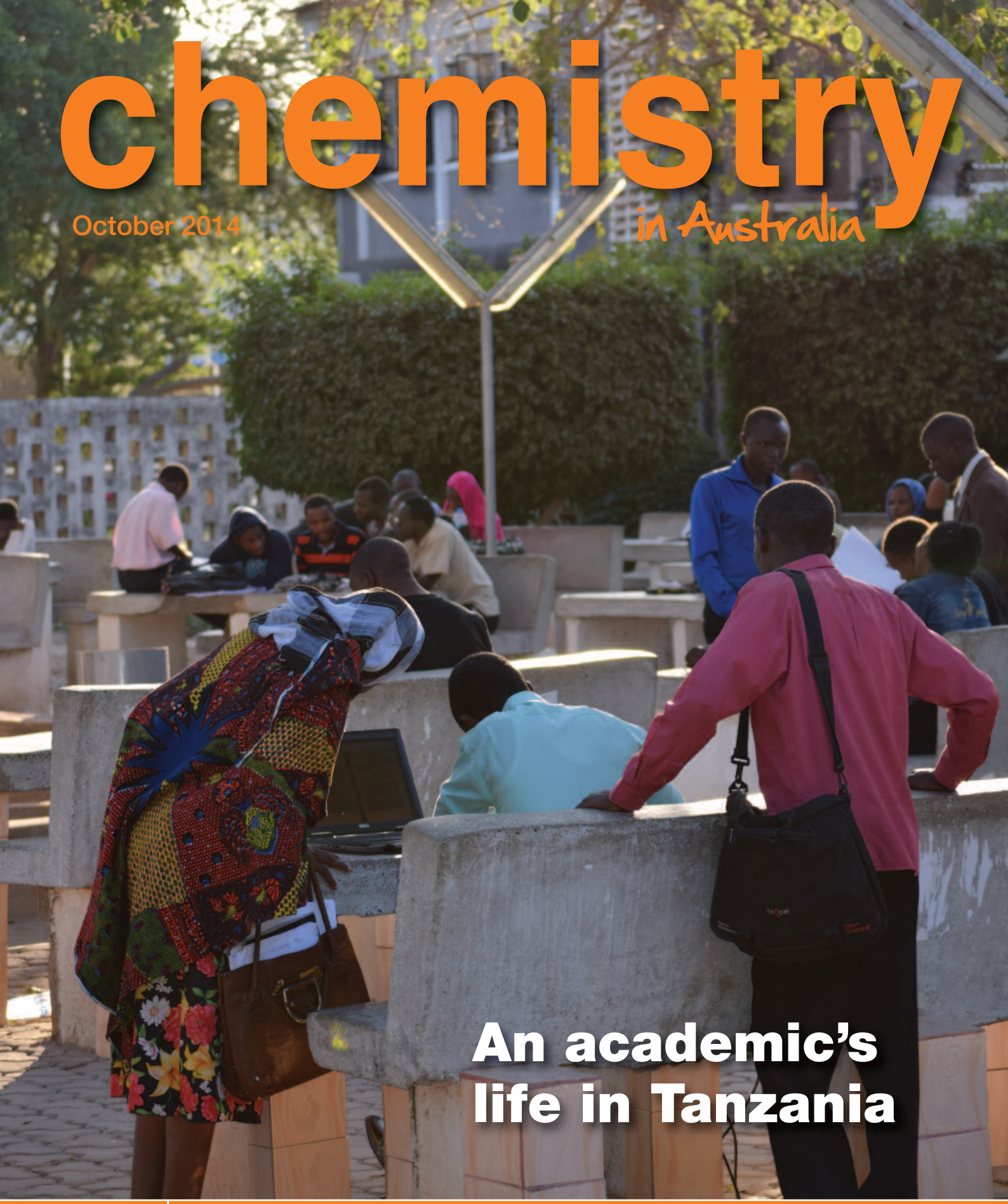
chemistry in Australia

October 2014



An academic's life in Tanzania

raci
Royal Australian Chemical Institute

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chemistry in Australia

October 2014

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Clinical practice in critical times

As this issue went to press, the number of cases of the Zaire strain of Ebola virus (EBOV) continued to rise in West Africa. Most deaths have occurred in Guinea, Liberia and Sierra Leone.

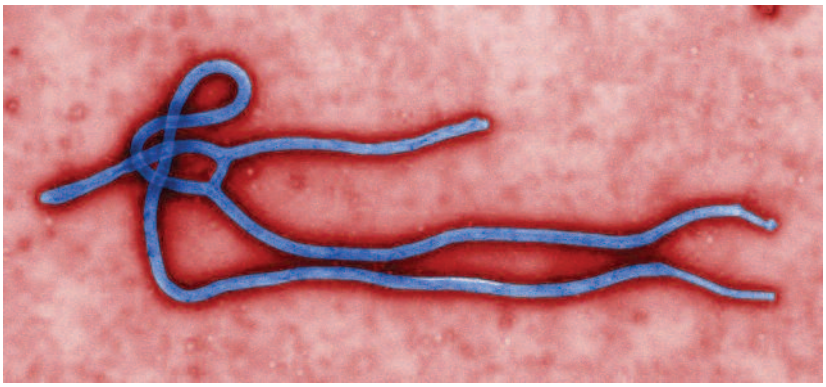
An international group of researchers has conducted epidemiological investigations, including genetic analysis, on samples collected from Guinea in March. They state in their paper, published in the *New England Journal of Medicine* in April (bit.ly/1oi0hMU), that 'The high degree of similarity among the 15 partial L gene sequences, along with the three full-length sequences and the epidemiologic links between the cases, suggest a single introduction of the virus into the human population.' The first suspected case is believed to have been a two-year-old girl from Guéckédou prefecture. She died last December.

Potential carriers of EBOV include the fruit bat species *Hypsignathus monstrosus*, *Myonycteris torquata* and *Epomops franqueti*. Some species of fruit bat have been shown to have symptomless infection – the virus is hosted but cannot be readily detected (bit.ly/1ybFrPu), so it's difficult to track down. Five strains of EBOV, belonging to the virus family Filoviridae, have been identified, but not all are dangerous to humans. The specific pathways of viral infection of human cells are unknown.

How do you maintain clinical protocols in the face of urgent calls, including in this situation some from eminent Ebola specialists, for access to experimental drugs? It's not a new dilemma. And it's exacerbated when private companies in some developed countries give these drugs to their infected nationals, while those in the worst-affected areas must wait. At the time of writing, WHO was in the process of convening a group of medical ethicists to 'explore the use of experimental treatment in the ongoing Ebola outbreak in West Africa'. It has declared this outbreak an international emergency.

> *We are in an unusual situation in this outbreak. We have a disease with a high fatality rate without any proven treatment or vaccine … We need to ask the medical ethicists to give us guidance on what the responsible thing to do is.*

Dr Marie-Paule Kieny, Assistant Director-General, World Health Organization



Colourised transmission electron micrograph showing some of the ultrastructural morphology displayed by an Ebola virus virion
Centers for Disease Control/Cynthia Goldsmith

In this issue, Malcolm Buchanan reflects from East Africa on his academic life at St John's University of Tanzania (p. 18). There are many challenges, and he explains that partnerships with colleagues in developing countries are so important, including 'for encouragement, advice, working together on small manageable projects and providing viable resources'. These services are some of the ingredients of mentoring, an activity discussed in two of this month's pieces. Read more about the mentor–mentee relationship on p. 26, and for an RACI perspective see p. 40.

Mentoring can be invaluable, and we need more of these relationships, both locally and across international borders.

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Mark Buntine FRACI CChem

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From the President

Last month I participated as a panel member at a symposium in Parliament House in Canberra, hosted by the Chief Scientist, Professor Ian Chubb. The Smart Science: Australia 2025 Symposium was the culmination of a project whereby Professor Chubb, in conjunction with The Conversation (http://theconversation.com/au), commissioned a series of articles by respected scientists about the importance of the scientific disciplines to Australia's future. The project began with the aspiration: 'Australia by 2025 will be strong, prosperous, safe and secure and positioned to benefit all Australians in a rapidly changing world.'

With the publication of the commissioned articles (www.chiefscientist.gov.au/2014/02/australia-2025-smart-science), we now have a remarkable atlas of the futures that science can open. The chemistry-related article, entitled *Proteins to plastics: chemistry as a dynamic discipline* was authored by Professor Andrew Holmes FRACI CChem (University of Melbourne), with additional contributions by myself (Curtin University) and Professor Jenny Martin (University of Queensland). The article presents a good balance of where chemistry has come from and the advances we, as a profession, have contributed to position us extremely well to further Australia's economic and social advancement.
I encourage interested members to look at this series of online articles.

In late August the RACI Board met for our second face-to-face meeting for the year in Canberra. On the evening of Friday 22 August, the ACT Branch hosted a 'meet 'n greet' dinner for Board and ACT-based RACI members. Unfortunately, due to constraints associated with the limited number of direct flights between Perth and Canberra and the associated time zone differences, I was unable to attend this event. However, I am told that the function went well. I thank the ACT Branch President, Professor Ashraf Ghanem FRACI CChem, for hosting the Board during its visit to our nation's capital. The Board meets via teleconference on a monthly basis. The next face-to-face meeting will occur in early December in Adelaide, immediately prior to the RACI Congress being held 7–12 December.

Planning for the RACI Congress has proceeded smoothly, and I anticipate that this major event for the chemistry profession will be a highlight of the RACI's activities this year. The number of registered Congress delegates, contributing authors and sponsorship and exhibition supporters are all in line with projected targets. My review of the scientific program is that an exciting, broad-based smorgasbord of oral and poster presentations has been developed. I congratulate the Chair of the Congress Organising Committee, Professor Joe Shapter FRACI CChem, and his team of symposium and event coordinators for pulling together such a great product. Details of the Congress can be found at www.racicongress.com. It's not too late to register and join us in Adelaide!

Immediately preceding the RACI Congress, the RACI will be gathering in Adelaide for our annual Awards Dinner and celebration (5 December), followed by a meeting of our Assembly (6 December) and the Board (7 December). The Awards dinner is a celebration of the very best chemistry and chemists in Australia, recognising the various RACI National Award winners and their outstanding achievement across the breadth of our profession. If you're planning on attending the Congress, I encourage you to consider arriving in Adelaide a couple of days early and joining us at the Awards dinner. Perhaps a weekend in the Barossa, Clare or McLaren Vale regions before the Congress kicks off is an attractive proposition!

Next month my two-year term as President of the RACI comes to an end. In next month's column I will have more to say on this, and to thank those who have supported me over the past few years. It has been a wonderful journey, to serve the RACI as President-Elect, then as President. I have met a lot of amazing people across the country (and around the world), engaged in some bold initiatives, and had some great successes (and a couple of big losses). Over the past four years I've learnt a tremendous amount, both about myself and even more about how our institute *really* works and its place in the Australian and international science professional organisation landscape. It has been an honour and a privilege to serve our profession.

Mark Buntine FRACI CChem (president@raci.org.au) is RACI President.

The value of breadth of knowledge

Congratulations on a great magazine. The content is just wonderful. Given the diversity of chemistry, it must be hard to keep it relevant to so many. Of recent years the content has been very balanced – well done. In particular, it has not been too technical but enough to give an understanding so that further reading can be done if desired.

I was inspired to write this note after reading Frank Eastwood's article about Sir John Monash (August issue, p. 27). I am already a fan of John Monash, and amazed that not many know about the great man or how much he achieved for Australia. His ability to think laterally, due to his amazingly diversified knowledge and experience of so many fields, redefined warfare. My grandfather was at the battle of Hamel and mentioned Monasch (how he spelt it) in his diaries. Who knows – if it weren't for Monash, I may not be here. He is certainly not just a name on a freeway or a university to me!

