

This doesn't mean that paper's day is over, though. In 2013, De La Rue won a Queen's Award for Enterprise for developing its Optiks product: an 18-millimetre-wide security thread with a large window on one side, giving paper the same clear window found in polymer notes.

Mark Harding is the hardware & materials development director at De La Rue. First published at chemistryworld.com. Adapted with permission.

In 1982, newly appointed Reserve Bank Governor R.A. (Bob) Johnston found a project that was going along without a definite end date. He had attended Coombs' two 1968 meetings in another capacity and was familiar with the project. He asked the project group to either close the project or commit to issuing a special polymer note in 1988, to commemorate the bicentenary of the arrival of the First Fleet. They were in favour of the latter and Johnston made the courageous decision to proceed to full-scale implementation.

The Bank released a limited number of commemorative \$10 polymer banknotes throughout the country in 1988. It was well received and the new series of polymer notes was introduced nationally in 1992. Polymer notes are in circulation in 24 countries, including two G8 countries, Canada and the UK.

Canada and the UK are the only G8 nations to decide so far to use the polymer technology. The person responsible for both decisions was Dr Mark Carney. In the early 2000s, the Canadian dollar had very high levels of forgery, up to 470 forgeries per million notes in circulation (fpm). (The Australian figure is 19 fpm.) Carney, as Governor of the Bank of Canada at the time, sought to fix this problem with polymer technology. Canada was the first G8 country to introduce polymer notes, in 2011. Carney became Governor of the Bank of England in 2013, and one of his first actions was to announce that pound sterling was moving to polymer technology. The £5 'Churchill' banknote was released in 2016. In his 2013 interview on the BBC, announcing the shift to polymer banknotes, Carney said:

Ensuring trust and confidence in money is at the heart of what central banks do. Polymer notes are the next step in the evolution of banknote design to meet that objective. The quality of polymer notes is higher, they are more secure from counterfeiting, and they can be produced at lower cost to the taxpayer and the environment.

Accounts of innovations usually emphasise the role of the inventors and developers. The introduction of radical banknote technology carries a great risk for the integrity and acceptance of a nation's currency. It cannot happen in any country without the support of the head of the central bank. In this time of anniversaries, it is important to acknowledge the roles of Coombs, Johnston and Carney.

Canada was the first G8 country to introduce polymer notes, in 2011.

Do we still need banknotes? It might surprise tech-savvy readers that the answer is 'yes'. According to the Reserve Bank, the percentage of consumer payments by cash declined from 69% in 2013 to 47% in 2017. Despite this, the amount of cash in circulation in 2016 was worth \$73 billion or slightly more than 4% of GDP. This is the highest currency-to-GDP ratio for several decades. The Reserve Bank is confident that cash will remain an important part of our payment system for the foreseeable future and will continue to ensure that we have reliable and secure banknotes. In 2013, an estimated 47% of consumer payments in Australia were made in cash, and the same percentage held true for the youngest age group surveyed (18–24 years; bit.ly/2kFYOTT). Cash transactions proved vital in coping with Hurricane Katrina in the US in 2005 and with the 2011 Tōhoku earthquake and tsunami in Japan.

So what will be the features of future banknotes? Banknotes have three levels of security device:

- The primary level includes those features that are recognisable by the person in the street. The current Australian banknotes have a host of

these features. The properties of the polymer substrate are themselves a security device. This includes the clear area.

- Secondary security devices need a machine to identify them. Australian banknotes traditionally do not have secondary devices but the new banknotes do have ultraviolet fingerprints.
- Tertiary security devices are those that can only be detected by the central bank when the banknotes are returned. Central banks do not disclose the presence or absence of such devices.

Together, Solomon, Hamann, Coombs, Johnston and Carney have played important roles in getting our currency to where it is today. The Reserve Bank continues to invest in strategic research focused towards the future of polymer banknotes and novel security features. The Bank's research and development section, led by Head Scientist Dr Greg Dicinoski, a distinguished analytical chemist, will play an important part in fulfilling this goal. The R&D team at the Bank consists of four research scientists with doctorates in the areas of chemistry, physics and material science, who together with Dicinoski will bring their significant skills to the task of maintaining world leadership in our banknotes.

The Reserve Bank keeps the public well informed, where appropriate, about the security devices in its banknotes. The first series of paper decimal currency banknotes was in circulation for 26 years. The first series of polymer notes was in circulation for 24 years. So we should expect that the new series will be around until 2040. Dicinoski, his team and their collaborators have time to make sure they continue to beat the forgers.

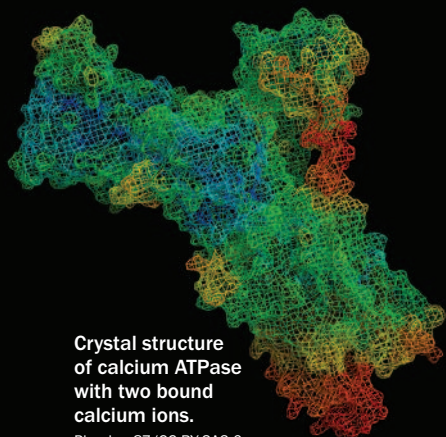
The plastic banknote, by **David Solomon** FRACI CChem and **Tom Spurling** FRACI CChem, was published by CSIRO Publishing in 2014. David Solomon introduced the concept of a polymer substrate to the Reserve Bank and was the driving force in the project. Tom Spurling was a member of the project team and is now at Swinburne University of Technology.

Pumps, channels *and* transporters

How chemists can help

BY **RONALD J. CLARKE**

Sixty years ago, a Danish doctor was the first to isolate an ion-transporting membrane protein. Much has been learned about the crystal structures and amino acid sequences of such proteins since then, and the scope for work in chemical synthesis is increasing.



Crystal structure
of calcium ATPase
with two bound
calcium ions.
Phoebus87/CC-BY-SA3.0

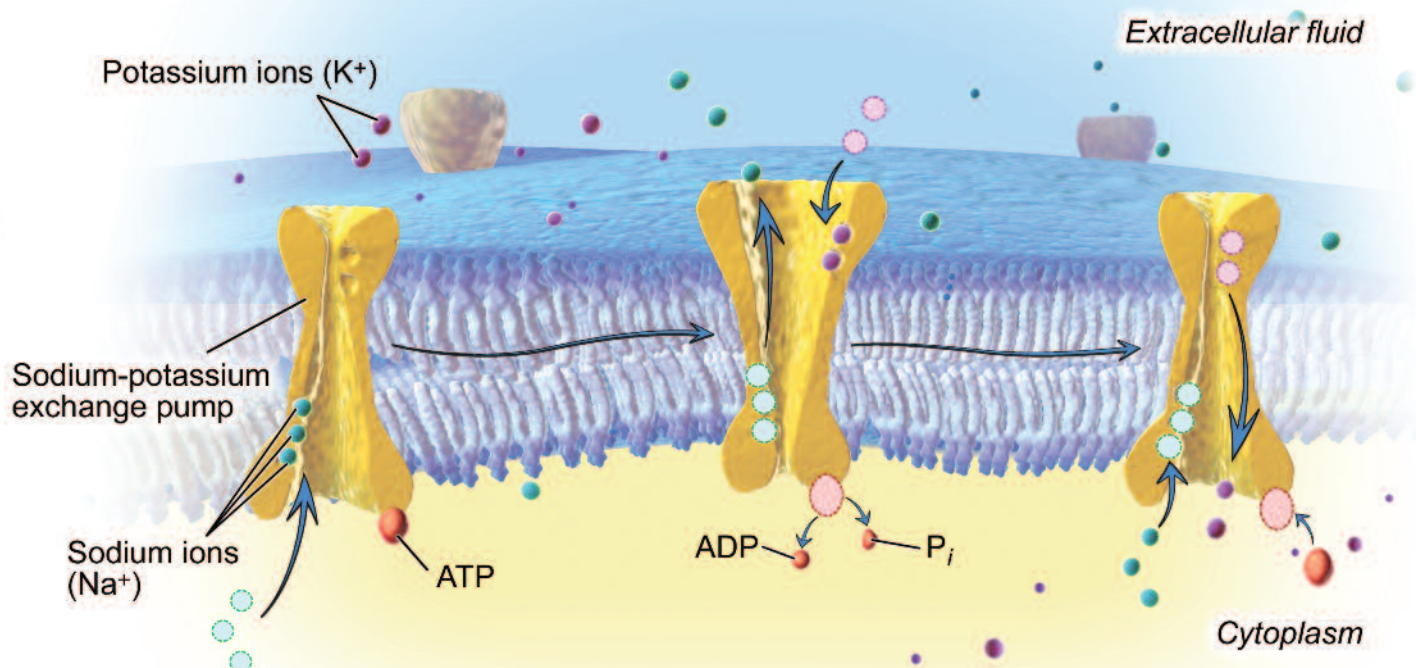
Pumps, channels and transporters are huge molecules. The Na^+, K^+ -ATPase, or sodium pump, the first ion-transporting enzyme to be discovered, consists of three subunits with a total molecular weight of around $150\,000\text{ g mol}^{-1}$. For most chemists, the idea of tackling such a molecule and developing an understanding of how it functions or how it could be manipulated (e.g. inhibited) would seem very daunting. Nevertheless, chemists have much to contribute to

research in this field and one can expect that their important contributions will increase as time passes. But first, what are pumps, channels and transporters and what do they do?

Pumps, channels and transporters are all proteins embedded in the membranes of living cells or cell organelles. Their role is to provide a mechanism for the transport of ions or small molecules across the membrane.

Kidney function is just one example where pumps, channels and

transporters play a crucial role. Another is in nerve and muscle function (including the heart). The electrical impulses that travel along nerve cells to muscle cells and eventually stimulate muscle contraction are triggered by the opening and closing of voltage-gated ion channels in the plasma membrane of these cells. The signalling agent for muscle contraction and relaxation is in fact Ca^{2+} , whose concentration in the cytoplasm of muscle cells is controlled by a complex interplay of Ca^{2+} -dependent channels, pumps and



ATP drives the sodium pump. ATP binds to the transmembrane enzyme ATPase and is hydrolysed to ADP and inorganic phosphate (P_i). BruceBlaus/Wikicommons

transporters. Even such a simple thing as cell volume is controlled by ion transport. Without the continual pumping of Na^+ and K^+ ions across the plasma membrane of all animal cells by the sodium pump, the osmotic conditions across the membrane could change and a cell would be in danger of swelling or even bursting.

Any research field goes through different stages, with the skills of different types of scientists being required at different times as new knowledge accumulates and the field matures. In the case of membrane transport, as is the case of many fields, the first stage was discovery. The first isolation of an ion-transporting membrane protein, the sodium pump, was achieved by Jens Christian Skou of the University of Aarhus, Denmark, who in 1957 purified the protein from crab nerve. From research carried out by physiologists predominantly in the US in the late 1930s and 1940s, it had already become clear that animal cells must possess a sodium pump to counteract the passive Na^+ permeability of the plasma membrane. For his discovery, Skou received the Nobel Prize in Chemistry in 1997. Why did it take the Nobel Committee 40 years to recognise

his work? One reason was probably scepticism, particularly within the chemical community, that a protein could distinguish between two ions, Na^+ and K^+ , that have such similar physical and chemical properties. Indeed, the mechanism by which proteins accomplish this is still unresolved and is the subject of much current research. Another reason for the late recognition of Skou's discovery was probably that much further research was required before there could be no more doubt that the protein he'd isolated and purified actually incorporated the complete active transport machinery necessary for sodium and potassium ions.

For the 30 years following Skou's discovery, research in the membrane transport field was dominated by medical scientists, biochemists and physiologists, in particular electrophysiologists. In the early 1960s, Robert Crane suggested that energy could be stored in living cells via ion concentration gradients, which could be utilised for nutrient transport, as described in the case of the Na^+ /glucose transporter (see box, p. 22). This idea was taken further by Peter Mitchell, who developed his

chemiosmotic theory describing how an H^+ gradient could be coupled to ATP synthesis in mitochondria, for which he received the 1978 Nobel Prize in Chemistry.