The real reason I am writing is not about just Monash and the article, which was very good, but because of the last line 'Frank Eastwood FRACI CChem retired as a Reader in Chemistry at *Monash* University in 1995, *since when he continued his education*.' How profoundly true the last bit is. I am retired and I have never learnt so much as I have in the last few years. Most, including me, stay focused on our roles and simply don't have the time (or make the time) to choose interests outside our everyday life as Monash did. Reading *Chemistry in Australia* has given me many chances to do this. I read a recent review in the magazine of Sam Kean's *The disappearing spoon*, which was a fantastic read. I am sure if it were compulsory reading in first year Chemistry, many more would stay in the discipline as it is very interesting, and not too technical – just like *Chemistry in Australia*.

I have also been interested in fine wines for many years and look forward to reading Grapevine by Geoffrey Scollary in every issue. I wish I had taken the time to diversify my knowledge when I was younger. The breadth of content in 'our' magazine is fantastic and in my opinion pitched at the right level. Hopefully, chemists who, like me, didn't widen their horizons as much as they should have, will now start thanks to Frank's article.

Ian Thomas MRACI CChem

Minimum EROI values

John Morgan's argument (August issue, p. 22) that renewable energy and storage systems need an EROI of about 7 to be viable is clearly nonsense. As long as society is structured around getting its energy from burning fossil carbon – which has an EROI of about 30 at the moment but is dropping steadily as we have to move onto digging up progressively less-accessible fossil carbon – an EROI of 7 may look like the lowest return we can easily live with, but an EROI of 2 could be made to work in a society structured to devoting half its energy (in the strictly thermodynamic sense) to building replacement energy-generation equipment.

The building of the new renewable-energy generators to replace the ones that were wearing out would clearly have to be heavily automated. But that's inevitable – the unit capital cost of a renewable kilowatt has halved several times in recent years as the production volumes have gone up by factors of ten, and there's another factor of ten to go before we could get all our energy from renewable sources.

His argument that energy storage systems have to push the EROI below his arbitrary margin of 7 is equally bogus. The smart grid is likely to be able to negotiate with a lot of energy users to restrict their use of energy to times when there's a lot available (like people recharging the batteries in their electric cars), so the energy storage systems only have to deal with a rock-bottom energy demand. A lot of work is being done on battery systems suitable for grid storage, and there's no thermodynamic argument that says that this hardware can't end up being cheap and long lasting.

The shallowness of his thinking is revealed by his discounting of molten salt energy storage in concentrated solar power stations, on the basis that it can't be as cheap as pumped water storage, despite the fact that it stores collected solar energy before it has been converted to electricity. It seems to be a constant feature of modern concentrated solar power systems, so would presumably have been built into the EROI of 19 that he cites for these systems.

A.W. Sloman MRACI CChem

Bill raises the important question of the minimum societal EROI. There's no precise value of course, and societies may be structured in different ways. But Weißach et al.'s value of 7 is consistent with other estimates derived using different methodologies. Hall, for instance, analysed the EROI required for oil to run a truck, and puts it thus: 'If the EROI were 1.1 you could pump the oil up, and look at it. At 1.3 you could refine and distribute it, but no more. An EROI of at least 3 would be needed to build and maintain the truck and the roads.'

To grow some grain and truck it somewhere needs about 5. To support the oil field workers and refinery workers and truck driver and farmer and their families needs around 7–8. More if the children are to be educated. More if they are to have health care. More if they want arts and leisure in their lives, perhaps – and here the numbers become increasingly speculative – around 14. And so on.

A similar hierarchy exists regardless of the nature of the energy source. Bill's putative society with an EROI of 2 would not have, for example, mechanised food distribution, or antibiotics. Such societies exist, but they do not make solar panels or batteries.

Questions of the falling cost of renewable energy, or automation, miss the point. It's a common, and misconceived, response that I explicitly anticipated in the article. It doesn't matter if the energy is monetarily cheap if the net energy is too low to run society on. We are currently capable of

producing low EROI energy systems at low cost because we have surplus energy from the high EROI fossil fuels we now use. This situation is probably temporary.

A smart grid does not improve the EROI of batteries or other energy storage systems. It may help reduce the need for energy storage by aligning consumption with time of generation, but within limits. At the level of energy use of a modern society, energy from night-time solar or becalmed wind still requires enormous storage capacity, smart grid or not. Such storage drops the EROI of these power sources below the level required to support a complex society. And a smart grid is additional infrastructure, requiring design, installation and maintenance, by educated engineers with families to raise, which further reduces the net energy.

Contrary to Bill's presumption, the EROI of 19 for concentrating solar is for a system without storage. If energy is stored by pumped hydro, this drops to 9, which is, arguably, viable. Pumped hydro, is the least energy-intensive storage method. All other storage technologies have higher embodied energy – ten times higher in the case of batteries – and reduce EROI to well below 9. By using pumped hydro, I made the most favourable assumptions about concentrating solar power available to me. The techniques actually in use, such as molten salt, are much worse from a net energy perspective. This is all written in the article.

If these ideas are 'clearly nonsense', there does seem to be a consensus delusion in the literature. I suppose, as Bill suggests, my thinking might be shallow and bogus. For our sakes I sure hope he's right.

John Morgan

EROI developments

On reading the article on EROI (or EROEI) of fuels by John Morgan in the August issue, I was surprised that some of the key developments in the topic did not feature.

A major point is that EROI is not an energy balance. 'Adventitious' energy, which would otherwise have had no use in engineering practice, need not feature. Adventitious energy can be mechanical, for example in a wind turbine. That energy has no alternative use. Adventitious energy can, however, be chemical and non-isothermal in its supply. The best example of this is refinery usage of associated gas which would otherwise have been flared or re-injected into the reservoir. Another point is that a low EROI from a carbon-neutral fuel such as biodiesel might be offset by the carbon credits that its use engenders. Also, when an oil field commences production, the amount of oil needed for payback of the energy used in drilling is exceedingly small. Produced water at an oil well can be factored into EROI in straightforward manner. All of these points feature in Jones J.C., 'Energy-return-on-energy-invested (EROEI) for crude oil', *J. Pet. Environ. Biotech.* 2013, vol. 4, pp. 150–3.

Clifford Jones FRACI CChem

Call for greater online presence of female scientists

UNSW

Nancy Millis Award winner Professor Emma Johnston (pictured) has called on the Australian public to help improve the online presence of women in science as part of the Academy's Women of Science Wikibomb (bit.ly/1A9KiUb).

Johnston is the inaugural winner of this Australian Academy of Science award, which 'recognises outstanding research and exceptional leadership by early- and mid-career Australian women who have established independent research in the natural sciences'.

Earlier this year, interested individuals were invited to help create and improve the Wikipedia pages of Australian female scientists. The Australian Academy of Science held the Wikibomb as part of National Science Week, Australia's biggest festival.

Johnston, a marine ecologist from the University of New South Wales, said: 'Wikipedia pages are the first place most students look. If there's not enough information on there about Australian women in science and their achievements, there's a risk they will go un-noticed.'

'We need to tell the stories of Australian women scientists online to bring more strong role models to girls, to inspire the next generation of scientists and to help Australians of all ages understand the contribution these scientists have made,' Johnston said.

'If you can't connect with the role models that are out there, then you might not be able to imagine yourself in a science career. That's such a shame because it's such a fun and rewarding job.'

Many Australian women scientists, including those who have made significant contributions to Australian science, have no Wikipedia page or a short 'stub article' of fewer than 100 words. The Wikibomb was held both online and at a physical event at the Shine Dome in Canberra on 14 August. This event was inspired by a similar initiative created by the UK Royal Society.

AUSTRALIAN ACADEMY OF SCIENCE

First fully compostable and recyclable paper cup

Netherlands-based paintings and coatings company AkzoNobel has created the world's first fully compostable and recyclable paper cup for cold drinks.

Using a coating known as EvCote™ Water Barrier 3000, made from plant-based oils and recycled PET bottles, the cups don't require any modification in the current recycle stream or special handling.

Roughly 200 billion paper cups are used around the world every year, but none can be recycled without incurring prohibitive costs or greatly diminishing the quality of the paper fibre. That makes this new technology remarkable, because when paper coated with EvCote is recycled, the quality of the paper fibre remains intact – which means the paper can be reused in the production of other paper products. In some cases, due to the fibres being strengthened by the coating, paper produced from the waste can even achieve higher strength than the original, uncoated paper.

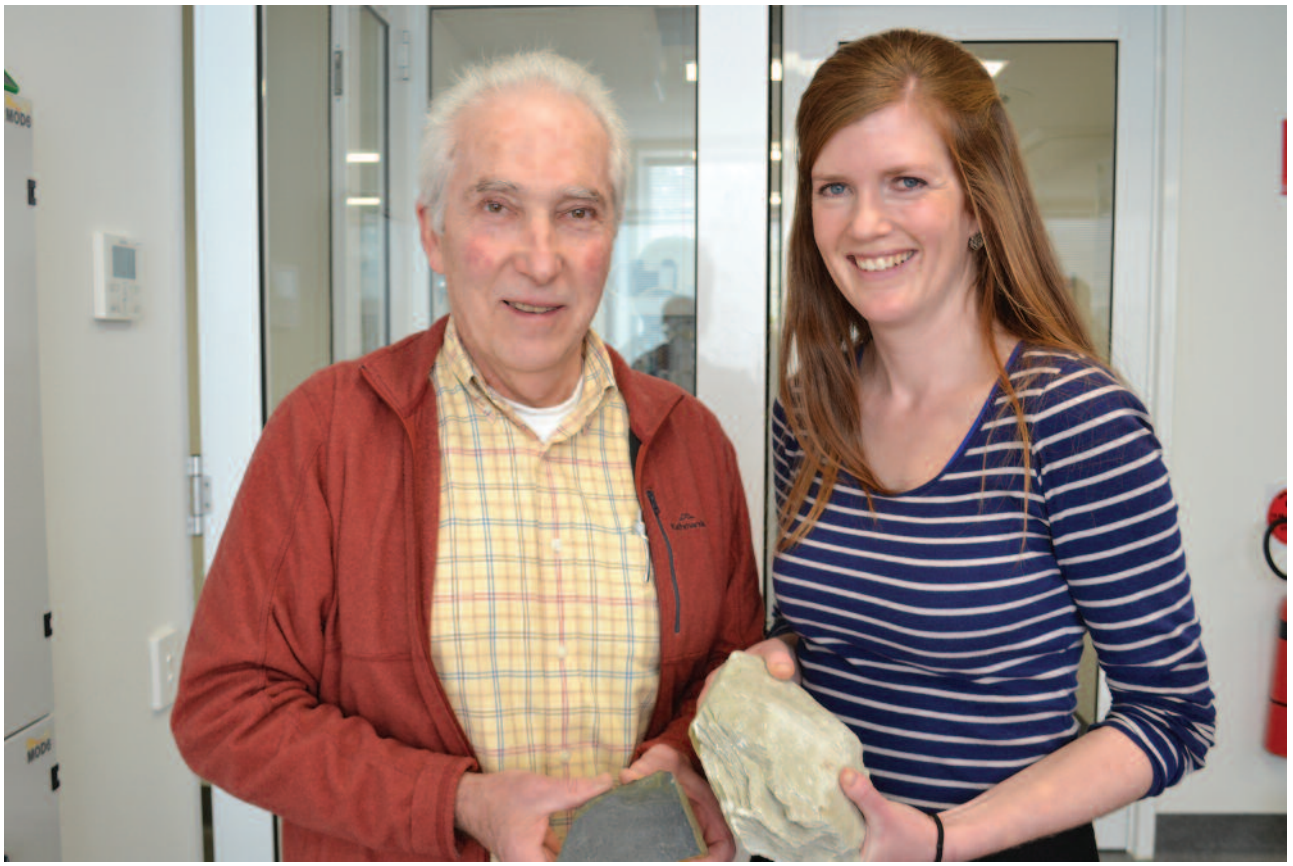
An additional advantage is that it enables paper mills to recapture 100% of the paper waste from the production process that is currently sent to landfill, resulting in significant financial savings.

'The cost of paper represents the highest single cost for cup makers, so recycling the industrial scrap means that there are both cost and environmental benefits,' said Gil Sherman, Market Development Manager at AkzoNobel's Paper Coatings business. 'With the growth of bio-PET, EvCote provides us with options to completely disconnect from the petrol supply chain, because now we can offer our customers a replacement for petroleum-based PE films.'

Made of up to 95% sustainable or renewable content, EvCote barrier coatings protect paper surfaces against water, grease and moisture. They can be used in numerous applications, including corrugated packaging, folding carton board, beverage carrier board and food service packaging.

AKZONOBEL

Ancient minerals suggest western North America and Tasmania were neighbours



Jacqueline Halpin and Peter McGoldrick with the mineral samples

Research from the University of Tasmania and Mineral Resources Tasmania has established a close prehistoric connection between Tasmania and western North America, places now located on opposite sides of the globe.

By analysing ancient minerals, the researchers Dr Jacqueline Halpin and Dr Peter McGoldrick (from CODES, the University's ARC Centre of Excellence in Ore Deposits) have compelling evidence that western North America was once our close geographical neighbour.

The research was published recently in *Precambrian Research* (bit.ly/1kxZNkQ).

The team age-dated tiny minerals monazite and zircon, found in sedimentary rocks from the Rocky Cape Group in north-west Tasmania. They found that these rocks were deposited in an ancient ocean between 1.45 and 1.33 billion years ago, making them the oldest rocks in Tasmania.

Dr Halpin said the patterns of ages in the Rocky Cape Group strongly resemble those in sedimentary rocks from Montana, Idaho, and southern British Columbia (the 'Belt-Purcell Supergroup' rocks), which is a strong genetic fingerprint and evidence that the Rocky Cape and the Belt-Purcell rocks were geographically close 1.4 billion years ago.

'At this time, both Tasmania and North America were part of a supercontinent called Nuna,' Halpin said.

'As plate tectonics and the supercontinent cycle started to rift Nuna apart, a large sedimentary basin formed that included the Rocky Cape Group and Belt-Purcell Supergroup rocks.'

The continued break-up of Nuna eventually dispersed parts of this ancient sedimentary basin to opposite sides of the Earth.

There was another discovery too.

McGoldrick said the new mineral dates also provide an age constraint for the Horodyskia ('string of beads') fossils recently discovered in the Rocky Cape Group. These fossils have also previously been found in the Belt-Purcell rocks.

'Fossils visible to the naked eye are exceedingly rare from rocks older than 635 million years. Horodyskia from the Rocky Cape Group and the Belt-Purcell Basin are nearly twice this age.'

From an evolutionary viewpoint, Horodyskia are exceedingly important.

'Unlike stromatolites, which are formed by communities of simple, single-celled organisms, Horodyskia may represent the oldest known 'tissue-grade' multicellular organism.'

UNIVERSITY OF TASMANIA

Bubble wrap test-tubes

Bubble wrap can serve as an inexpensive alternative to full-size test-tubes.
American Chemical Society

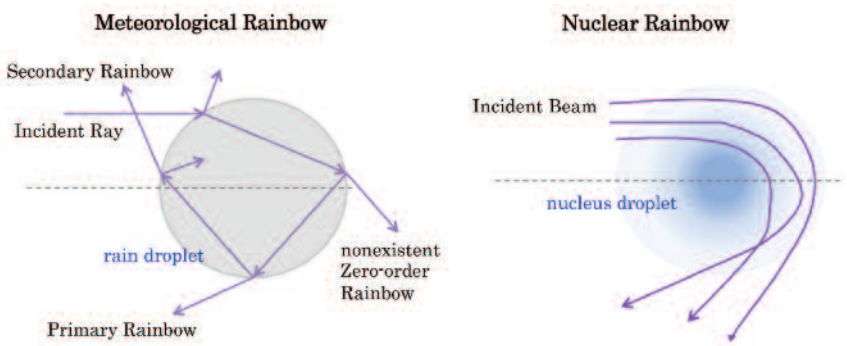
Popping the blisters on the bubble wrap might be the most enjoyable thing about moving. But now, scientists propose a more productive way to reuse the popular packing material – as a sheet of small, test-tube-like containers for medical and environmental samples. Their report, which shows that analyses can take place right in the bubbles, appears in *Analytical Chemistry*.

George Whitesides and colleagues explain that although bubble wrap filled with biological samples, such as blood or urine, or chemicals would have to be handled carefully, the material offers numerous advantages for those living in resource-limited areas. The material is available almost everywhere around the world, is inexpensive, doesn't generate sharp edges when broken (like glass containers), is easily disposed of by burning and is flexible. The interiors of the bubbles also are sterile, so there's no need for costly autoclaves that have to be plugged in – a huge plus for the nearly 2 billion people around the world who do not have regular access to electricity.

To show that their idea could work, the team injected liquids into the air-filled pockets of bubble wrap with syringes and sealed the holes with nail hardener. They successfully ran anaemia and diabetes tests on the liquids. They also could grow microbes such as *E. coli* in the blisters, which is important for detecting contamination in water samples. 'The bubbles of bubble wrap, therefore, can be used for storing samples and performing analytical assays,' they conclude.

AMERICAN CHEMICAL SOCIETY

Evidence of a secondary bow in a nuclear rainbow



Evidence of the existence of a secondary bow in a nuclear rainbow, previously believed to be non-existent in principle, has been discovered by researchers at the Research Center for Nuclear Physics and the Information Initiative Center of Hokkaido University in Japan (bit.ly/1pLWTsb).

Similar to those seen on Earth, rainbows can be observed in the microscopic world of nuclei. These are caused solely by refraction (zero reflection) as incident particles are strongly bent by strong nuclear forces, a theory founded by Professor Hideki Yukawa, Japan's first Nobel laureate. This type of rainbow (Newton's zero-order nuclear rainbow) cannot occur on Earth. Since reflection is not involved, secondary bows, as observed in meteorological rainbows, had been believed to be non-existent in principle. However, the researchers theoretically showed the existence of secondary bows caused solely by refraction.

A stripe-patterned bright region could be faintly observed on the dark side of a nuclear rainbow when an oxygen nucleus bombarded on a carbon nucleus at a high energy of about 300 MeV. A secondary bow was identified in this region.

HOKKAIDO UNIVERSITY

RSC welcomes funding for core chemistry equipment

Universities across the UK are celebrating the award of £15 million of funding for an open distributed network of infrastructure to underpin chemistry research.

The Engineering and Physical Sciences Research Council Core Capability for Chemistry Research grants will increase the strength and productivity of the research base reliant on chemistry by investing in four experimental techniques: mass spectrometry, nuclear magnetic resonance, X-ray diffraction and atomic level microscopy.

The Royal Society of Chemistry, together with Heads of Chemistry UK, helped shape the funding call for the grants. Dr Richard Walker, Physical Sciences Programme Manager at the Royal Society of Chemistry, welcomed the funding.

He said: 'This investment in new equipment for chemistry research is fantastic news. Chemistry in the UK is in dire need of this sort of funding, which is essential for ensuring that universities are able to maintain their triple helix of capability: performing world-leading research, providing world-class education and training and maintaining strong links to business and their local economies.'

A list of UK chemistry departments awarded grants to expand, refresh or upgrade equipment can be found at rsc.li/1oFSBn6.

ROYAL SOCIETY OF CHEMISTRY

European chemical industry benefits from general economic recovery

European chemicals output will grow by 2.0% this year, driven by rising demand from customer industries, particularly car-makers, and some stabilisation in the construction industry, Cefic, the European Chemical Industry Council, said.

Production growth is expected to continue in 2015, although the pace is likely to slow to 1.5% as restocking tails off. The return to growth follows a modest fall in output during 2013 as the industry wrestled with the second slow-down of Europe's double-dip recession. After a slump by more than 20%, Europe's production of chemicals has yet to match the peak of 2008.

Cefic President Kurt Bock said: 'We expect a return to growth in output by the European chemical industry this year. However, the recovery is volatile and the pace of expansion is being held back by high energy prices, which put European producers at a severe disadvantage compared to those in North America and the Middle East, who benefit in particular from cheaper gas.'

In its biannual industry forecast, Cefic said that chemical industry output contracted by 0.2% in 2013, slightly less than the 0.5% expected. The outlook for 2014 has also improved: growth in 2014 is now expected to reach 2.0%, excluding pharmaceuticals.

Looking at the wider economy, European confidence indicators are positive, and purchasing managers' expectations suggest that Europe's industrial recovery is broadening out.

CEFIC

Australia lagging in medicine investment

New OECD data shows Australia lagging in investing in medicines. Data newly released by the Organisation for Economic Cooperation and Development (OECD) reveals that Australia is not matching other industrialised countries in investing in medicines to treat disease.

The new OECD Health Data 2014 report shows that Australia's public spending on pharmaceuticals is at 0.7% of GDP, compared with the OECD average of 0.8%, on the most recently available international data.

Medicines Australia Chief Executive Dr Brendan Shaw said these figures are very worrying.

'Australia is investing proportionately less of its income on new treatments for things like cancer, diabetes, rare diseases and cardiovascular disease than many other OECD countries,' Shaw said.

'The OECD data shows that Australia has consistently committed lower levels of public spending on medicines than the OECD average for many years.

'These OECD figures don't even take into account the massive price reductions and billions of dollars in savings delivered in Australia over the last 12 to 18 months through price disclosure reforms.

'We've seen from the latest Federal Budget figures that public spending on medicines as a proportion of GDP has fallen even further, to 0.6% last year.

'While some critics lament Australia's spending on medicines, the fact is we spend much less compared to many industrialised countries. We are underperforming, and will continue to lag behind countries such as Germany, Japan and even Greece.

'Without action, it's likely that Australia will fall further behind the OECD average in coming years.

'We don't have good data on the effect of long-term under-investment in medicines on other parts of the health system. But given that medicines have directly contributed to falling death rates in cardiovascular diseases and cancer, it may well be that this under-investing is also leading to higher spending in other parts of the health system.'

MEDICINES AUSTRALIA

First woman to receive Fields Medal

Courtesy Maryam Mirzakhani

Maryam Mirzakhani

Maryam Mirzakhani, a professor of mathematics at Stanford University, has been awarded the 2014 Fields Medal, the most prestigious honour in mathematics. Mirzakhani is the first woman to win the prize, widely regarded as the 'Nobel Prize of mathematics', since it was established in 1936.

Officially known as the International Medal for Outstanding Discoveries in Mathematics, the Fields Medal was presented by the International Mathematical Union at the International Congress of Mathematicians, held in August in Seoul, South Korea.