This exciting initial discovery phase of the field continued, with the first ion channels and transporters being isolated in the 1970s. Throughout this period, however, from the late 1950s to the early 1980s, nothing was known about the molecular structure of pumps, channels and transporters, apart from the fact that they were proteins, i.e. polypeptides. Nevertheless, once these molecules had been isolated and purified, much could be learned about their substrate specificity and their reaction mechanisms by both steady-state and pre-steady kinetic methods, e.g. using radioactive isotope flux measurements, current recordings via electrophysiological techniques and rapid reaction techniques such as stopped-flow with spectroscopic detection. Such techniques led to the development of mechanisms, with letters and numbers signifying different protein conformations. For example, for the P-type family of ion pumps, to which the sodium pump belongs, the

Diseases associated with defects in ion channels are often referred to as ‘channelopathies’.

mechanism is known as the Albers–Post or E1–E2 cycle, with the E1 and E2 conformations alternating between phosphorylated (E1P and E2P) and unphosphorylated states.

In the 1980s, the membrane transport field started to gradually become more molecular. Following major advances in the field of genetic engineering and molecular biology, the

amino acid sequences of pumps, channels and transporters could begin to be determined. The first sequences of the sodium pump and the sarcoplasmic reticulum Ca^{2+} -ATPase were published in *Nature* in 1985. Today, countless sequences of membrane proteins are stored in databases such as that of the National Center for Biotechnology Information (US Library of Medicine, NIH) and are freely available as a resource to scientists all around the world.

A further significant advance was the development of methods of crystallisation of membrane proteins in detergent-solubilised form and the determination of their three-dimensional structures at atomic resolution by X-ray crystallography. The first structure to be determined was that of a bacterial photosynthetic reaction centre, for which Michel, Deisenhofer and Huber won the Nobel Prize in Chemistry in 1988. Ten years after the publication of this first structure, one could still count the number of published crystal structures of membrane proteins on two hands, but, although crystallisation is still not easy, structures are now appearing at increasingly faster rates. In 2003, Roderick MacKinnon won the Nobel Prize in Chemistry for determining the first crystal structure of an ion channel, and crystal structures of a number of ion pumps (including the sodium pump and the sarcoplasmic reticulum Ca^{2+} -ATPase) in different conformational states have now appeared. The E1–E2 cycle is still used in describing the mechanism of these pumps, but now actual molecular structures can be associated with the letters and numbers.

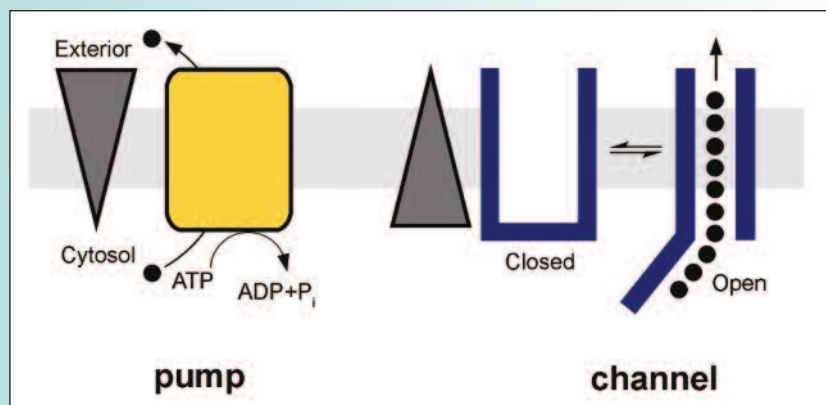
With the expansion of the structural information available, computational chemists and physicists have more recently been entering the field. Simultaneously with developments in molecular and structural biology, the capability of molecular dynamics simulations to handle larger systems, i.e. more atoms, and to extend simulations over longer timescales has

Energetics of transport proteins

The major difference between pumps, channels and transporters lies in their energetics. Pumps utilise a source of energy (e.g. sunlight, hydrolysis of adenosine triphosphate (ATP) or in principle any chemical reaction that releases energy) for the transport of ions or molecules uphill in energy, i.e. against a concentration gradient in the case of neutral molecules or against an electrochemical potential gradient in the case of ions.

Channels, on the other hand, provide a pore through the membranes that allows ions or molecules to diffuse downhill in energy. The pore is not permanently in an open state but instead undergoes conformational transitions between open and closed states, with the open probability usually dependent on either membrane voltage (voltage-gated channels) or the presence of another molecule (ligand-gated channels).

Transporters, like pumps, transport ions or molecules across a membrane in a direction that is uphill in energy and therefore require a source of energy. However, in contrast to pumps, the energy does not come directly from the sun or a chemical reaction, but rather from the coupling of the transport to the diffusion of an ion downhill in energy. A prime example is the Na^+ /glucose cotransporter, present in the membrane of cells lining the collecting tubule of animal kidneys. By pumping Na^+ ions out of these cells, the sodium pump creates a large Na^+ concentration gradient across the membrane. Diffusion of Na^+ ions back across the membrane through the Na^+ /glucose cotransporter releases energy, which is coupled to the re-absorption of the essential nutrient glucose from the urine and thus eventually back into the blood supply. This process is called secondary active transport, whereas pump activity is termed primary active transport. Channel activity, on the other hand, is referred to as facilitated diffusion.



The different mechanisms of pumps and channels. Figure 1.2, R.J. Clarke, M.A.A. Khalid, *Pumps, channels and transporters: methods of functional analysis*, vol. 183 of *Chemical Analysis*, John Wiley & Sons, 2015.



Archibald D. Ollé Prize

Associate Professor Ron Clarke was awarded the 2016 RACI Archibald D. Ollé Prize for *Pumps, channels and transporters: methods of functional analysis*, volume 183 of *Chemical Analysis*, a series of monographs on analytical chemistry and its applications (see July 2016 issue, p. 31, for a review). Archibald Ollé was very active in the chemical and scientific life of New South Wales in the first 40 years of the 20th century, and his wife, who outlived him, left a bequest to the RACI to his name with an annual prize. The Ollé Prize is awarded to a member of the Institute who submits the 'best treatise, writing or paper' on any subject relevant to the Institute's interests. The award is administered by RACI's NSW Branch.

been continually improving. Although still not simple, with appropriate caution and careful consideration of the systems, it is now possible to tackle simulations of membrane proteins embedded in a simulated membrane and to consider questions such as the origin of ion specificity or the mechanism of ion permeation through a channel.

Apart from playing crucial physiological roles, pumps, channels and transporters are also intimately involved in disease and are potential targets in the treatment of disease. Diseases associated with defects in ion channels are often referred to as 'channelopathies'. Because of the involvement of ion channels in nerve excitability, there are a number of ion channel defects that cause epilepsy. As far as I am aware, no one has suggested the word 'pumpopathies' for pump-associated diseases, but probably simply because it is impossible to pronounce. In fact, many diseases associated with defects in ion pumps do exist. An example is Wilson's disease, which is associated with an increase in the concentration of copper ions within the cytoplasm due to a defect in a Cu^+ -ATPase responsible for pumping copper ions out of the cell.

When discussing disease, it is important to realise that pumps, channels and transporters are not exclusively animal proteins. They are present in all forms of life. Bacteria and plants possess an H^+ -ATPase in their membranes, and utilise the energy stored in the H^+ gradient for the absorption of nutrients, in a similar way

to the utilisation of the Na^+ gradient by animal cells. Inhibition of crucial ion pumps of infectious microbial or bacterial organisms is, thus, potentially a powerful strategy for combatting disease. An important example is malaria, which is caused by the protozoan *Plasmodium falciparum*. It has recently been discovered that after infection of a host's red blood cells, the *Plasmodium* expresses a sodium pump, PfATP4, in its plasma membrane in order to counterbalance Na^+ influx from the cytoplasm of the dying host cell. Inhibition of PfATP4, thus, represents a potentially novel antimalarial treatment. In 2013, the group of Professor Kieran Kirk at ANU reported that the new antimalarial drug cipargamin, a spiroindolone drug, acts by inhibition of PfATP4. With the growing international problem of antimicrobial resistance to current antibiotics, such new strategies are urgently required. In the case of malaria, resistance to current treatments involving the use of the drug artemisinin have already been reported throughout South-East Asia.

Many infectious bacteria have recently been found to express a calcium pump in their membranes after infecting the host. Bacterial cells contain much lower calcium concentrations than their animal hosts. Therefore, they require calcium pumps to counterbalance the influx of Ca^{2+} from the host and prevent the bacterial cell swelling and bursting. This is analogous to the Na^+ influx problem encountered by *Plasmodium* just described. Inhibition of bacterial calcium pumps could, thus, represent an effective

treatment for a multitude of bacterial infections, including pneumonia and anthrax.

With the increasing level of structural information on pumps, channels and transporters becoming available in the form of amino acid sequences and crystal structures, and the more sophisticated molecular understanding of their mechanisms that this is yielding, the hope is of more informed predictions of the structures of small molecules that could act as inhibitors. This is an area in which both synthetic and theoretical chemists will increasingly be in demand. Returning to the problem of malaria as a prime example, although cipargamin is an effective inhibitor of PfATP4, like many keys opening a single door, a bewildering range of drugs with varying structures have been found to have inhibitory activity. Because no crystal structure of PfATP4 has yet been determined, it is not currently clear how these promising new drugs work. The Open Source Malaria Consortium founded by my colleague Associate Professor Mat Todd at the University of Sydney is examining one such potential antimalarial and has decided to use crowdsourcing (with a little cash incentive) to try and solve this problem once and for all (bit.ly/2kXZYap). Here is an excellent example of how collaborations between chemists, bioinformaticians, molecular biologists and parasitologists are being used to reveal the role of ion pumps in the treatment of human disease.

Ronald J. Clarke MRACI CChem is at the School of Chemistry, University of Sydney.

Celebrating the RACI years

1917-2017



Helmut Hügel looks back at the RACI's beginnings and the changes over the past 100 years.

Since 1917, the RACI has catalysed the advancement, growth and development of the chemical sciences at the highest professional level. Life is an expression of molecular chemistry, and the chemistry profession has made and will continue to make a dynamic and essential contribution to society.

From foundation to incorporation

As the driving force behind the establishment of the Australian Chemical Institute, its first president (1923–4) Sir David Orme Masson is a much celebrated figure in RACI's history (see box, p. 26).

Orme Masson was a gifted teacher, the 'prince of lecture demonstrations'. At the University of Melbourne (where he was Professor of Chemistry from 1886 to 1923) he began lecturing to first-year medical students, producing brilliant scholars including David Rivett and his own son Irvine. Interestingly, he persuaded both to change studies from medicine to chemistry.

Masson tried to establish an Australian Chemical Institute in 1914 but this was considered to be premature. When a group of chemists in 1916 in Lithgow set up an Australian

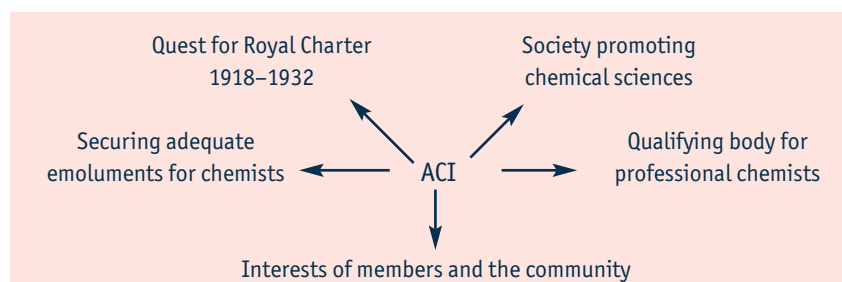
Association of Chemists, with a union focus of increasing the wages of chemists, Masson's idea became more real and relevant. In July 1916, Masson and Charles Edward Fawsitt convened a meeting of leading chemists in Sydney to support the formation of a national body for chemists. Six months later, a draft constitution was completed, and provisional committees emerged in the five mainland states. Foundation committee members included Orme Masson (Victoria), Edward Rennie (South Australia), Thomas Cooksey (New South Wales) and John Henderson (Queensland). Inaugural meetings were held in September 1917 by state branches in New South Wales, Victoria, Queensland and South Australia. These state branches, coordinated by a central council, became ACI, with 237 founding members.