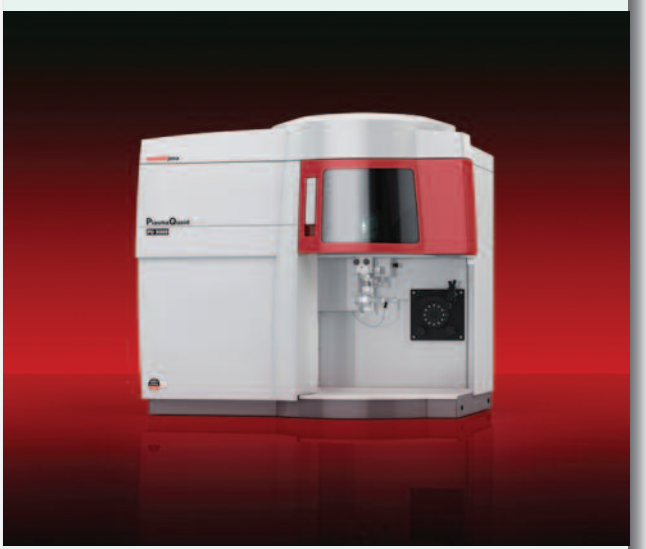
The award recognises Mirzakhani's sophisticated and highly original contributions to the fields of geometry and dynamical systems, particularly in understanding the symmetry of curved surfaces, such as spheres, the surfaces of doughnuts and of hyperbolic objects. Although her work is considered 'pure mathematics' and is mostly theoretical, it has implications for physics and quantum field theory.

Mirzakhani was born and raised in Tehran, Iran. Mirzakhani became known to the international maths scene as a teenager, winning gold medals at two International Math Olympiads. Mathematicians who would later be her mentors and colleagues followed the mathematical proofs she developed as an undergraduate.

'I don't have any particular recipe,' Mirzakhani said of her approach to developing new proofs. 'It is the reason why doing research is challenging as well as attractive. It is like being lost in a jungle and trying to use all the knowledge that you can gather to come up with some new tricks, and with some luck you might find a way out.'

STANFORD UNIVERSITY/BJORN CAREY

High-resolution array ICP-OES now available



Analytik Jena has introduced its PlasmaQuant® PQ 9000 high-resolution array ICP-OES (optical emission spectrometry using inductively coupled plasma) for multiple element analysis in Australia and New Zealand.

The PlasmaQuant® PQ 9000 has been developed to master the most complicated analytical challenges in emission spectrometry with the highest degree of precision, method flexibility and operating comfort.

Technological advances in the product include the significantly improved optical resolution, the plasma torch design and the generation and observation of the plasma.

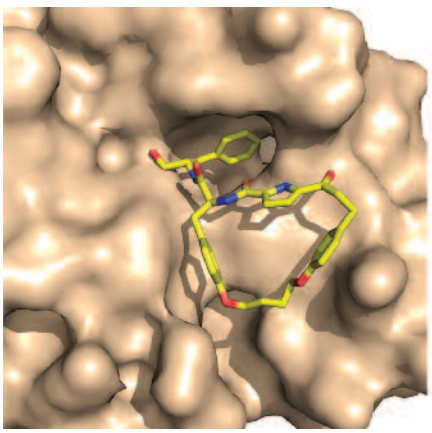
With its array technology, excellent spectral resolution and clever design of the plasma torch, the PlasmaQuant® PQ 9000 is a specialist for demanding samples and complicated matrices. It is high performing in identifying spectral interferences. Thus it permits a precise evaluation of analysis results of samples with high salt content or just traces of elements as well as of acids and bases.

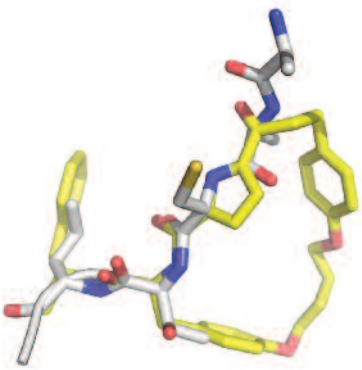
Optical emission spectrometry using an inductively coupled plasma (ICP-OES) is an analysis method in which very hot argon plasma is used to analyse the elements present in a sample. Based on the emitted characteristic radiation, the content of the individual elements can be determined. ICP-OES technology is routinely used in many industry sectors, for example, environmental analysis, material research and the metal and pharmaceutical industries.

For more information, please contact MEP Instruments on (02) 8899 5200 or info@mep.net.au or visit www.mep.net.au.

Macrocyclic protease inhibitors with reduced peptide character

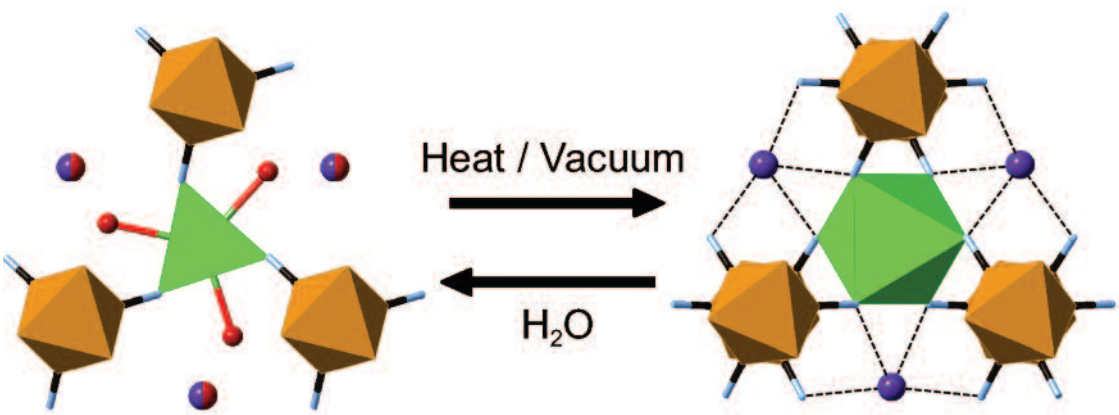
A β-strand provides the basis of many peptide–protein interactions, such as the binding of a peptide substrate to a protease. Consequently, an important approach to the design of protease inhibitors involves stabilising the β-strand conformation in a peptidomimetic, thereby reducing entropy loss associated with ligand–receptor binding. Suitably constructed peptide macrocycles can do this effectively, but these structures are not ideal in that they retain considerable peptide-like character and are therefore susceptible to metabolic degradation. Researchers at the Universities of Adelaide, Bonn and Cologne have developed a new class of macrocyclic protease inhibitor in which a backbone amino acid is replaced with a planar pyrrole (Chua K.C.H., Pietsch M., Zhang X., Hautmann S., Chan H.Y., Bruning J.B., Gütschow M., Abell A.D. *Angew. Chem. Int. Ed.* 2014, **53**, 7828–31). The structures have reduced peptide character, while retaining a backbone β-strand geometry to facilitate active site binding. The macrocycle links the P2 amino acid and N-terminus to leave the C-terminal P1 position free for incorporation of appropriate functionality for targeting a particular protease, an amino aldehyde in this first instance. Examples of this new class of peptidomimetic proved to be particularly potent against cathepsins L and S, with K_i values in the picomolar range. A crystal structure of one exemplary inhibitor bound to chymotrypsin confirmed the design features. Work is underway to extend these new peptidomimetics to other proteases and in other applications requiring a backbone β-strand geometry.





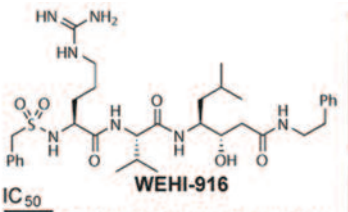
Anomalous structural mechanics

Materials that undergo low-energy structural deformations are of interest due to their anomalous thermomechanical and adsorptive properties. Researchers at the University of Sydney, the Australian Nuclear Science and Technology Organisation and the Advanced Photon Source have shown through a combination of variable-temperature X-ray and neutron diffraction, and guest adsorption/desorption measurements, that the framework materials $Ln^{III}M^{III}(CN)_6 \cdot nH_2O$ and $A^{I}Ln^{III}M^{II}(CN)_6 \cdot nH_2O$ (Ln = La–Lu, Y; M = Fe, Co; A = Li, Na, K; $0 \leq n \leq 5$) display a remarkably varied structural dependence on metal composition, ion inclusion, degree of hydration and temperature (Duyker S.G., Halder G.J., Southon P.D., Price D.J., Edwards A.J., Peterson V.K., Kepert C.J. *Chem. Sci.* 2014, **5**, 3449–56). In contrast to the highly rigid neutral $Ln^{III}M^{III}$ framework phases, members of the latter family undergo a dramatic transformation upon their dehydration, wherein the Ln coordination geometry reversibly converts from a 9-coordinate tri-capped trigonal prism to a 6-coordinate octahedron, accompanied by a large (14–16%) decrease in cell volume (see figure). The work demonstrates that modification of framework flexibility through chemical means influences both dynamic and static lattice effects, leading to fine control over anomalous thermal expansion and host–guest behaviours.

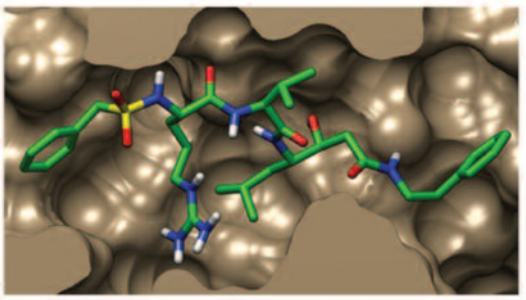


New compound blocks ‘gatekeeper’ enzyme to kill malaria

A research team led by Drs Brad Sleebs and Justin Boddey, at the Walter and Eliza Hall Institute, are homing in on a new target for malaria treatment, after discovering a compound, WEHI-916, that blocks the action of a key ‘gatekeeper’ protease essential for malaria parasite survival (Sleebs B.E., Boddey J.A. *PLoS Biol.* **12**, e1001897). The team has shown that WEHI-916 blocks the function of the aspartic protease plasmepsin V from *Plasmodium falciparum* and *P. vivax*, and prevents transport of effector proteins from the parasite to the host erythrocyte. They have demonstrated in a model system that *Plasmodium* parasites treated with WEHI-916 were unable to use the natural mechanism to evade the host immune system, and showed that WEHI-916 killed *P. falciparum* blood stage parasites as a direct result of blocking the function of plasmepsin V. These promising findings provide the foundation to develop a first-in-class antimalarial therapeutic with a novel mode of action.

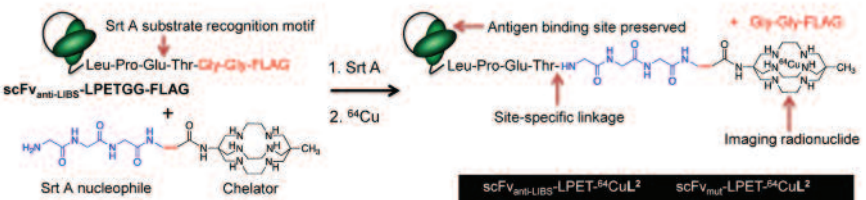


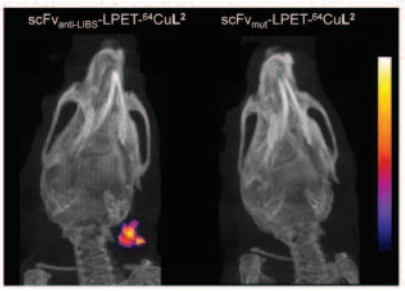
IC_{50}
19 nM *P. falciparum* plasmepsin V
24 nM *P. vivax* plasmepsin V
EC_{50}
2.5 μM *P. falciparum* parasite viability
>50 μM HepG2 cytotoxicity



Model of WEHI-916 bound to plasmepsin V

Enzyme-mediated radiolabelling

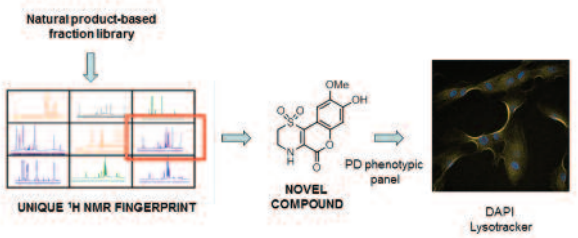




The incorporation of radioactive isotopes into antibodies can combine the diagnostic and therapeutic possibilities of nuclear medicine with the exquisite selectivity of antibody targeting. Metal radionuclides can be tethered to antibodies by adding ligands that coordinate to the metal ion and preclude its release in vivo. Attaching the chelator to the antibody or fragment requires careful consideration to avoid compromising the affinity of the antigen-binding site for the target. Drs Brett Paterson and Paul Donnelly from the School of Chemistry, University of Melbourne, in collaboration with colleagues at the Baker IDI Institute, used enzyme-mediated bioconjugation for the site-specific incorporation of a radioactive metal complex into an antibody that is selective for activated platelets (Paterson B.M., Alt K., Jeffery C.M., Price R.I., Jagdale S., Rigby S., Williams C.C., Peter K., Hagemeyer C.E., Donnelly P.S. *Angew. Chem. Int. Ed.* 2014, **53**, 6115–19). The new immunoconjugates were radiolabelled with the positron-emitting isotope ^{64}Cu and were used for diagnostic imaging of carotid artery thrombosis by positron emission tomography.