High on the agenda of the first

meeting of the ACI Council in Sydney on 8–9 January 1918 was securing a Royal Charter. As there was no uniform Companies Act covering the Commonwealth of Australia, ACI could only achieve national operating powers if granted a Royal Charter. Without it, the council's authority and professional effectiveness would be compromised. Fifteen years after the Institute petitioned the British Institute of Chemistry, the Royal Charter was granted.

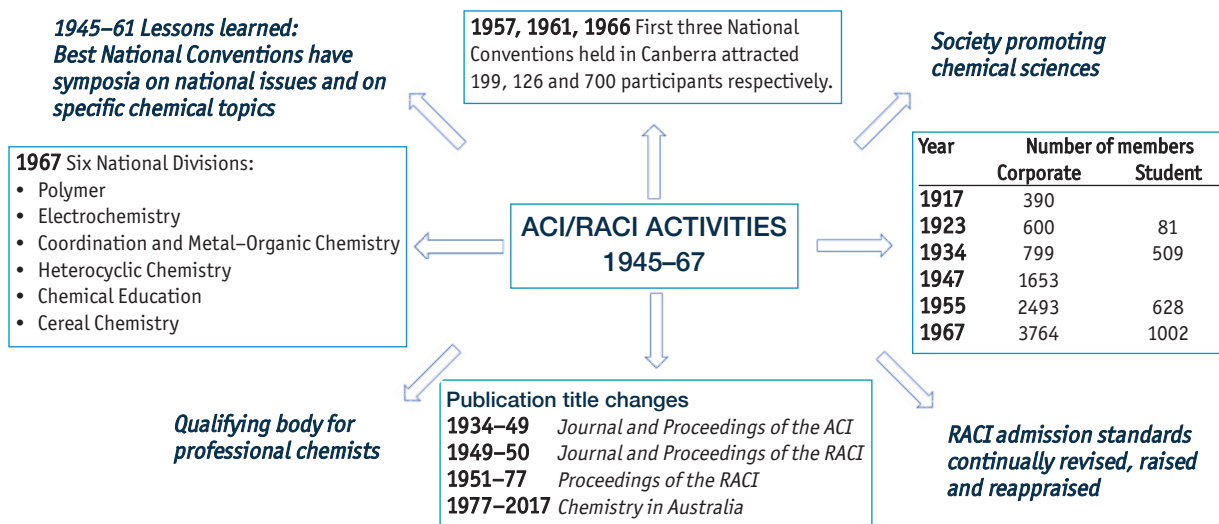
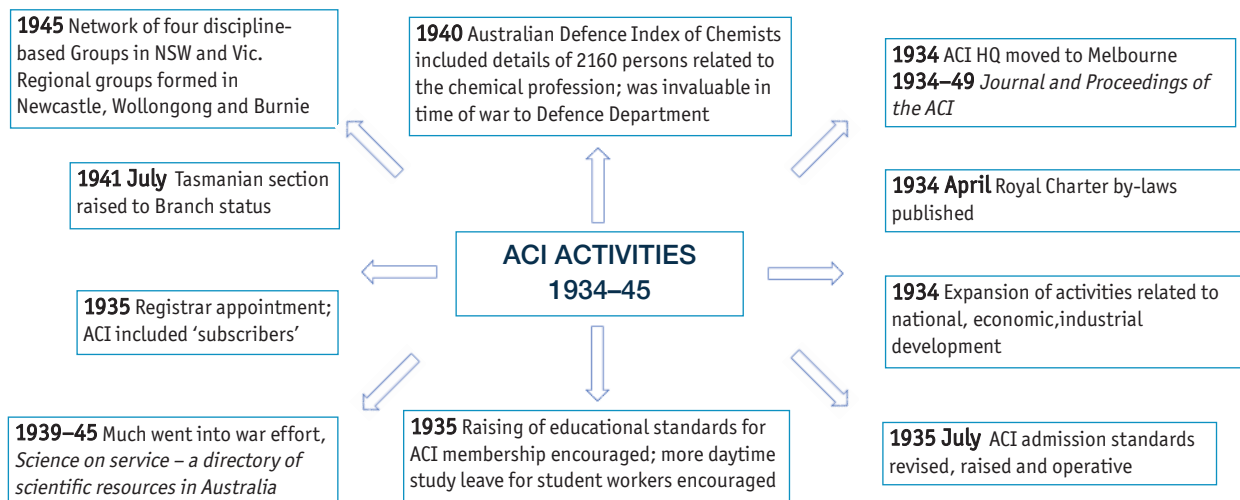
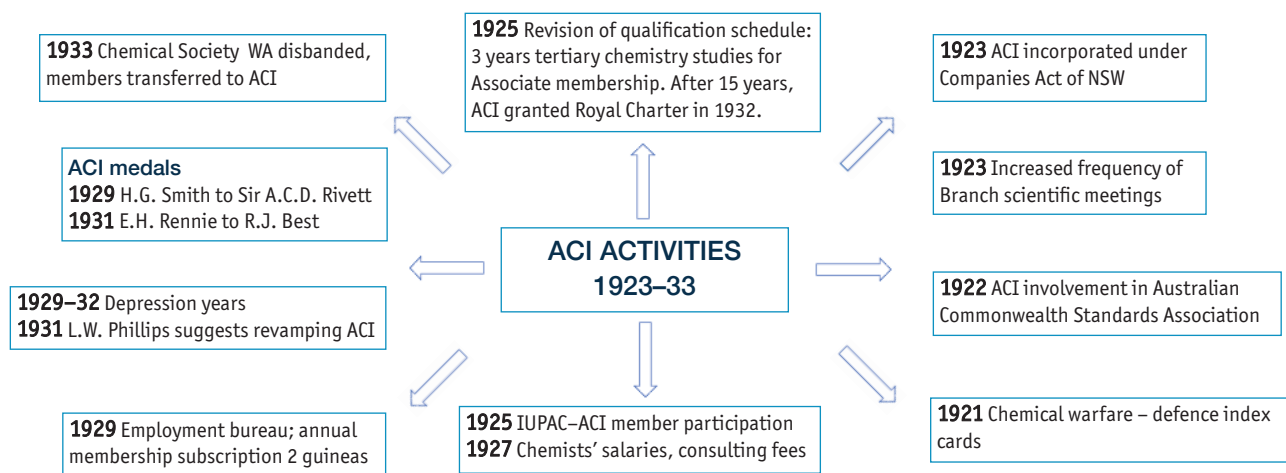
In 1932, the Royal Charter was granted and became the catalyst for increased Institute activity, which was reflected in increased membership. The ACI headquarters were relocated in 1934 to Melbourne and the publication *Journal and Proceedings of the Australian Chemical Institute* was brought to life.

In 1951, the ACI publication was replaced by the *Journal and Proceedings of the Royal Australian*

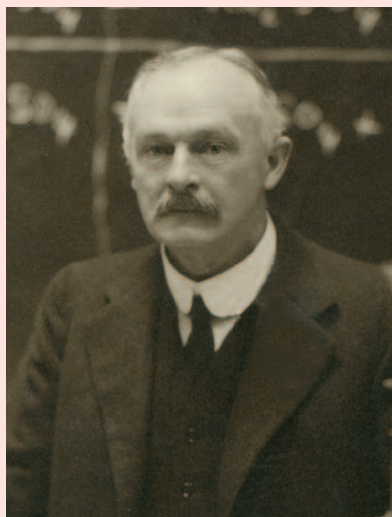


The Australian Chemical Institute in 1917.

Selected ACI and RACI activities, 1933–1967



Masson and his chemistry legacy



Professor David Orme Masson

Colin Sach collection; photo by Kricheldorf, 1913

Besides his heavy teaching load, research and administration, Sir David Orme Masson was involved in a wide range of scientific and public activities. Masson:

- founded the Society of Chemical Industry of Victoria, and was the first president, in 1900
- founded the Melbourne University Chemical Society in 1904
- helped organise the 1911–14 expedition of Douglas Mawson to the Antarctic
- was President of the Australasian Association for the Advancement of Science, 1911–14
- was invited in 1915 by the Prime Minister of Australia, W.M. Hughes, to provide the blueprint for what in 1926 became known as the Council for Scientific and Industrial Research
- along with Sir Edgeworth David, founded the Australian National Research Council and served as the president 1922–26.

True to his word, David Orme Masson raised the status of chemistry in Australia, and received a KBE in 1923. He is commemorated by the Masson lectureship from the Australian Research Council and the Masson Memorial Scholarship from the RACI.

Chemical Institute and a new quarterly, *Reviews of Pure and Applied Chemistry*. The provision of a supplemental Royal Charter allowed the use of 'Royal' in RACI from 1953. In 1957 the Council introduced the first National Convention to raise the professional profile of chemistry and the chemical industry. At the same time, the state Branch-based active Groups evolved into National Divisions to advance community interests.

From the introduction of National Chemistry Week in June 1982 to promote chemists and chemistry in our community followed in 1984 the Chemistry in Schools program. The Australian Bicentennial Authority was the inspiration for the 1989 RACI *Chemistry in an Australian context sourcebook*. Also in 1989, the RACI published *Masson of Melbourne* by Len Weickhardt.

The restructuring of the Institute in 2000 was performed to provide better continuity of management and more efficient changes to the Constitution. Based on the American Chemical Society model, the Royal Charter was replaced by the operation of the RACI under the *Victorian Incorporations Act* and the Institute became RACI Inc Australia-wide.

Citizens, sustainability and reinventing the RACI

Science is key to finding answers to human and environmental problems, and to economic prosperity. The career opportunities of the future will be brightest for those with a STEM education. The potential of science will be realised when the world's scientific societies become a global society of scientific citizens.

In the 1972 RACI-funded book, *Nature in the balance*, authors Hanns Hartmann, Noel Norman, Alfred Triffett and Donald Weiss said:

Life on our earth depends on a delicate balance of events. Each living thing depends for its existence on other living things, on the chemical composition of air, soil and water, and on the energy

from the sun. If for any reason the balance is disturbed, life is affected. If the balance is destroyed, life could be destroyed.

'If we are citizens of anything, we are citizens of the earth', said Nobel laureate Sir John Warcup Cornforth as speaker at the RACI 75th anniversary lecture, 'Scientists as citizens', in 1992. His outlook contrasted with that of one based on economic growth and resource exploitation that is ultimately unsustainable.

Cornforth's lecture covered the essentials of fundamental scientific thinking and practice, evidence-based discoveries, corrections, and that the knowledge generated by scientists serves as the precursor for society's prosperity. He warned that:

Scientists are apt to overvalue the importance of new discoveries, and to underrate the extent of their own ignorance. As citizens they cannot afford to be humble, but as scientists they must be.

Cornforth admitted that building an environment/society in which human growth potential is realised, rather than a consumer-based economy and material growth, would be challenging.

The 21st century challenge is for Australia as a developed nation to move to a sustainable society, achieving greater science education in society, the simultaneous rebalancing of economics, energy, agriculture and behaviour, delivered and driven by a sustainable scientific enterprise.

To remain relevant, the RACI must be part of his scientific enterprise. The RACI is reinventing itself. The first steps in this process have been made with the formulation of a strategic plan (www.raci.org.au/document/item/2758 and www.raci.org.au/document/item/2759); the next step is its implementation.

The diversity of RACI's work today, the higher professional demands and expectations, are the consequences of the competitiveness and globalisation of science and technology. In 1917, the world was a simpler place, but ACI's

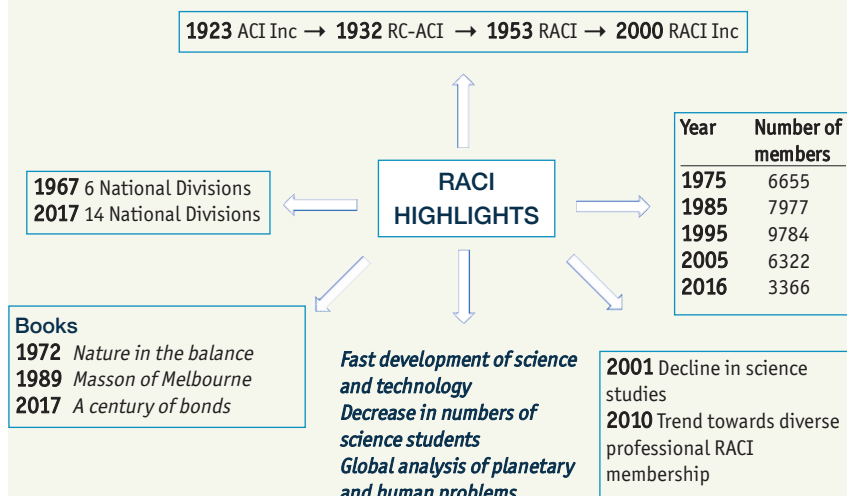
leaders knew what they were doing. Ten decades later, RACI's focus is much broader, but its activities, ideals and initiatives remain relevant to its members and Australia's future.

Acknowledgement

Thanks to all the RACI members, to the RACI staff for their professional dedication and personal contributions to chemistry and the Australian community.

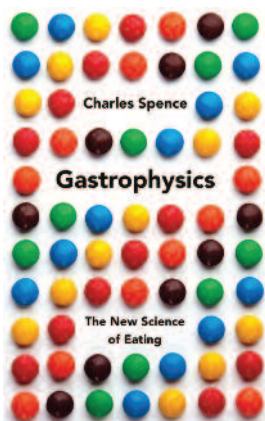
Helmut Hügel FRACI Chem, FRSC, is currently Associate Professor of Chemical Synthesis and Medicinal Chemistry at RMIT University in Melbourne. His dominant outlook is that research is really relevant when it has impact on human lives, and improving lives is the only goal that really matters. The RACI centenary book, *A century of bonds*, was written by him with contributions from RACI members and produced by Bounce Books for the July 2017 RACI Centenary Congress.

RACI historical highlights



RACI structure in 2017

RACI BOARD (7–9 members)	COMMITTEES ANCO <i>Chemistry in Australia</i> Equity Audit and Finance	DIVISIONS Analytical and Environmental Carbon Chemical Education Interfaces, Colloids and Nanomaterials Electrochemistry Health, Safety and Environment Industrial Chemistry Inorganic Chemistry Materials Chemistry Medicinal Chemistry and Chemical Biology Organic Chemistry Physical Chemistry Polymer Chemistry Radiochemistry	BRANCHES ACT BRANCH ACTIVITIES NSW BRANCH ACTIVITIES GROUPS: Analytical and Environmental Chemistry, Bioactive Discovery and Development, Chemical Education, Consultants and Contractors, Industrial Chemistry, Inorganic Chemistry, Natural Products Chemistry, Organic Chemistry, Pharmaceutical Sciences, Polymer Chemistry, Young Chemists SECTIONS: New England, Newcastle, North River, River Murray, Western Sydney, Woolongong NT BRANCH ACTIVITIES Qld BRANCH ACTIVITIES GROUPS: Analytical and Environmental Chemistry, Chemical Education, Polymer, Young Chemists SECTIONS: Central Queensland, Northern Queensland SA BRANCH ACTIVITIES GROUPS: Chemical Education, Chem Matters, History and Archives, Industrial Chemistry, Pharmaceutical Sciences, Physical Chemistry, Polymer Chemistry, Retired Chemists, Synthetic Chemistry, Young Chemists Tas. BRANCH ACTIVITIES Vic. BRANCH ACTIVITIES GROUPS: Bioactive Discovery and Development, Chemical Education, Food, Nutrition and Analytical Chemistry, Health, Safety and Environment (HSE), Inorganic Chemistry, Leadership and Career Development, Organic Chemistry, Peptide Users, Polymer, Women in Chemistry, Young Chemists SECTIONS: Geelong, Gippsland WA BRANCH ACTIVITIES GROUPS: Analytical Chemistry, Chemical Education, Tertiary Students, Health, Safety and Environment (HSE), Synthetic and Organic Chemistry, Management and Career Development
------------------------------------	---	--	---



Gastrophysics. The new science of eating

Spence C., Penguin, 2017, paperback, ISBN 9780241270097, 464 pp. \$32.99

From the get go I must confess *Gastrophysics – the new science of eating* is chemistry light. In fact, if you discount a mention of androstenone, the Maillard reaction and the relationship between pressure and the number of volatile aromatic molecules in the air, then you may conclude the chemistry content of this fascinating book is rather closer to zero. But what

it lacks in chemistry, it more than makes up with gastronomy and psychophysics, or more succinctly put, ‘gastrophysics’.

Author and experimental psychologist Professor Charles Spence has coined the term ‘gastrophysics’ to describe a new approach in food science, which draws on disciplines from psychology, neurobiology and sensory sciences to marketing, behavioural economics and design. Gastrophysics looks to better understand how we perceive eating and to design and deliver healthier, happier dining experiences.

Spence heads up the rather curiously named Crossmodal Research Laboratory (CRL) at Oxford University. As you might expect, social scientists dominate his laboratory. However, my online investigations suggest of the half dozen or so staff, at least two hold science degrees, possibly even chemistry! The laboratory’s online manifesto is studying ‘the integration of information across the various different sensory modalities (hearing, vision, touch, taste, and smell) using a variety of paradigms and techniques’, especially as this relates to our perception of food and drink.

In the book’s early chapters, Spence explains and examines how the five senses function and together contribute to the total dining ‘experience’. Dining is a multi-sensorial experience, a dynamic interplay between and involving taste, smell, sight, touch and hearing. The visual, aural and olfactory cues we detect before actual physical contact with food, plus the touch itself, have a significant bearing on our overall expectations of taste. Cooks, chefs, food and beverage manufacturers and marketers alike increasingly manipulate these signals (e.g. ‘mood’ music, lighting, aromas and scents) to shape and set our expectations about flavour, taste and the total dining experience. Spence is also interested here to consider how the mode or medium of food delivery into the body, be it a takeaway cup, beer glass, plate or piece of cutlery, might be redesigned or reconfigured to achieve a more satisfying, and healthier, dining experience.

Yes, it’s so much more than just the cuisine. Where (e.g. home, workplace, restaurant) and how (e.g. in silence, with a surprise) a meal is served, what you have been told about it (e.g. its origins, preparation) prior to dining, with whom you are dining, the nature of the venue (e.g. the design, shape, building materials and orientation or presentation of the

tableware and furnishings), among a host of others. Subtle or not so subtle changes to any one of the dining factors or variables can cause or lead to quite dramatic changes to how we interpret and perceive the dining experience. For example, altering the shape, colour or weight of crockery can have quite a profound effect on aspects such as energy intake, how highly we rate a meal and food memories. Another example familiar to most of us concerns how food is plated, or simply the orientation of the plate. Studies show we are prepared to pay substantially more for the same meal presented more ‘pleasingly’ on the plate, or simply when the plate is rotated a few degrees!

Over the ‘course’ of the book’s middle to latter chapters Spence ‘serves’ (apologies) as our international culinary guide. Figuratively jetting from country to country, restaurant to restaurant, he tucks into, digests and ... (again, apologies) regurgitates the results of gastrophysics research for us to ponder and, in many cases, apply in our everyday lives.

Speaking of jetting, Spence actually devotes an entire chapter to airline food, which for a time was quite a focal point of air travel. The advent of economy class not only put an end to fine food, but tarnished the reputations of many ‘brand name’ chefs contracted in to restore airline dining to ... greater heights. Even dishes by the best chefs will not rate as highly in the air as on the ground due to significant differences between pressure, humidity and sound. The gastrophysics research suggests airlines would do better to invest, for example, in noise-cancelling headphones and genuine glass wineglasses to enhance passengers’ dining experience rather than costly chefs!

Squeezed in between in-flight dining and the personalised dinner chapters is ‘the meal remembered’. Here Spence explains how food memories are developed, why the details of a meal (particularly the name of a dish and how it tasted) fade so rapidly and how to create ‘stickier’, more readily recalled food memories by exploiting ‘tricks of the mind’, portion size, sequencing, and other factors. Spence is constantly exploring ways to enhance the dining experience (like remembering it!) for the masses, especially the disadvantaged. For example, he helped develop an ‘aroma-based’ intervention, essentially a plug-in device to emit food scents around mealtimes, to help remind people with early stage dementia to eat.

Spence literally samples from the exciting, often esoteric, menu of global gastrophysics (and gastronomical) study and research. For a relatively modest-sized text, it is peppered with interesting and broad references, about 400 in all. And even the references come with ‘sides’, Spence’s additional commentary about the chosen research. Studies by Spence’s own CRL feature prominently of course, but he also includes and critiques research from a diverse and comprehensive gastrophysics field. Researchers and contributors include fellow psychologists, imaginative chefs and cooks, medical and allied health

The personalised dinner chapter is at times rather creepy. Restaurateurs and the like are 'data mining' and Googling the tastes, interests, proclivities and peculiarities of potential diners in order to 'personalise' their dining experience. According to the research, this more 'attentive' and tailored approach is associated with higher levels of dining satisfaction. While some of you may be impressed by your host's uncanny inside knowledge, I for one am more perturbed by this approach. Admittedly, online intelligence gathering to inform your ultimate dining experience works best perhaps for those with online profile presence, namely those in the public eye or others who are simply heavily immersed in social media. So by this measure I would be spared the feelings of intrusion and perhaps being stalked. According to Spence, however, this personalised approach is finding traction.

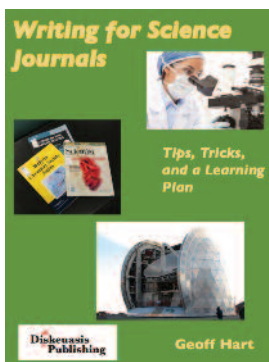
Fittingly, Spence concludes the book with a chapter highlighting the culinary ‘experiments’ of the Italian Futurists, the forerunners of modernist dining. Spence is the Futurist’s number one fan. He credits the origins of modernist cuisine to Futurist founder Filippo Tomaso Marinetti and his colleagues, who in the 1930s were, among others, deliberately confusing diners by miscolouring foods, playing ambient soundscapes during meals and inviting them to feel different textured materials while eating. Of course, the Futurists didn’t have the scientific knowledge, tools or indeed the intent to optimise the multisensory dining experience. It was more about moving people out of their comfort zone. Spence includes part of the Futurist’s manifesto, concerning the ‘perfect meal’, in this chapter and draws parallels with many of the practices of contemporary chefs. He also provides his own set of tips to stage your own ‘Futurist dinner party’. If enacted, a night sure to be remembered!



Spence's style is engaging, casual and congenial, his analyses and discussion of the gastrophysics research leavened with good humour. While this approach is a fun and entertaining way to deliver information, it's also responsible I think for the book's most obvious fault, namely a lack of brevity.* Some tighter editing, particularly in the second half of the book, would prove beneficial. Figures, while usually illustrating a very interesting gastronomic curiosity or other, are used rather too sparingly. Ultimately, these are relatively minor quibbles in an otherwise fascinating book. If you can get the 'staging' (to optimise your reading experience) right, and forgive *Gastrophysics* its 'name dropping' and scant chemistry content, then I warrant its reading will help you realise more rewarding, memorable and healthier dining experiences.

*A crime I fear I am now guilty of given the extended nature of this review.

Chemistry in Australia | 29



Writing for science journals: tips, tricks, and a learning plan

Hart G., Diaskeuasis Publishing, Quebec, Canada, 2014, ISBN 9781927972014, 434 pp., US\$32

Two years ago I attended a short course on writing science publications, at which the presenter began with the premise: you have not really done the work until it has been written, and has been read and understood (Emeritus Professor David Lindsay, the University of Western Australia, Perth).