NMR fingerprints reveal novel natural products

Researchers from the Eskitis Institute for Drug Discovery, Griffith University, have reported an application of NMR fingerprints of a pre-fractionated natural product library. Their methodology allows a non-targeted interrogation of the drug-like natural product metabolome, which has the potential to simplify and accelerate isolation and identification of new natural products (Grkovic T., Pouwer R.H., Vial M.-L., Gambini L., Noël A., Hooper J.N.A., Wood S.A., Mellick G.D., Quinn R.J. *Angew. Chem. Int. Ed.* 2014, **53**, 6070–74). The approach was exemplified on an Australian marine sponge, *Iotrochota* sp., from which four new natural products and one novel compound, iotrochotazine A, were isolated. The authors also completed a total synthesis of iotrochotazine A and examined its biological activity profile. The novel compound was shown to have an effect on the morphology and cellular distribution of lysosomes and early endosomes in a cell model of Parkinson's disease, and may therefore be a useful tool for studying the molecular mechanisms underlying the disorder.



Compiled by **Matthew Piggott** MRACI CChem (matthew.piggott@uwa.edu.au). This section showcases the very best research carried out primarily in Australia. RACI members whose recent work has been published in high impact journals (e.g. *Nature*, *J. Am. Chem. Soc.*, *Angew. Chem. Int. Ed.*) are encouraged to contribute general summaries, of no more than 200 words, and an image to Matthew.

Erratum

In the August issue, the research 'Tetravinylethylene resurrected' was incorrectly referenced as Lindeboom E.J., Willis A.C., Paddon-Row M.N., Sherburn M.S. *Angew. Chem. In. Ed.* 2014, **55**, 5440–3. The research actually appears in volume 53 of that journal.

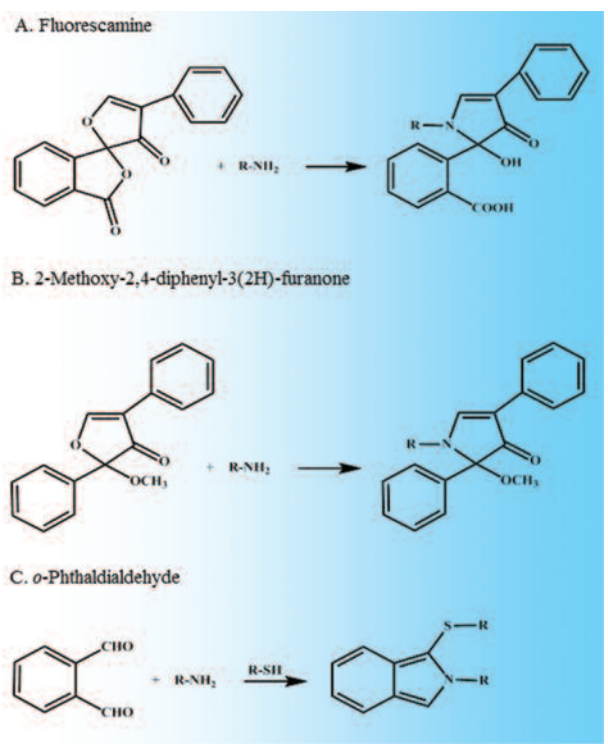
Aust J Chem

The October issue will contain a selection of papers authored by participants in the 4th Molecular Materials Meeting (M3) @Singapore, which was organised by Dr Yun Zong and Professor T.S. Andy Hor of the Institute of Materials Research and Engineering (IMRE), Agency for Science, Technology and Research (A*STAR), and the National University of Singapore, in January 2014.

The presentations at this M3 conference mainly focused on the themes of sustainable technology, energy and additive manufacturing, advanced materials technology, materials for health care and lifestyle, as well as food science and technology.

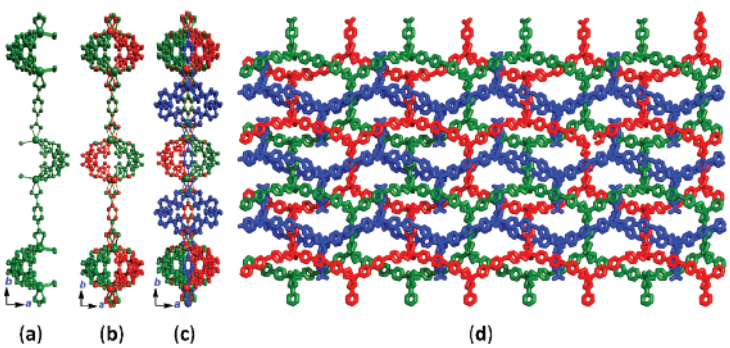
In the hot arena of 2D nanomaterials, Lay et al. (Aix-Marseille Université, France) highlight the rise of elemental 2D materials beyond the well-studied graphene. In the brief highlight, the authors introduce the topics from single-layer silicene to multilayer silicene, germanene and stanene/tinene, as well as phosphorene, which are all being hotly pursued in non-graphene 2D materials. These non-traditional 2D materials possess significant advantages over graphene-based materials in terms of easier materials transfer and integration. Some of them could be potentially used for quantum computing applications, thus promising a bright future.

In fluorescence-related research, Low, Han et al. (IMRE, Singapore) demonstrate a simple, fast and sensitive method for the quantification of albumin using non-fluorescent fluorescamine, which on reaction with primary amines form highly fluorescent products, which serve to detect albumin. The figure shows the formation of fluorophores from non-fluorescent fluorescamine, 2-methoxy-2,4-diphenyl-3(2*H*)-furanone and *o*-phthaldialdehyde.



Pan, Liu et al. (IMRE, Singapore) report photoluminescent chitosan with low cytotoxicity produced via the reaction of the amines with CO_2. The photoluminescence of this chitosan material is excitation wavelength dependent, whereby excitation with a longer wavelength leads to a red-shift of the emission wavelength. The low cytotoxicity of chitosan makes it a good candidate for fluorescent labels for bioimaging applications.

For CO_2 absoprtion, Chen (Southern Medical University, China), Zhang and Hor (IMRE) present a Cd-based coordination polymer containing three integrated polymeric components, which is porous and selectively adsorbs CO_2. This interpenetrated coordination polymer, based on 1,4-benzenedicarboxylic acid, 1-(4-carboxybenzyl)-4,4′-bibenzyl and Cd^{II} was constructed by two neutral and entangled 2D nets and one zwitterionic 1D chain with corner-sharing grids propagating along the *c* direction that lock the consecutive ligand struts of the nets. The polymer can be readily isolated by a simple mixing of ligands, indicating good thermodynamic stability of such an unusual interpenetrating motif. As stabilised by strong ligand π–π stacking, the interpenetrated polymer structure even remains if the larger and softer bromides are subsitituted with chlorides. The material is intended for use in the removal of CO_2 from fuel gas.



Framework structure looking along the c axis featuring: (a) an individual net with corrugations; or (b) interpenetrated nets with corrugations arranged in a face-to-face fashion; or (c) inclusion of 1D chain to complete a lantern-like shape. (d) Structure of the three-component 2D interpenetrated coordination network

The 5th M3@Singapore is tentatively scheduled for 3–5 August 2015 to coincide with the celebration of Singapore's 50th birthday as an independent state.

Curt Wentrup FAA, FRACI CChem (wentrup@uq.edu.au), http://researchers.uq.edu.au/researcher/3606

iStockphoto/bortonia

Teaching chemistry in Tanzania

BY **MALCOLM BUCHANAN**

A Scottish natural product chemist shares his experiences of academic life in one of the world's poorest countries.

Tanzania in East Africa has great natural beauty, but according to the UN Human Development Report (bit.ly/1y3ThmY), it is one of the world's poorest and least developed countries (152nd out of 186 countries). Health problems with HIV-AIDS, tuberculosis and malaria are significant and the country struggles with corruption (www.pccb.go.tz). Most Tanzanians are very religious people. An estimate of 30% Christian, 35% Muslim and 35% African traditional religions is usually given for the mainland, while Zanzibar is more than 99% Muslim (1.usa.gov/1nqGDbC).

No universities were founded during colonial times, but the first university, the University of Dar es Salaam, began in 1970 (although it was established in 1961 as an affiliate college of the University of London). In his Arusha Declaration of 1967 (bit.ly/UU9zlA), first Tanzanian president Julius Nyerere (1962–85) saw education as an important means to nurture Tanzanian identity and self-reliance.

St John's University of Tanzania (SJUT) was set up by the Anglican Church of Tanzania and was officially opened in 2007 in the political capital, Dodoma. At the time of writing, the university (English medium) has approximately 6000 students and has the vision 'to be a centre of excellence for developing humankind holistically to learn to serve'. Until now, the university has been focused on establishing teaching with little research output. This is something new for me, having been involved in research-based universities all my working life. In the Faculty of Natural and Applied Sciences, the main program is a three-year Bachelor of Science with Education.

I started working at SJUT in July 2011 and these are my personal reflections (those of a Scot living in Africa with his family) on some of the challenges and opportunities of working in the chemistry department.

Opportunities

At SJUT, I have become involved in research, teaching and administration, while working to develop in myself a model of excellence and integrity.

Teaching undergraduate experimental chemistry and building research capacity in institutions within developing countries involve formidable challenges. I co-authored an article on this topic, published last year in the *Journal of Chemical Education* (doi: 10.1021/ed3006105). In the paper, entitled 'Connecting resources for tertiary chemical education with scientists and students in developing countries', we also described the initiatives addressing the challenges in developing countries and suggested how concerned scientists in industrialised nations might become involved.

I obtained a small grant from the Royal Society of Chemistry Educational Initiatives Fund for the project 'Drugs, religion and chemistry in Tanzania: an interactive seminar for chemistry students'. The seminar responds to the difficulty facing most Tanzanian students with poorly equipped and maintained laboratories, and whose chemical education is strongly based on a Western construct – often having little relevance to their lives. Essentially, this seminar aims to teach the interconnectedness of Tanzanian culture (emphasising traditional medicine and religion), the fundamentals of the chemical sciences and relevant application of the

St John's University of Tanzania science laboratories

chemical sciences to help make the chemical sciences become real to Tanzanians. The relevant application here is natural product drug discovery to combat diseases prevalent in Tanzania (malaria is used as an example).