These three points form the basis of a comprehensive self-published book by Geoffrey Hart called *Writing for science journals: tips, tricks, and a learning plan*. The work covers the whole spectrum of preparing science research for publication, including designing experiments to yield meaningful results, communicating with journal editors, responding to peer review, and every aspect of the process in between. At nearly 600 ebook pages (434 printed pages), it must be one of the most expansive books available on the subject.

Origins and aims

Hart is well qualified to write this book. After postgraduate work in forestry and forest biology, he moved into editing science writing. In nearly 30 years, he has worked with authors on thousands of papers submitted to peer-reviewed journals, and has had several hundred of his own articles published. In short, he knows thoroughly the process of writing and publishing science.

Why this book, now? Having research papers published is a competitive process and careers hang on it. It's important to convince journal editors that your manuscript is worth publishing, and it's equally important that your readers can get the most out of your papers. The book is for scientists of any discipline at any level of their career, but may be of greatest value for science graduates and those writing their first papers.

What's the book about?

The book covers an impressive array of subjects that reflects Hart's wide experience and knowledge. According to the back cover blurb (unfortunately not attached to the ebook), '... writing publication-quality manuscripts and guiding them through the peer-review process is difficult, time-consuming, and often frustrating.' There is a lot to know and learn, but this book covers just about everything needed to reduce the chances of a manuscript being rejected.

There is sound advice on avoiding some of the ethical pitfalls waiting to ensnare the would-be published author. This is good stuff to know because there is nothing more embarrassing, or potentially career-limiting, than to have other researchers point out glaring flaws in method or statistical presentation, or level accusations of plagiarism. A list of subject-specific organisations, their publications and websites,

that maintain guidelines for ethics in science publication, is a good start for anyone interested in keeping up to date with science-writing protocol.

Other aspects of good practice are covered in various chapters later in the book. There is a section dedicated to handling statistics, and another on preparing figures and tables. Hart acknowledges that valid presentation and interpretation of statistics is a book in its own right, and instead focuses on common misunderstandings of the significance of statistical results. Combining these subjects with ethics, experimental design, and advice on the peer review process, in one volume, lends the book depth and breadth. These, of course, are all alongside more usual subjects such as essential parts of the manuscript, writing style, and citation and referencing.

With so much to consider, however, I was left wondering if it is too much. Would users find it more approachable if the topics were divided into two volumes? In one could be ethics and topics more directly to do with writing process, writing style, referencing, and manuscript submission. In a second volume could be other topics, such as experimental design, statistics, and preparation of supplemental information. Certainly this division would make the first volume more like other publications on the market. However, the latter would usefully supplement a good working relationship between early-career researchers and their supervisors or mentors. Providing a clearer separation between topics – those related to writing compared with those directed towards how to do science – might make both parts more transparent, and less daunting to someone starting out in science writing.

Navigation

What is the best way to read this book? It is available in hard copy from Amazon.com, but most users will probably download the ebook or PDF. Browsing electronically makes navigation relatively straightforward because, in the table of contents, chapter and chapter section titles are hyperlinked to their destination. I viewed it in Apple iBooks, which provides a drop down contents list that is also hyperlinked, allowing navigation directly to chapters and sections of interest.

Each chapter is subdivided into specific and digestible sections with informative subheadings and cross-references to other parts of the book. Early chapters make good use of hyperlinks to published sources of further information. At the end of each chapter is a useful bullet-pointed subsection called 'Key points to learn' that summarises the take-home message from that chapter.

The chapter sequence is a little counterintuitive. Chapter 19 English difficulties, and Chapter 20 Writing style, are sandwiched between chapters on how to prepare experimental, numerical and supplemental material, and chapters on review and publication. On Hart's website, the chapters are grouped

into parts, and Chapters 19 and 20 belong to Part III: Details and style problems. The ebook could probably be improved if it also used these part headings.

More use could have been made of internal hyperlinks to take the reader from one part of the book to another. In Chapter 16 Figures (more on this below), hyperlinked cross-references could have been used to jump to (and back from) Chapter 17 Tables, and links could have been created between figure citations and the example figures to which they refer. Although each figure is only a page or two from its first citation, if the figure is cited later, it's useful to be able to jump back to it, rather than having to remember where it was or use the search tool. Internal hyperlinking is a feature we have come to expect in digital publications.

Style and accessibility

The large text and generous line spacing make reading in ebook form fairly stress free. The writing style is conversational, and flows easily without undue repetition. The text is studded with useful examples to illustrate principles, and the judicious use of bullet points helps the reader focus. However, some of the sentences are long and complicated and a simpler, shorter sentence structure would be more effective in some instances.

Examples, illustrations and learning points

In most cases, Hart demonstrates principles well with the use of good examples.

In Chapter 5 Using your word processor, we are introduced to some of the peculiarities of different versions of Microsoft Word on both Mac and PC platforms. This is worth knowing because precious hours can be wasted trying to format a document that has been opened in a new version of MS Word, only to find the function has been moved or replaced with something even more complicated.

Chapter 6 Structure and format of a journal manuscript is a valuable introduction to the essentials of how to prepare a paper for the target publication. The chapter opens by comparing a journal manuscript to a mystery novel, which is apt insofar as setting out to make discoveries in science is a bit like solving a mystery, but novice authors beware: it's usually unwise to write a paper while keeping the results a secret until the twist at the end!

Figures and tables are key elements of publications in almost every discipline of science. Readers will value the guidelines Hart provides in Chapters 16 and 17 for preparing figures and tables. Descriptions and examples of figure and table captions he uses are effective and usefully illustrate points made in the text.

By the same token, I would have liked to see more figures used elsewhere in this book. Only Chapters 16 and 17 appear to use figures and tables to illustrate their points, and more use could have been made of line diagrams or process flow charts to graphically illustrate sequences of steps described elsewhere in the text. For instance, in Chapter 14 Experimental design and

statistics, could the process of choosing a suitable experimental design have been presented in a flow chart with decision points? Overall, the book is very text rich and the visual impression might have been lightened by breaking it up with non-textual elements.

An element that does enhance the visual appearance is the use of pull-out boxes of information. Scattered through the book every three or four pages, these provide useful and interesting extra snippets of clarification, websites or other sources of information, or notes and tips about exceptions to the rule or traps for the unwary.

Verdict


With *Writing for science journals*, Hart has put his soul into a project he cares about very much. And rightly so, because much of the debate we're subjected to from the media and scholarly institutions – about climate change, genetic modification of food, medical 'breakthroughs' – depends on us being able to distinguish good science from bad. That task relies on science being written well.

There is plenty here to help authors plan, write and submit their research to science journals. I highly recommend this book for scientists at any level of their career, but especially those in the early stages. The topics covered offer expert and informed pointers for turning journal publications from 'just another paper about ...', into work that influences other scientists.

There are excellent sections on writing style, and on effective, as well as scientifically valid, ways to present figures and tables. Chapters on the review process are a boon to early-career scientists who may have had little exposure to the publishing world, and these are balanced with good advice about preparing research results for publication. In short, all aspects of writing for science journals are covered.

The book is attractively priced and easy to download, or order from Amazon, and is a valuable addition to the science writer's toolkit.

Stephen White. Review first published at <http://editorswa.com/2016/12/book-review-writing-science-journals>.



ROWE SCIENTIFIC
PTY LTD ABN 63 009 437 790
www.rowe.com.au
Pledge to Chemists

If chemists in Australia are experiencing difficulty in obtaining supply, please send me an email; peter.sommers@rowe.com.au and I promise to help you.

This is not a 'subtle' attempt to obtain more business, but a sincere pledge to help fellow scientists source the items they need to do their work, and thereby help Australia grow. This is the raison d'être for Rowe Scientific Pty. Ltd.

Peter Sommers (FRACI)

Quality System
Quality Endorsed Company
ISO 9001:2008
UK 10392
SA-Certified

ADELAIDE
08 8186 0523
rowesa@rowe.com.au

BRISBANE
07 3376 9411
roweqld@rowe.com.au

HOBART
03 6272 0661
rowetas@rowe.com.au

MELBOURNE
03 9701 7077
rowevic@rowe.com.au

PERTH
08 9302 1911
rowewa@rowe.com.au

SYDNEY
02 9603 1205
rowesw@rowe.com.au

Albert (Al) Rileigh

Paint and ink chemist

Albert (Al) Rileigh FRACI CChem personified the old-fashioned values that are the hallmark of professionals in the surface coatings industry. He was a member of OCCA/SCAA since 1953 and achieved the professional grade of Fellow, which acknowledged his qualifications and contribution to our industry. He came from an era when it was not unusual for people to stay for decades, and even a whole career, at one firm.

After finishing school, Al commenced employment as a lab assistant at the Mascot, Sydney, factory of Lusteroid Pty Ltd, a well-respected, family owned, nationwide paint and ink manufacturer. He studied part time for a Diploma of Chemical Engineering from Sydney Technical College. At the time, this qualification was well respected in the industry and was sufficient. It enabled him to be progressively promoted to chief chemist.

Al later realised that his diploma was insufficient qualification for further advancement, so while working full time, renovating a home and raising a young family, he completed a Master of Science degree at the University of New South Wales. His foresight paid off when Lusteroid was purchased by Croda. He was appointed as technical director of the new entity. Years later he was asked how much of the knowledge gained from the degree was useful to him at work. 'None!' he replied firmly. He needed the qualification, so he got it.

Lusteroid's Sydney factory was old and small. The limitations that this imposed caused Al much frustration. He lobbied for a new factory, but the private owners were not willing to invest the money.

It was thus a highlight in his professional career when Croda commissioned him to design and supervise the construction of a new factory at Seven Hills, New South Wales. Typically, he acquired a Clerk of Works qualification to facilitate this.

Al was able to avoid the shock of retirement by doing it gradually. He was able to progressively reduce the number of



He came from an era when it was not unusual for people to stay for decades, and even a whole career, at one firm.

days worked. After retirement, Al continued his involvement in the coating industry by providing consultancy services for several years under the trade name Chemal.

Initial retirement was to a home he built himself in the Blue Mountains west of Sydney. Later, he and Jean moved to Albury for family reasons. This was to a new build house. An incident illustrated Al's quiet wry humour. There was a technical dispute with the site manager. Finally, the site manager played his trump card. 'I am a Clerk of Works', he announced triumphantly. Ever so quietly, with a wry grin, Al said 'So am I'. Dispute over! This house pleased him greatly and he enjoyed a long, contented retirement there. He died in March 2016 at age 90, and is survived by his daughter Jennifer and son John.

John Rileigh

The wasteful wake of tourism

In the February issue (p. 40), I wrote of how receding ice due to changing climate was opening up the prospect of free navigation of the Northwest Passage between the Atlantic and Pacific Oceans. I mentioned that cruise ship operators were particularly keen on the idea. This month I'd like to explore the environmental impacts of travel and tourism in a little more detail.

A growing middle class worldwide with higher disposable incomes, notably in east and south Asia, is driving the demand for tourism and travel. This is being enabled, mainly, by continual falls in airfares, in real terms. A recent press report on Singapore Airlines' 50th anniversary of flying to Australia noted that current airfares are about 5% of what they were in 1967, when measured as a multiple of Australian average weekly earnings. A large part of this cost reduction is due to advances in aeronautical engineering, which see lighter, larger planes held aloft by more powerful engines with lower fuel consumption; and these reductions continue. The end result is the mass movement of people, purely for leisure, on a scale not seen before.

The more fuel-efficient jet turbine engines enable lower input costs and exhaust emissions per passenger kilometre. Lighter materials mean that payload is a larger proportion of the weight of aircraft, although with aircraft ranges extending, more fuel is burned simply to carry the fuel needed for the flight. As more passengers travel, lower fuel consumption and emissions per passenger kilometre can still be overwhelmed by the weight of numbers, meaning more fuel burned and more atmospheric emissions.

For most of the 50 years being celebrated by Singapore Airlines, airline food and its quality have been a topic of conversation. Often, one could be forgiven for thinking that the phrase 'airline food' was an oxymoron. Perhaps to quell this image, Fairfax Media travel supplements recently ran an article about preparation of food in bulk for airline and cruise ship passengers. As a case study, the story looked at Emirates' catering centre in Dubai – the biggest hub for the world's busiest airline. Daily, about 180 000 meals are prepared. Emirates takes pride in sourcing fresh ingredients from around the world, but I doubt that such pride extends to acknowledging that it takes a great deal of energy and emissions to achieve this. While Dubai makes sense as an aviation hub, given flying times and aircraft ranges from there to most of the world, as a city-state it is nowhere near self-sufficient in food. It seems inefficient to fly food into Dubai in order to fly it out again as airline meals.

Also, with the number of meals being prepared, there is scope for significant wastage. The Fairfax article made a virtue of Emirates' practices for ensuring food freshness, such as emptying refrigerators of uneaten meals on at least a daily basis. Discarding only a small percentage of the 180 000 meals would create a significant waste disposal problem.

According to the travel industry media, the fastest growing tourist segment is ocean cruising (and I have contributed to this, personally!). Food and water for all passengers and crew, and the wastes they generate, must be carried on board, at least until the next port of call. The waste disposal issue then becomes a matter for local on-shore agencies, in a reversal of customary garbage management. In this case, the waste is left behind while the waste generators sail away, rather than a householder staying put and their waste being transported.

How modern tourism affects the local environment was illustrated to me by a travel agent who noted that the permanent population of a well-known cruise stop in Alaska was 800 people. However, it is common for five ships to call at once, landing 10 000 passengers, all in search of a unique experience. Generally, they will be walking around but, in the absence of sealed footpaths, or if travellers go off the beaten track, the impact of all those feet can take its toll. I experienced this first hand last year at the Krka Falls in Croatia. As well as cruise ship visitors, the attractive flowing stream appeals to locals on their summer holidays. While there were graded paths, and the occasional boardwalk, the erosion the landscape, particularly at photo stops, was quite noticeable, detracting from the enjoyment of the experience.

The management of the Penguin Parade attraction of Victoria's Phillip Island addressed this same issue many years ago, by installing boardwalks, viewing platforms and bridges over drainage lines. This also served to keep visitors away from the penguins roosting holes. While the old adage in wilderness travel is 'Take nothing but photographs, leave nothing but footprints', unless the footprints are of the local wildlife, they can still leave quite a mark on the landscape.

A growing middle class worldwide with higher disposable incomes, notably in east and south Asia, is driving the demand for tourism and travel. This is being enabled, mainly, by continual falls in airfares, in real terms.



Paul Moritz FRACI CChem (Paul.Moritz@douglaspartners.com.au) is a Principal Contaminated Land Consultant with Douglas Partners, and an EPA-appointed Environmental Auditor in Victoria, New South Wales and the Northern Territory.

Elevated lead levels in Sydney back yards: here's what you can do

In our recent study (Rouillon et al. *Environ. Pollut.* 2017, vol. 222, pp. 557–66) we found that 40% of 203 Sydney homes we sampled contain lead in garden soil above the Australian health guideline of 300 mg/kg.

This presents a hazard because soil lead can adhere to or get absorbed into edible plants. An additional pathway of exposure occurs when contaminated soil dust enters homes and is accidentally ingested. Lead is a potent neurotoxin that affects childhood development.

Urban agriculture and VegeSafe

Urban agriculture is becoming more popular across Australia. Almost half (48%) of all households in metropolitan areas are now growing some form of edible produce.

Most lead contamination is a result of the historical use of lead petrol and lead-based paint (now phased out) and previous industrial emissions. Scientists and regulators are well aware of these legacy issues, but the general public remains underinformed about the potential risks.

To help urban gardeners assess contamination risks associated with their garden soils, we started the community science initiative VegeSafe in 2013. This program offers free soil metal screening to participants.

Each participant receives a formal report on their soil metal results and advice about what to do next if soils contain elevated concentrations of metals. We have provided 5500 free soil metal tests to over 1300 homes and community gardens (Australia-wide), the largest program and study of its kind in Australia.



Marek Rouillon (front) and Mark Taylor testing a back yard soil.

What did we find?

As well as the 40% of Sydney gardens containing soil above the 300 mg/kg Australian health guideline, approximately one in seven homes had soil lead levels greater than 1000 mg/kg. Soil metal concentrations were typically greatest around drip lines.

Soil lead concentrations were greatest in the City of Sydney and former local government areas of Leichhardt Municipal Council and Marrickville Council, which had mean soil lead concentrations of 883 mg/kg, 960 mg/kg and 689 mg/kg, respectively.

Homes with painted exteriors built before 1970 were more likely to have soils contaminated with lead. The highest levels are at homes 80 years or older. This is likely to have been caused by lead-rich paint, which contained up to 50% lead prior to 1970. Lead in paint was reduced to less than 1000 mg/kg (0.1%) by 1997.

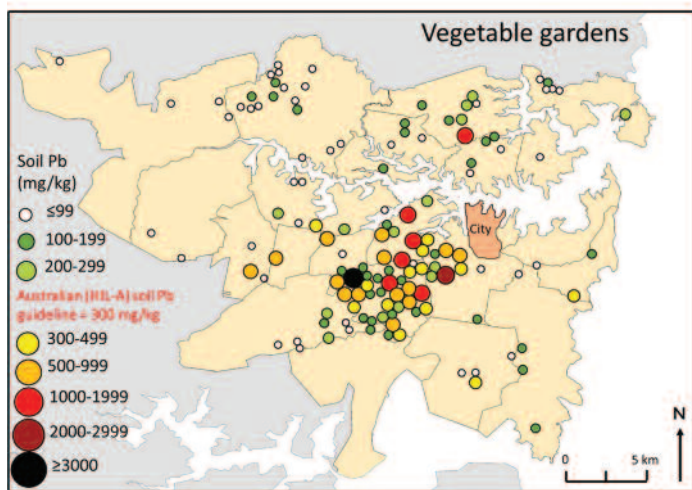
We observed the environmental benefit of the withdrawal of lead from paints and leaded petrol (removed in 2002) in our study. Garden soils at newer homes contain the least lead. Soil lead concentrations decrease with distance from Sydney's city centre, where there are more old homes and greater density of traffic and industry.

Public health

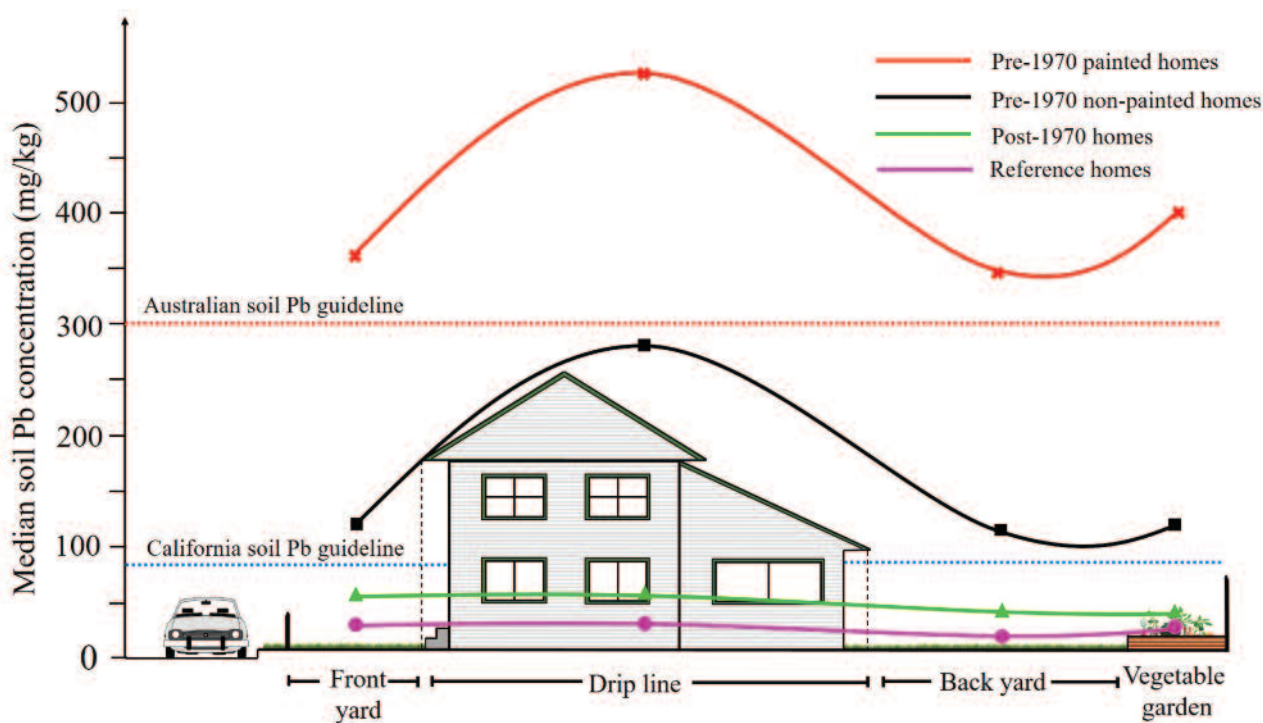
Lead exposure is especially detrimental for children because their neurological and skeletal systems are developing. Adults are also adversely affected, with studies showing increased blood pressure and hypertension associated with subclinical exposures.

Toxicological evidence also shows that exposure reduces semen quality and extends the time to pregnancy. In short, lead is detrimental to all human systems and exposures should be avoided or minimised at all times.

Our study demonstrates lead contamination in garden soils is greater at painted homes than non-painted homes. Many pre-



Soil lead concentrations of vegetable garden soils from 141 Sydney homes. Map represents one of four areas around homes (front yard, drip line, back yard and vegetable garden) in this study. Source: Rouillon et al. 2017.



Cross-section schematic of a typical inner-Sydney residential home with median soil lead concentrations for painted pre-1970 homes, non-painted pre-1970 homes, post-1970 homes and reference homes. The vegetable garden is displayed at the rear of the back yard, as this was the case for the majority of homes. Source: Rouillon et al. 2017.

1970 Australian homes still contain paint with up to 50% lead on exterior walls, fences, eaves, doors and window frames.

The main risk of exposure arises when lead-based paint deteriorates or is removed improperly. Indeed, many home renovators unwittingly expose themselves and others due to a lack of knowledge of lead hazards.

Reducing exposure

The United States Environmental Protection Agency introduced legislation specifically targeting houses with lead paint to prevent contamination and to minimise avoidable lead exposures.

Unfortunately this regulatory gap has not been filled in Australia. Despite the widespread historic use of lead-based paints and the high proportion of exposure related to it, our data reveals a concerning legacy of soil lead contamination in older suburbs.

We recommend that people residing at or planning to purchase or renovate homes built before 1970 should get their soils and paint tested for lead. Using a qualified lead-abatement decorator in older homes would also help prevent exposure. Where parents and homeowners think they may have caused exposure, their GPs can provide a blood lead test.

Reducing even low-level exposures is critical, as demonstrated by Bruce Lanphear's 'prevention paradox'. This states that the majority of IQ points lost from lead exposures, across a population, occurs in children with low blood lead concentrations ($<5 \mu\text{g/dL}$).

What can gardeners do?

Where non-food-growing soils exceed the Australian soil metal guidelines, we recommend maintaining year-round cover of lawn or mulch to minimise dust generation.

Where metal guidelines are exceeded in food-growing soils, we recommend either replacing existing soil with new, uncontaminated soil, or relocating the food garden to an above-ground vegetable plot (again with new soil).

In this way, gardeners can exercise our motto, which is to carry on gardening knowing their soils are clean.

The VegeSafe program is ongoing for all Australians. Gardeners can send their soil samples to Macquarie University for free soil metal screening of their soil. We do, however, take donations to help sustain our program – so please support your citizen science.

Marek Rouillon is a PhD candidate, Louise Kristensen is a postdoctoral research fellow, Mark Patrick Taylor is Professor of Environmental Science, Paul Harvey is Researcher of Environmental Science and Steven G. George is Researcher of Environmental Science at Macquarie University. First published at www.theconversation.com.