Final year undergraduate research projects in natural product chemistry are being conducted and these have been interesting to supervise. Resources are lacking, so typically this involves a traditional African medicine (TAM) survey followed by the collection, extraction and partial purification of a plant species. TAM is still foundational to African culture and generates great interest. A new area of interest for me has been the interactions between science, theology and culture.

A shortage of qualified teaching staff has given me the opportunity to teach, both standard undergraduate chemistry courses and two new courses – 'Natural Product Chemistry' and 'Science, Faith and Culture'. The former course adds extra interest because of the significance of traditional medicine in Tanzanian society. The latter endeavours to equip scientists with information supporting the harmony between faith in God and science and has been well received. This is not surprising considering that most Tanzanians remain very religious.

In an effort to model excellence and integrity in a country that still struggles with corruption and a shortage of honourable leaders (bit.ly/1saqZJe), I try to demonstrate a dedicated work ethic with the right balance between task and people. Taking time for people shows a respect and value of the person, which is important to them (and to their education). Relationship is just one cultural factor for which it is necessary to reflect on different views in Tanzania from the West and respond appropriately. Establishing healthy and safe practices in the laboratory has been important in emphasising the need for professionalism and to keep to international health and safety standards. Students have been told that staff are concerned for their general well-being, and staff are encouraged to adhere firmly to these practices.

Challenges

Tanzanians often struggle with English, which is at best their second language, but more commonly their third (or

Developing the students' ability to think and problem solve is challenging when rote learning is so much part of the educational upbringing.

more) language. It is humbling for me as I continue to struggle with Swahili as a second language. Government schools use Swahili in primary education and English in secondary, which may not help matters. This has made interpreting students' written work challenging and the students struggle to avoid plagiarism.

There is a strong expectancy that students must pass (and also get better grades). A lot of pressure is put on academic staff (to the extent that some may fall to corruption). It is important for students to understand they have to attain a certain performance standard; otherwise, education and society in Tanzania will suffer if people cannot perform in positions for which their degree qualifies them.

Developing the students' ability to think and problem solve is challenging when rote learning is so much part of the educational upbringing. However, there are a number of gifted Tanzanian students who can certainly think critically and ask thoughtful questions.

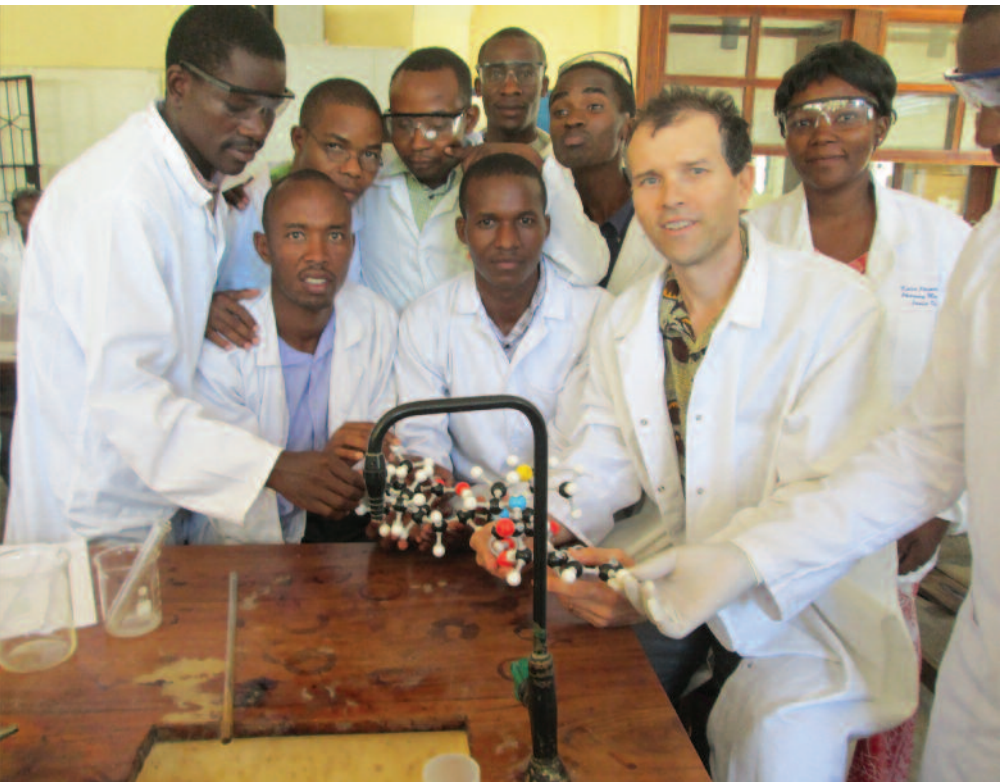
Students often have sad stories to tell of severe financial needs and difficult family situations. It is not unusual to hear about the death of a parent or even a child. There are emotional and psychological challenges in responding appropriately to these occasions. This happens not only for students, but also with staff and community members. On one occasion a woman from the surrounding village, with her baby on her back, came to my office asking for money to get medicine for her sick child.

At SJUT, many staff are currently undergoing postgraduate studies and there is a shortage of properly qualified teaching staff. The rapid growth of private and public universities has made it difficult to achieve a full complement of African teaching staff. This leaves the remaining staff overwhelmed by administrative and teaching responsibilities with little time to do research or write research proposals. Furthermore, PhD opportunities in Tanzania are very limited and there is the added challenge of the 'brain drain'.

Currently, SJUT survives only on student fees. A lot of problems are a result of the lack of funds and logistical issues. The science laboratories have minimal resources, but it is still possible to carry out some of the basic, yet essential, undergraduate experiments –such as aldol condensation by reaction of cinnamaldehyde with acetone, extraction of caffeine from tea leaves, and preparation of alum from scrap aluminium metal. Equipment repair and maintenance are challenges in the resource-limited set-up. The equipment is simple at SJUT and the few 'sophisticated' pieces of equipment are generally lying redundant because they need repair. Presently (to my knowledge) there is no functioning NMR spectrometer in the whole of East Africa for chemists to determine molecular structure.

Overcoming the challenges

When considering working at a developing country university such as SJUT, you need to examine your motivations. Is it for career advancement or perhaps something exciting to do for a period of time? A decision based on these reasons may lead to frustration and disappointment. More appropriate would be a willingness to serve the people, without desiring self-advancement. In my case, this would include a desire to go arm-in-arm with our developing country colleagues to support the



Malcolm Buchanan with some final year students in the chemistry laboratory

advancement of the chemical sciences in Tanzania and the progression of the university.

A lack of cross-cultural understanding and preparation can be detrimental to the most experienced academic. Cross-cultural awareness and sensitivity are very important. I am very thankful for the five-month full-time cross-cultural training we received from the Church Missionary Society – Australia (CMS-A: the organisation through which we are in Tanzania) before we left for Tanzania. This prepared us very well for the cross-cultural context we live in and for us to do more than just survive. The training has not removed the challenges, but because of it many of them have not come as a surprise and some acquired knowledge and skills were very useful. Examples are keeping expectations low, not being so task-focused, having an awareness of power outages and the presence of a basic infrastructure and beginning to understand the Tanzanian view of the world.

Learning the local language on arrival in Tanzania was greatly encouraged and has been invaluable for building friendships while enabling us to have a better understanding of what is going on around us. For almost five months when we first arrived in Tanzania, we studied Swahili full-time. Although the university is English medium, conversations outside the classroom are generally in Swahili. Knowing some Swahili is also useful in the classroom for some gentle humour and to support explaining a concept or worked example.

Having partnerships with Western academics who have an interest in supporting universities in the developing world is helpful to overcome the challenges, in particular, for encouragement, advice, working together on small manageable projects and providing viable resources. One partner raised the funds to help provide us with a water distillation unit – a critical piece of equipment in the chemistry laboratories, considering the hardness of the water in Dodoma.

Students sitting a chemistry test

To inspire more inquiry in the classroom I believe in allowing time for students to ask questions about the current lecture (even with large class sizes). This has worked well and I have received some very clever questions. It has helped me become more approachable as a lecturer. Traditionally, teachers are not really questioned in Tanzania, but this is changing.

The ability of developing countries to provide a sound tertiary chemical education is a key ingredient to the improvement of living standards and economic standards within these countries. A *Nature* editorial in November 2012 (doi: 10.1038/491159b) stressed the need for Western donors, non-governmental aid organisations and African governments alike to invest in post-secondary education in Africa. 'Science needs Africa as much as Africa needs science' and African talent needs to be developed to participate as a scientific peer. I fully concur with these statements, but would also add that investing in people skills is an admirable model to follow, but education needs to be contextualised for African culture living in global times, and that there is the need to develop academics and graduates who are excellent in their discipline and have integrity.

The challenges are daunting but, despite this, it is a privilege to be able to contribute to the well-being of the developing nation of Tanzania and serve its people.

Malcolm S. Buchanan is a natural product chemist and an associate professor within the Faculty of Natural and Applied Sciences at St John's University of Tanzania, Dodoma, Tanzania.

The ability of developing countries to provide a sound tertiary chemical education is a key ingredient to the improvement of living standards and economic standards within these countries.

World War I

A turning point for Australia's innovation system

BY **TOM SPURLING** AND **JOHN WEBB**

The tragedy that was World War I led to substantial transformations in the way innovation occurred in Australia.

The Australian Bureau of Statistics' *Year Book Australia, 1974* puts it quite succinctly: 'Prior to the 1914–18 war, Australian science was based largely on the individual achievements of a few outstanding scientists.' This was true of Australian science but gives an inadequate picture of the range of science, technology, engineering and innovation activities that characterised the Australian colonies before 1901 and the young nation between Federation and the end of World War I. Much of the country's scientific output concerned Australia's unique flora and fauna, astronomical observations, geological mapping and meteorology (Moyal, see Further reading).

By the end of the 19th century, Australia already had a good record of practical innovations directed to solving problems in agriculture, mineral exploration and extraction as well as animal husbandry. Innovators were often inspired, dedicated individuals such as the Peppin brothers, who developed through cross-breeding the Merino strain that flourished across semi-arid Australia; William Farrer, the Cambridge mathematics graduate who became the pioneer of scientific wheat breeding in Australia; and Lawrence Hargrave, the pioneering innovator of flight using cellular box kites. The stump-jump plough was invented in 1876 and the flotation process for the separation of minerals was patented by Melbourne brewer and chemist Charles Potter in 1901. As noted by physicist Alan Walsh in 1977, 'in terms of economic value, no Australian invention can have been of more importance to Australia than the flotation process for the separation of minerals' (*From stump-jump plough to interscan: a review of invention and innovation in Australia*, Australian Academy of Science, Canberra, 1977, p. 17).

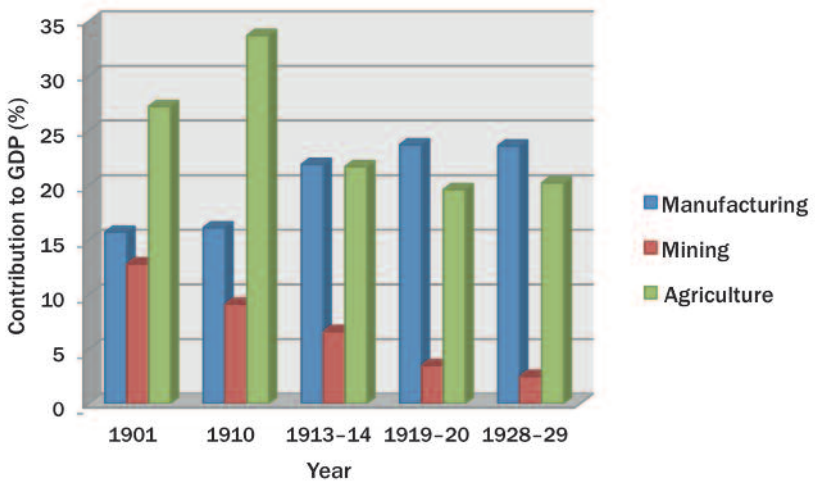
The stump-jump plough was invented by Richard Bowyer Smith to overcome the problem of cultivating South Australian mallee lands.
State Library of South Australia/Wikimedia Commons

As David Kilmartin discussed in a recent issue (June 2014, p. 16), as Australia approached nationhood, a defence science capability was developing with the appointment of Australia's first defence scientist Cecil Napier Hake. The strong mining and agricultural industries were fostering innovation not only in their own activities but also in associated manufacturing industries.