... many home renovators unwittingly expose themselves and others due to a lack of knowledge of lead hazards.

Colourful kitchen chemistry: cabbage juice pH indicator

My February (p. 38) experiment to try at home explored a 'magic' way to put out a candle. While these experiments might look like magic, science differs from magic in one fundamental way. A magician aims to delight and amaze by doing tricks without explaining how they work. Science does the exact opposite! I find myself saying this regularly when I am performing a show, when people are surprised and shout out something like 'Wow, that's magic!'. To me, the real magic is in understanding how something works.

This experiment is another of my 'magic' home chemistry favourites. As for my previous ones, no chemistry experience is needed. Here, we will investigate the pH of various things found in the home. pH is a measure of how acidic or alkaline a solution is. Two common times where people need to measure pH are testing the water of a swimming pool, or testing soil for gardening.

What you'll need

- 1/4 of a red cabbage (When buying from the supermarket, choose the piece which is in the worst condition, as this is the one most likely to end up being thrown out as waste.)
- Water
- Hotplate
- Sieve
- Kitchen jug
- 5 colourless drinking glasses/jars
- Vinegar
- Bicarb soda (sodium bicarbonate)
- Lemon juice
- Laundry liquid/powder

What to do

Preparing the cabbage juice indicator solution

Chop the cabbage until the largest pieces are about 2 cm² in size. Put the cabbage in a saucepan and fill the saucepan with water until the cabbage is just covered. Bring the water to the boil over high heat and immediately turn off the hotplate. Remove the pot from the hotplate and allow it to cool. Once cooled, filter the cabbage through a sieve to remove all the cabbage pieces. You will be left with a dark purple solution of cabbage juice.

Investigating the pH of various household items

Half-fill your five glasses with:

- 1 water, stir in 1 teaspoon of laundry detergent/powder
- 2 water, stir in 1 teaspoon of bicarb soda
- 3 water
- 4 water, stir in 1 teaspoon of lemon juice
- 5 vinegar

These glasses should all contain a solution of colourless liquid (see upper image opposite). (Note: in my experiment, the lemon juice mixture was a little cloudy.)

To each of these, add about a tablespoon of your concentrated cabbage juice, stir, and observe the colour change (see lower image opposite)!

Warning: This experiment requires use of a hotplate to prepare an indicator solution – adult supervision is required.





What's happening?

The cabbage juice is acting as a pH indicator, which is a molecule or mixture of molecules that changes colour depending how acidic or alkaline the solution is. The molecules responsible for this in cabbage juice are anthocyanins. These molecules are some of the highly coloured components that give cabbage and other fruit and vegetables their colours. The particular mixture of these that is in red cabbage has been shown to be a great indicator over a large pH range with a number of distinct colours possible.

Another way to do this experiment that makes the reaction much slower is to freeze the cabbage juice in an ice-cube tray and add it to your solutions frozen. This can be fun to watch as the purple ice cubes will melt slowly and the trail of cabbage juice coming off them will change colour as it moves through the glass.

The chosen household solutions gave a nice range of colours

from green and blue (alkaline), to purple (neutral), all the way to pink and red (acidic). There are many other products you might be able to find around the kitchen, laundry, or garden shed that you can test – just make sure if they're more hazardous (e.g. bleach) that children don't use these unsupervised. If you find something that is very strongly alkaline, the solution will turn yellow.

In writing these up, I hope to encourage more and more science experiments to be done at home. I am still amazed by the sheer number of fun and exciting experiments that can be done with the simplest of items. Until next time, happy sciencing!



Jeremy Just MRACI is a Hobart-based PhD candidate in organic chemistry and a passionate science communicator, specialising in chemistry shows and demonstrations.

Australian universities' chemistry performance: a comparative ERA study

The Australian Research Council (ARC) has now conducted three exercises (in 2010, 2012 and 2015), known as the Excellence in Research for Australia (ERA) project. Research performance in Australian universities is assessed against international benchmarks. This valuable indicator of the quality of our scientific research provides a basis for policy and investment decision-making by governments, universities and the business sector. A further exercise will be conducted in 2018.

Chemical sciences is one of 22 Fields of Research (FOR) evaluated. Some 26 institutions submitted data in 2015 for evaluation in the chemical sciences category. The data collected relates to the institution as a whole. Performance is not aligned exclusively to a Department of Chemistry because many entities within an institution may contribute to chemical sciences outputs. Within the chemical sciences FOR (designated by the two-digit code 03) are eight discipline-related subfields (designated by the four-digit codes 0301–0307 and 0399) with many Units of Evaluation (UoEs) assessed. A quality rating scale from 1 (well below world standard) to 5 (well above world standard) has been used by the ARC.

A previous article examined the 2010 results for the chemical sciences (November issue 2011, pp. 20–23). In this article, the performance of the chemical sciences is compared with that of the other science-based disciplines – physical sciences (02), earth sciences (04), environmental sciences (05) and biological sciences (06). The 2015

outcomes are reviewed along with the changes from the 2010 ERA outcomes. The relevant primary data, representing the performance over several years, is sourced from the two ARC ERA reports. Details may be obtained from the ARC website (www.arc.gov.au/era-reports).

2015 ERA results

The discipline performances are based upon data reported by universities in six main categories: the number of Full Time Equivalent (FTE) research staff, research publication outputs, research income received, patents, research commercialisation income and esteem measures. For this comparative study, only the first three performance parameters are considered along with the number of universities submitting, the units assessed at the four-digit level and the average national rating. The aggregated data submitted by all the participating universities is shown in Table 1.

The data serves to highlight the dominance of the biological sciences in the Australian research scene in 2015. The level of activity is two to three times that of any other FoR. Nationally, the chemical sciences ranked second in the number of active researchers, third in the number of research publications, but lowest of the five discipline areas in terms of research income received. This is a very important outcome because chemical research is unlikely to be the cheapest discipline to conduct among the sciences.

The chemical sciences with 94 units assessed was the second largest in quantity, underlying the breadth of

chemical research activities in universities. Chemistry along with the other science FORs received an average national rating above the world standard (>4). This encouraging outcome is a clear indication of the international competitiveness of Australian scientific research.

Performance relative to the number of researchers

Normalising the data to the number of FTE researchers provides a different perspective. The research output and research income per FTE are shown in Table 2. The physical sciences are the most productive in terms of research outputs and the environmental sciences receive the most research income.

The chemical sciences do have a similar research output performance to the earth and environmental sciences, while being superior to the biological sciences. The research income is the aggregate for three years. The chemical sciences figure is surprisingly low. Are the chemical sciences being underfunded relative to other science-based disciplines? A more detailed investigation may be warranted.

Performance trends 2010–2015

The percentage change data in Table 3 serves to highlight the overall growth in scientific research in Australian universities since the 2010 ERA exercise. With the exception of the biological sciences, all other fields have increased the number of researchers over the five-year period. The total number of research outputs and the research income received

Table 1. The 2015 ERA discipline-based results

	Physical sciences	Field of research Chemical sciences	Earth sciences	Environmental sciences	Biological sciences
FTEs	1148.8	1333.9	980.5	828.2	3294.0
Research output	16 990.8	15 288.8	11 090.4	9288.4	28 786.3
Research income	\$354 091 710	\$335 252 137	\$360 562 621	\$418 507 503	\$988 548 549
Universities submitting	23	26	20	34	33
Four-digit units assessed	65	94	62	53	137
Average national rating	4.6	4.3	4.4	4.5	4.1

Table 2. 2015 ERA outputs on an FTE basis

	Physical	Chemical	Field of research Earth	Environmental	Biological
Research output/FTE	14.8	11.5	11.3	11.2	8.7
Research income/FTE	\$308 227	\$251 332	\$367 733	\$505 322	\$300 106

Table 3. Percent change in ERA performance 2010–2015

	Physical	Chemical	Field of research		
			Earth	Environmental	Biological
FTE	19.0	15.6	36.6	24.5	–0.6
Research output	24.3	28.3	34.3	97.8	23.0
Research income	74.1	21.0	87.2	76.5	10.6
Research output/FTE	4.4	11.0	–1.7	58.9	23.7
Research income/FTE	46.3	4.7	37.1	41.7	11.3

have increased for all the disciplines. While the chemical sciences income was the lowest of all the disciplines for 2015, the amount had increased since 2010. Physical, earth and environmental science disciplines have nevertheless outperformed the chemical sciences.

When the performances are normalised on a FTE basis, the standout discipline is environmental sciences with a 59% increase in output and a 42% increase in income. The chemical sciences have performed reasonably well, but the growth is less than that for other

disciplines on the indicators examined. There is a concerning relative growth trend that may adversely impact on the future competitiveness of chemistry researchers.

This analysis supports the conclusion that university research in the chemical science ranks highly by world standards. However, the discipline appears to be seriously underfunded on a per researcher basis. Furthermore, 2010 chemical sciences activities have not grown at a comparable rate to the physical, earth and environmental sciences disciplines. Only the biological sciences are similarly challenged for future development. In a subsequent article, the performance of individual universities at the four-digit discipline-related subfield level will be examined.

Professor Emeritus Frank P. Larkins FRACI CChem is at the School of Chemistry, University of Melbourne.



Tickets on sale NOW through RACI office

raci

The RACI Victorian Branch cordially invites you to the

Centenary Gala Dinner & Ball

\$150 for 3 course dinner, drinks and dancing

Celebrate in style . . . dinner and cocktail attire

Plaza Ballroom, Collins St., Melbourne

Saturday 22nd July 2017

7pm - midnight

Timing the grape harvest

Timing the grape harvest can be extremely stressful for both grape growers and winemakers. Weather forecasts and climate history play a significant role in this decision-making process. For example, if rain sets in, the grapes can take up water, swell and split, possibly leading to 'grey mould' or *Botrytis* bunch rot. While sprays may be effective, the timing is often a challenge and the amount and type of spray that can be used is regulated: the 'Dog Book' published by the Australian Wine Research Institute (bit.ly/2nV925d) is the industry's guide on these issues.

Harvesting at 'optimal maturity' is always the preferred goal and this term is often used on wine labels to justify to the consumer the care taken in timing the harvest. The difficulty is that there are many conflicting factors that make choosing the best time a challenge. Sugar accumulation is faster in warmer than in cooler climates. So, a harvest might occur in the first week of January in Bourke, New South Wales, but in late March or early April in Tasmania.

As the grapes ripen in our warm to hot climates, sugar accumulation is accompanied by a loss of acidity (see my May–July 2016 columns). As we are able to add acid to the crushed grapes to supplement the amount at harvest, greater emphasis tends to be placed on the sugar concentration. This combination of sugar and acid concentrations is sometimes referred to as technological maturity.

For red grapes, phenolic maturity is another important issue in the decision to harvest. Phenolic maturity refers to the ripeness and extractability of phenolic compounds, including anthocyanins, from the skins, pulp and seeds as well as the stalks if these are used in the winemaking process. If phenolic maturity is less than optimal, the tannins in the finished wine tend to be rather coarse, bitter and astringent, sometimes described as 'green'. In warm to hot climates, exposed berries can suffer considerable loss of anthocyanins, resulting in less wine colour.

The frustration for grape growers and winemakers is finding the balance between the technological maturity and the phenolic maturity, as achieving phenolic maturity is slower than sugar accumulation. In warm to hot years, rapid sugar accumulation may reach concentrations that will yield 16% natural alcohol or more while waiting for phenolic maturity to be reached. This in turn implies the need to reduce the amount of alcohol to achieve the sweet spot (see March issue, p. 38).

Several viticultural practices including bunch thinning and early defoliation have been claimed to generate beneficial outcomes for enhancing phenolic maturity. These are labour-intensive practices that may have a detrimental outcome should extreme weather effects (excessive heat or cold) occur after the treatment. An alternative that has been explored is to try and manipulate or speed up the metabolic processes associated with the production of phenolic compounds using a foliar spray.