The 1974 Year Book's view on Australian science is confirmed by searching the Web of Science for papers published between 1900 and 1914 with 'Australia' in their address. This finds that there are 67 such papers with 590 citations between them. One of the Year Book's 'outstanding scientists' was W.H. Bragg at the University of Adelaide. Papers from his group have been cited 493 times, 84% of the total citation number. Bragg and his son W.L. Bragg were awarded the Nobel Prize for Physics 'for their services to the analysis of crystal structure by means of X-rays'. The most cited chemistry paper (with 13 citations) was by the 1907 Victorian Rhodes Scholar, A.C.D. Rivett, who had returned to the University of Melbourne in 1911 from studying at Oxford with N.V. Sidgwick and at the Nobel Institute in Stockholm with S. Arrhenius. Rivett was interested in understanding equilibria in heterogeneous systems.

The Web of Science does not capture the work of all the 'outstanding scientists' working in Australia before the 1914–18 war. The late 19th and early 20th centuries saw a burgeoning of State-based royal societies whose journals have not been abstracted by Thompson Reuters. David Collins has compiled a comprehensive list of papers in chemistry published by Australians (www.eoas.info/ciab.html). A total of 1936 papers were published, the first by A. Liversidge in 1882 on 'The Deniliquin or Barrata Meteorite' in

By the end of the 19th century, Australia already had a good record of practical innovations directed to solving problems in agriculture, mineral exploration and extraction as well as animal husbandry.



Changes in contributions to Australia's economy around World War I by key sectors

Data from: Haig B. New estimates of Australian GDP: 1861–1948/49, *Australian Economic History Review*, 2001, vol. 41, p. 1

the *Journal and Proceedings of the Royal Society of New South Wales*.

One of the papers in the Collins list is by C. Napier Hake, entitled '(1) Manufacture of 'Cordite'; (2) 'Lyddite' as a Bursting Charge for Shells: (3) Importance of Establishment of a 'Cordite' Factory in Australia, and its Bearing on Imperial Defence'. This paper was read to the Society of Chemical Industry of Victoria and published in *The Chemist and Druggist of Australasia* (1900, vol. 15, pp. 312–13) before the Society had its own journal.

Hake was appointed Chief Inspector of Explosives in Victoria in 1890 on the recommendation of the Chief Inspector of Explosives to Queen Victoria, Colonel Sir Vivian Majendie. He modernised the Explosives Branch and introduced innovations and protocols to improve the safety of explosives manufacture and handling.

Explosives were important in the economic development of Australia. They were used in mining and quarrying for the gold, coal and construction industries. Jones Scott & Co established a factory in Deer Park, Victoria, which began operations in May 1876. It became the leading producer of explosives in Australia, and was a major boost to the mining and quarrying industries. Having gone through many name changes and purchases, the company is a forebear of ICI Australia, now Orica.

The tragedy of World War I and the ANZAC campaign has tended to dominate perceptions of the political climate of the late 19th and early 20th centuries. It is worth noting that 2014 is not only the 100th anniversary of the start of World War I but is also the 110th anniversary of the start of the Russo-Japanese War and the 115th anniversary of the start of the Boer War.

It is also the 160th anniversary of the 'Russian war scare' of 1854. The Crimean War between Russia, the Ottoman Empire, France, Sardinia and Britain commenced in October 1853, with Britain and France entering the conflict in 1854. A Russian naval squadron made a Pacific cruise in 1854 and this raised considerable alarm in Victoria, with active steps being taken to protect Melbourne from sea attack. In August 1854, the British Government authorised raising volunteer forces in the Australian colonies and in the same year the Victorian Government undertook to meet the whole expense of maintaining the Imperial forces in Victoria. Various Russian warships visited Melbourne, Sydney and Brisbane over the next few decades and their visits aroused concern and sometimes panic in the colonies, including in the neighbouring colony of New Zealand.

It was during another Russian scare, that of 1885, that Major John Whitney, an officer in the colonial forces in New Zealand, saw the opportunity caused by the ammunition shortage in the colonies and formed a partnership with W.H. Hazard, a gunsmith from Auckland, to produce munitions. This partnership failed but in the same year Whitney set up a private company, Whitney and Sons, to manufacture ammunition in New Zealand. Initially, the quality of his product was not high, but he persisted and by the end of 1887 about two million rounds had been produced. In 1888, he was approached by the Minister for Defence for Victoria (Sir James Lorimer) to manufacture cartridges for the Victorian Government. His company, the Colonial Ammunition Company, set up a factory in Gordon Street, Footscray, for this purpose. The present location of DSTO in Melbourne is 506 Lorimer Street, a street named after Sir James.

Threats of war also raised the urgency of producing cordite for munitions. Cordite formulations were derived from the original (1889) UK patent of a mix of nitroglycerin, gun cotton and petroleum jelly, extruded as spaghetti-like rods. The Commonwealth Government planned to establish a cordite factory in Maribyrnong, now an inner western suburb of Melbourne, on a then disused racecourse. This factory brought to Australia a figure who was to greatly influence Australia's chemistry industry – Arthur Edgar Leighton, who was appointed in January 1909.

Leighton came to Australia from his appointment at the newly established (1904, and still in operation) explosives factory in Aravunkadu in the Nilgiris

Hills of southern India, being recruited while on leave in the UK by C. Napier Hake, the above-mentioned chief director of explosives for Victoria (*Australian Dictionary of Biography* 1986). Leighton's experience and expertise soon saw him back in Britain as a technical adviser on the manufacture of munitions to the British Government. He initiated a scheme that brought Australian chemists and engineers, technicians and tradesmen to Britain to work on munitions, an extensive cohort of expertise that would benefit Australia's own industrial development and innovation capabilities after the war. In Leighton's absence, Noel K.S. Brodribb, assistant manager, was in charge and eventually became manager of the Maribyrnong plant in early 1917 (*Australian Dictionary of Biography* 1993).

Returning to Australia in 1919, Leighton became chairman of the board of management of Commonwealth Government factories and instituted the Defence Research Laboratories. He remained a significant figure in the post-war development of Australian industry, with R.G. (Lord) Casey writing, on Leighton's retirement in 1950: '… you are the father of munitions production' (*Australian Dictionary of Biography* 1986). Leighton was deeply involved in the early association of chemists in Australia, the Australian Chemical Institute, serving eventually as its President and, in later years, writing a history of the Institute.

The changing make-up of the Australian economy around World War I is reflected in the changes in the contribution to the nation's GDP according to key sectors (see chart, p. 24).

It was not until the late 19th century that the direct association between economic development and the systematic application of scientific knowledge became a matter that concerned governments on the Australian continent. How the Colonial, Commonwealth and State Governments developed science and industry policy is well documented in the authoritative works of Currie and Graham, and of Schedvin (see Further reading).

The Commonwealth's direct interest commenced on 22 December 1915, when Prime Minister W.M. Hughes was invited to speak at a luncheon at the University of Melbourne on a scheme for national scientific research. Hughes was in good spirits, the day being when the last of the Australian soldiers were evacuated from Gallipoli. As Schedvin reports, he 'announced without prior planning or consultation that his government would support the "idea of the national laboratory" which would undertake major projects and co-ordinate scientific endeavour throughout the country.' An Advisory Council of Science and Industry was appointed in 1916, which recommended that an Institute of Science and Industry be established free from the provisions of the Public Service Act. After prolonged arguments between the Commonwealth and the States, the Science and Industry Bill was passed in 1920 and the Institute launched in 1921. The Institute had an appropriation grant of around £23 000 a year, which was not enough to fund significant new research projects.

National Library of Australia

Humphrey, T. Portrait of the Australian politician Billy Hughes (1862–1952) as a young man

Renewed public policy interest in the role of science for industry in Australia grew in the 1920s as the UK and the Dominions worked out new economic relations in the period of post-war economic uncertainty. As a consequence, in 1925 Prime Minister S.M. Bruce commenced a process to reform the Institute, and in May 1925 a conference of scientists, businessmen and politicians was convened to advise the Government how to reform publicly funded science. From this came the eventual creation of CSIRO, the national network of research laboratories.

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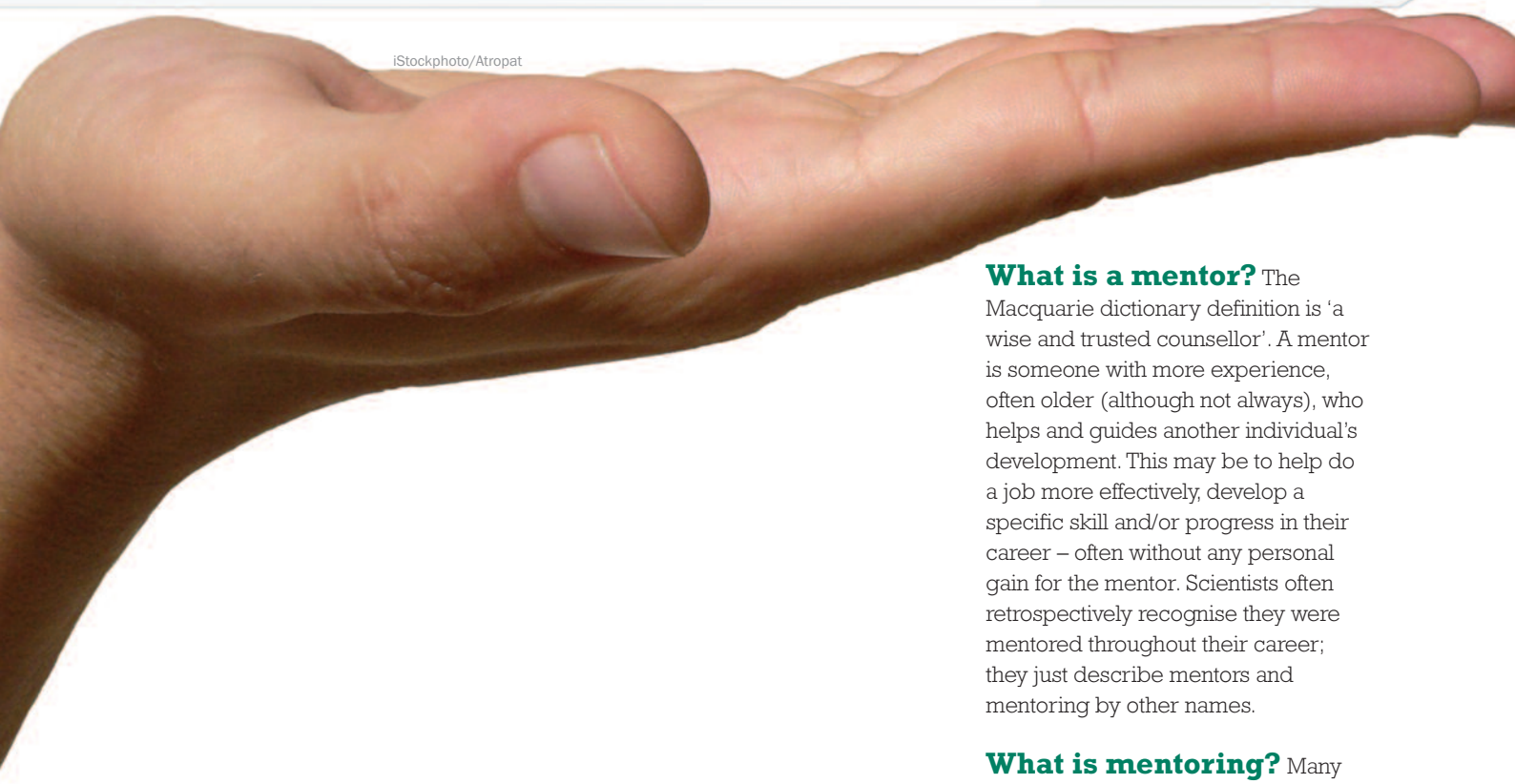
Further reading

Moyal A. *A bright and savage land: scientists in colonial Australia*, William Collins Pty Ltd, 1986, p. 169.