Some years ago when teaching in Budapest, I met Szabolcs



Villangó who was at the time undertaking a field-based research project for his doctorate on the enhancement of phenolic maturity, using a then recently released foliar spray. Working on Syrah (Shiraz to us) in the Eger region of Hungary for the 2012 and 2013 vintages, Szabolcs assessed changes in grape berry anthocyanin extractability and skin texture characteristics. Wines were made from the treated and control vines at different harvest points for subsequent chemical and sensory analysis. In essence, grapes with thicker skins were found for the treated vines compared to the control vines. Although the climate differed markedly between the two vintages, the impact of the foliar spray in both vintages clearly showed a greater level of phenolic maturity. Sensory analysis (17 trained assessors) showed a distinct preference for the wines made from grapes of the foliar-spray treated vines. This study has been published (*S. Afr. J. Enol. Vitic.* 2015, vol. 36, pp. 305–15) and also earned Szabolcs his well-deserved doctorate.

The organic foliar spray used in this study has the commercial name of LalVigne® Mature, supplied by Lallemand, a major international supplier of reagents to the wine industry. It is a yeast-derived product that can be suspended in water and sprayed on vine leaves around véraison, the time when red berries colour up (see photo of sprayer in action). It is simple and easy to use and is capable of stimulating secondary metabolite synthesis that impacts on phenolic maturity. The actual biochemical method of action is not apparent, but there is increasing evidence for a beneficial effect in warm to hot grape-growing conditions. That is, by advancing phenolic maturity, an earlier harvest date can be chosen at a lower berry sugar concentration, resulting in more rounded wines at a lower alcohol concentration.

With the increasing heat load in our vineyards, treatments such as this may well become more common. There is also a positive effect in cool climates, but that is a story for another day.



Geoffrey R. Scollary FRACI CChem (scollary@unimelb.edu.au) was the foundation professor of oenology at Charles Sturt University and foundation director of the National Wine and Grape Industry Centre. He continues his wine research at the University of Melbourne and Charles Sturt University.

Dr Findlay's casebooks

The name of Alexander Findlay (1874–1966), Professor of Chemistry at the University of Aberdeen (1919–45), came to my attention several times during recent reading and research. I recalled that I had his *Introduction to physical chemistry* that had served through undergraduate years. I still have it and although little consulted, it must have had some talismanic value to have survived my changes of address and consequent library purges over the years. I'm not even sure that it's my 'original' copy since this one clearly had previous owners, first J.J. Bischoff and then Gerald Oppenheim who, with his wife Rae, founded Ego Pharmaceuticals.

Findlay was born on Scotland's east coast and studied chemistry in Aberdeen, taking his MA in 1895 and DSc in 1902. In between, he completed his PhD at Leipzig (1900), working with Ostwald. His first academic job was a lectureship at the University of Birmingham, following which he was Professor of Physical Chemistry at the University College of Wales in Aberystwyth.

The University of Aberdeen was formed in 1860 by the union of two Colleges, Kings and Marischal. Kings, part of the local Catholic polity, was founded in about 1500, while Marischal was founded nearly a century later by Protestants. Chemistry was taught at both colleges but there was no research in the early days and very little of it even after the union. John Smith, foundation Professor of Chemistry and Experimental Physics at the University of Sydney, was a Marischal graduate (MA 1843, MD 1846) who served as a staff member there for a few years until his appointment to Sydney in 1852.

Something not so well known is that in 1888 when the University of Aberdeen advertised the chair of chemistry upon the retirement of James Smith Brazier, who had served since 1862, there were 19 applicants among whom was 'Orme Masson MA, DSc (Edinb)' of the University of Melbourne. This application is not mentioned in the standard biographies of Masson but I learned of it in *The teaching of chemistry in the Universities of Aberdeen*, a book that Findlay wrote in 1935 about the work of his predecessors.

David Orme Masson was born in London, where his father was professor of English Literature, but his chemistry education was in Edinburgh because the family relocated there when his father, who had been born in Aberdeen and educated at Marischal College, moved to a chair in Edinburgh. After a lightning courtship and a brief engagement, Orme married Mary Struthers who had been born in Edinburgh but grew up in Aberdeen where her father was a medical professor. Orme had applied unsuccessfully for the chemistry chair at St Andrews, just before the newlyweds left for Australia, and one biographer noted that they both 'anticipated a swift return, assuming that Orme would soon secure an academic position in Scotland or England'. Perhaps this explains why, when they had barely settled in Melbourne, Orme was putting himself forward to the Aberdonians.



Marischal College, University of Aberdeen.

Jackofhearts101 at English Wikipedia, CC BY-SA 3.0

The successful applicant in 1888 was Thomas Carnelly, and he was followed in 1890 by Francis Robert Japp, who boosted the research performance of the department. It was after his resignation in 1914 that Findlay was appointed. A year later, Findlay delivered the Thomson Lectures (named after John Arthur Thomson (1861–1933), Regius Professor of Natural History at Aberdeen) for the United Free Church College in Aberdeen and took as his topic what we would call 'chemistry for non-chemists'. He concentrated on industrial applications of chemistry, especially agriculture, 'the greatest industry of all', but included some background on chemical structures, reaction rates and so on. Being a thrifty Scot, and not one to waste all that effort, he amplified and transformed his lecture notes into *Chemistry in the service of man* (1916). After a couple of editions, this morphed into *The spirit of chemistry: an introduction to chemistry for students of the liberal arts* (1930, second edition 1934).

I'll have a bit more to say in a subsequent Letter about Findlay and this book, but suffice to note at this point that he was an inveterate scribbler and that a good deal of his published and unpublished scribbling has been preserved in libraries and archives. In 1924–25, Findlay was a visiting professor at Stanford University, where he kept a diary of his activities there and his speaking engagements across the United States. In 1981, the diary was gifted to Stanford by Findlay's son, Ian. Before that, and shortly after Findlay's death, his autobiographical notes and publication list were donated to the University of Aberdeen by his widow.



Ian D. Rae FRACI CChem (idrae@unimelb.edu.au) is a veteran columnist, having begun his Letters in 1984. When he is not compiling columns, he writes on the history of chemistry and provides advice on chemical hazards and pollution.

3rd International Conference on Organic and Inorganic Chemistry

17–19 July 2017, Chicago, Illinois, USA
<http://organicchemistry.conferenceseries.com>

Vic Branch Centenary Gala Dinner and Ball

22 July 2017, Plaza Ballroom, Melbourne, Vic.
<https://icmsaust.eventsair.com/raci2017/centenary-gala-dinner/Sign/Sign>

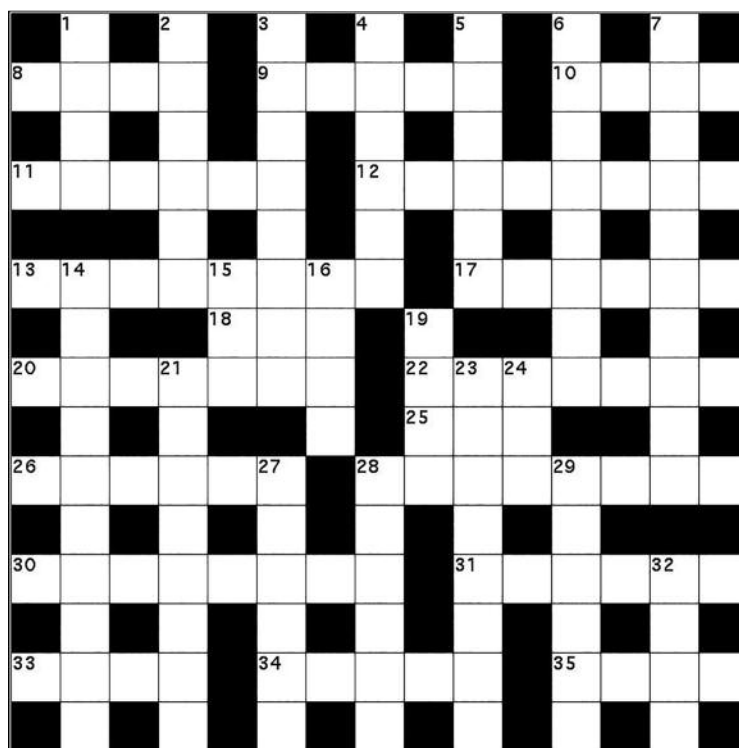
6th Modern Solid Phase Peptide Synthesis and its Applications Symposium

12–14 October 2017, Fraser Island, Qld
www.solidphase.org

International Conference and Exhibition on Pharmaceutical Nanotechnology

27–29 October 2017, Rome, Italy
<http://nanotechnology.pharmaceuticalconferences.com>

RACI events are shown in blue.



Across

- 8 Out of noble gas? Zilch! (4)
 9 Make about 891. (5)
 10 Canned notice about noble gas. (4)
 11 Tin a way to lie. (6)
 12 Toned down feeds not chewed. (8)
 13 & 19 Down Sodium carbonate, perhaps, is a street and a road foundation. (8)
 17 Dependable stable. (6)
 18 See 28 Down.
 20 Compounds between 5 and a less electronegative element give oxygen to new partners. (7)
 22 A growing proceeding. (7)
 25 The group decided. (3)
 26 & 28 Across Housemaster's neon to be used for procedures which can be trusted. (6,8)
 28 See 26 Across.
 30 Compiles prayers. (8)
 31 Circumvents expressed average inclusion on return. (6)
 33 Exhausted rhythm. (4)
 34 Be flame one way. (5)
 35 Aide fixed thought. (4)

Down

- 1 Deep unconsciousness of second Schrödinger formulated ammonium carbonate. (4)
 2 About sea stay. (6)
 3 Eat a drug cocktail having 4 Down. (8)
 4 Expired but returned in triglyceride's saponification. (6)
 5 Changes dresses. (6)
 6 Leave west, not east, breaking up brief oscillations. (8)
 7 Reliance on Pence ended in confusion. (10)
 14 Soon petrol will run out for production of 2-hydroxycyclohepta-2,4,6-trienones and derivatives. (10)
 15 Pop and add 5 Down. (3)
 16 Stretch out 25 Across radical reaction. (4)
 19 See 13 Across.
 21 Perfection doesn't really exist. (8)
 23 About a fellow's substances for use in chemical reactions. (8)
 24 Internal transcribed spacer regions after resistant centres. (3)
 27 There's paper in the aromatic ketone. (6)
 28 & 18 Across Chew resin bit. (9)
 29 Our organisation involved in first useful life nucleobase. (6)
 32 V and N in this flat. (4)

Graham Mulrone FRACI CChem is Emeritus Professor of Industry Education at RMIT University. Solution available online at Other resources.

Perfect Setting. Great Company. Generous Savings.

23-28 July 2017 | Melbourne
100 raci
Centenary Congress

Whether you're celebrating a birthday, having a family dinner, or romance is on the cards, we've got some great restaurants that are perfect for any occasion.

Your RACI Member Benefits lets you access up to 400 participating restaurants offering great discounts and savings.

To discover venues where you can take advantage of your benefits;
Call 1300 853 352 or visit
www.memberadvantage.com.au/raci



Your one-stop-shop for all laboratory supplies... face to face service or online ordering, we give you the choice.

ROWESCIENTIFIC
PTY LTD

ADELAIDE | BRISBANE | HOBART | MELBOURNE | PERTH | SYDNEY

A 100% Australian owned company, supplying scientific laboratories since 1987.



See our specials.

LABORATORY CONSUMABLES - CHEMICALS - INSTRUMENTATION - REPAIR SERVICES

Order online at your convenience at: WWW.ROWE.COM.AU



New South Wales & ACT
Ph: (02) 9603 1205
Fx: (02) 9603 1084
rowensw@rowe.com.au

Queensland & PNG
Ph: (07) 3376 9411
Fx: (07) 3376 9455
roweqld@rowe.com.au

South Australia & NT
Ph: (08) 8186 0523
Fx: (08) 8186 0524
rowesa@rowe.com.au

Victoria & Tasmania
Ph: (03) 9701 7077
Fx: (03) 9769 2560
rowevic@rowe.com.au

Western Australia
Ph: (08) 9302 1911
Fx: (08) 9302 1905
rowewa@rowe.com.au