Currie G., Graham J. *The Origins of CSIRO: Science and the Commonwealth Government, 1901–1926*, Melbourne University Press, 1966.

Schedvin C.B. *Shaping science and industry. A history of Australia's Council for Scientific and Industrial Research, 1926–1949*, Allen and Unwin, Sydney, 1987.

The value of MENTORING



iStockphoto/Atropat

BY **MARGUERITE V. EVANS-GALEA** AND **CHARLES A. GALEA**

Trainees in science often express the need for 'a mentor'. What does this mean and what should mentees and mentors expect?

What is a mentor? The Macquarie dictionary definition is 'a wise and trusted counsellor'. A mentor is someone with more experience, often older (although not always), who helps and guides another individual's development. This may be to help do a job more effectively, develop a specific skill and/or progress in their career – often without any personal gain for the mentor. Scientists often retrospectively recognise they were mentored throughout their career; they just describe mentors and mentoring by other names.

What is mentoring? Many students, early career researchers and established investigators are not entirely sure what mentoring means – and expectations can vary. Mentoring continues throughout one's career, at every level. To mentor and be mentored is not only to pass on knowledge gained over a lifetime, but to also share wisdom from past mistakes and provide guidance for future decisions. In science, the benefits of mentoring are becoming more widely recognised and valued. The National Institutes of Health in the US recognises proficient mentors as part of their grant evaluation process and actively encourages the practice through Mentored K Awards. These

awards transition young investigators to independence under the mentorship of a senior investigator. The PhD and postdoctoral phase is one of ongoing education and training, with the ultimate goal of scientific independence. It is therefore essential that early career researchers identify one or more mentors early in their career and actively establish positive mentoring relationships.

Who should be your mentor? Early career researchers typically seek mentoring from people with more experience or different experiences. These can include senior investigators within their institution, particularly those who have won fellowships and/or grants. This may be their supervisor, but for a variety of reasons this is not always the case. Supervisors have an incentive to mentor their students, fellows and staff since they have invested in them, but they are also captive to their own experiences and can sometimes have a conflict of interest. This is why it is important to consider a mentor outside your institution, such as investigators with whom you have served on committees or met at conferences. Developing a good rapport with a mentor is a plus, particularly for an ongoing mentoring relationship, but this is not always essential. Occasional mentorship from a 'straight-talking' individual who doesn't know you well can provide advice with reduced risk of bias; however, they may not fully appreciate your situation.

Women in science sometimes feel they 'should' be mentored by another woman; however, all scientists are well-placed to mentor women (and men!). Diversity within the ranks of senior faculty will benefit everyone and contribute to a productive mentoring and research environment. With fewer women scientists in senior positions, however, it is essential women be willing to engage with mentors of both genders. In the US, Women in Biomedical Careers sponsors national workshops on mentoring women in biomedical careers and best practices for sustaining career success. Several leading scientific bodies in Australia also recognise the need to support women in science more effectively, including effective mentoring for women scientists. The National Health and Medical Research Council and the Australian Academy of Science have publicly endorsed such initiatives in the last two years.

A mentor we all have, but don't always realise we have, is the peer mentor. These are friends and colleagues at the same stage of their career and lives as you. Peers can bounce ideas, share their experiences and advice they have received and, importantly, celebrate your successes!

What are the qualities of a good mentor? Words describing a good mentor include respectful, honest, positive, enthusiastic, experienced, optimistic, realistic, encouraging, strategic, supportive, sensitive and 'human'. In an informal survey by the authors of more than 150 postdoctoral fellows in the Parkville Precinct (Melbourne), the number one word associated with good mentoring was *respect*. Mentees want to feel respected both in a personal and in a professional sense. This was especially important to more reserved individuals and those from a different cultural background or who identified strongly with a minority group. The second most common word was *empowering*. One fellow said 'I want a mentor who helps me to help myself.' A good mentor will want to see you progress in your career and will enjoy seeing you fulfil your goals and succeed in the future.

How do you find a mentor? Mentoring is often informal, subtle and non-exclusive and is easier to get if you are engaged in a range of activities such as committees and social events. It is important to talk to your colleagues – who mentors them? How did they meet? Who do they recommend? Word of mouth is a powerful thing!

Before seeking a mentor, it is important to self-evaluate – ascertain

Dos and don'ts of mentoring

- ✓ Expect honest guidance and advice that aims to improve your chances for success!
- ✓ Expect 'constructive criticism' – hard to hear, but good to listen to!
- ✓ Be flexible – mentoring needs ebb and flow. You will have challenging periods with frequent questions/advice and others where you just need to 'touch base'.
- ✓ Give people a go – not everyone 'clicks' at the first meeting, but over time, positive and beneficial mentoring relationships can be nurtured.
- ✓ Have more than one mentor.

- ✗ Don't be afraid to ask questions.
- ✗ Don't expect your mentor to tell you what to do – they guide and advise, but it is ultimately your decision.
- ✗ Don't expect your mentor to make your career 'happen' for you – only you can.
- ✗ Don't expect to hear only good things about yourself.
- ✗ Don't forget – like you, mentors are busy people with professional and private lives of their own. Don't cancel meetings at the last minute or take it for granted.
- ✗ Don't expect your mentor to be your best friend, available 24-7 – this is a professional relationship. There are boundaries.

Developing a good rapport with a mentor is a plus, particularly for an ongoing mentoring relationship, but this is not always essential.

Speaking from experience

Mentor reflections

Learning a bit about students as 'people' (their personal and professional situation without overstepping boundaries) is a good basis for ongoing discussions. It is important for me to provide positive feedback and constructive criticism without passing judgement. Since it is easy to forget what it was like being a student, I try to put myself in their shoes. Sharing my own experiences and mistakes can reassure mentees that they are not alone, but it isn't always helpful to their situation, since everyone's experiences and circumstances are different. With this in mind, I discuss the options, the pros and cons, but always state 'It is up to you'. Logistically speaking, I check if a mentee requires a confidential meeting, since this is best done in a more formal setting. If a mentee seems to be struggling with their physical or mental health – I encourage them to seek support and point them in the right direction, especially if it is something beyond my capabilities or expertise. (MVEG)

I enjoy passing on the knowledge and experience I have gained during my career to students and peers. It is important to understand that everyone is different and their needs and expectations will vary. When mentoring students, I have found it best to first discuss their expectations, future career aspirations and past experience. Mentoring can vary greatly and may involve providing technical advice (e.g. problem solving, experimental design, data interpretation, presentations, scientific writing) or advising about career options (e.g. choosing the best lab to do a postdoctoral fellowship in and future career goals). I have invariably been asked for advice about a more personal issue (e.g. problems with other lab members or a supervisor). This can be delicate and if I advise I try to remember to consider the other person's perspective and always be positive (often the situation is not as bad as it seems). Science is tough and researchers at all career stages can sometimes feel a bit 'blue'. This is when I have found my advice as a mentor to be truly appreciated. After carefully listening to a mentee's concerns, if I am unable to advise, I recommend others who are qualified to assist. It is up to the mentee to decide whether they wish to take my advice (and I am not offended if they don't!). (CAG)

Mentee reflections

The truth can sometimes be difficult to take; however, we must remember it is 'constructive criticism'. Your mentor wants to help you, particularly if they will not benefit at all should you take action on their advice. No matter the mentor, I aim to be open to constructive criticism. I believe there is something I can learn from everyone. Committee service has allowed me to develop a 'mentoring team'. Some mentors I meet regularly (e.g. each month), others less often – and one only when I need the 'hard word'. Peer mentoring is some of the most valuable mentoring I have received to date, especially with juggling family and career responsibilities. I haven't always taken advice and some mentors can actually give very poor advice. Getting involved in non-research activities such as fund-raising, policy development and science communication has exposed me to talented professionals who openly share their advice and skills – mentoring by osmosis! All of which has directly benefited my research career. I maintain a healthy work–life balance, but most importantly, I have a dream. (MVEG)

I have had a number of supervisors who have provided invaluable advice and support at different times in my career. I have come to appreciate their candour and the advantages of looking at issues from a different perspective. However, I have sometimes been surprised by the lack of gender and ethnic diversity within senior faculty in universities and research institutions, especially within Australia. For this reason it can be difficult to find a mentor who fully understands the issues faced by those of a different gender or ethnic background. For example, assertive women can sometimes be considered 'aggressive', while people from a conservative culture, a different ethnic background or overseas, can sometimes be criticised for lacking assertiveness if they do not openly question things or fail to share their opinions unless specifically asked to. I have always valued an intuitive mentor who is sensitive to such issues. (CAG)

the areas in which you require mentoring. Critically examine your current situation and be pragmatic about your strengths and weaknesses. Needs differ between individuals, but may include public speaking, scientific writing, negotiating skills, teaching, grant-writing, priority setting, communicating your research, strategic planning or determining what you need to achieve to be competitive in the next stage of your career. Developing professional networking skills is essential. If you are seeking a mentor in a particular field or career, then aim to meet people who are already where you want to be – attend symposia, seminars, conferences and networking events.

Some organisations have formal mentoring programs. Such programs are often under-utilised and under-valued. Yet they are an excellent avenue to mentors who are prepared to devote time and energy in facilitating the professional development of those around them. A mentoring program is particularly useful if you are shy, lack confidence, have moved interstate/internationally or simply do not know where to begin.

Once you have a mentor – what then? Finding a mentor is not that difficult, but after the initial connection, it can sometimes feel a bit 'awkward' – especially if the mentor is someone you do not know well or see often. As for any relationship, maintaining a healthy mentoring relationship takes time and effort. Boundaries and expectations are best discussed at the first meeting, such as where and how often you will meet, whether you are both comfortable with a formal/informal setting or a mix of both. 'Doing coffee' provides a relaxed setting, but is not always suitable for difficult or confidential conversations. Using technology can work well (email, text and/or social media), but only if your mentor welcomes this interaction.

What can you do to make the most of mentoring?

Mentoring is not a one-way street. You have to give as much as you hope to receive – if not more. Maintain an individual development plan that involves honest self-assessment and goal setting. Use this as the basis for discussion with your mentor. Describe your career aspirations and devise a strategy to attain your professional goals. Expect the unexpected – major decisions may need to be made quickly and a positive 'can do' attitude will help. As scientists, we are trained to think critically and be sceptical in our research. This should not equate to cynicism or negativity in all we do or say! Be proactive and harness your initiative. It is *your* career – take it where you want it to go!

What is the difference between mentoring and sponsorship? Sometimes senior investigators will refer to a long-term mentor who has provided invaluable advice at every career transition, helped them meet the right people at the right time, put their names forward for conferences – someone who advocated and promoted their talent both within their organisation and more broadly. This is 'sponsorship' and it has proven successful in advancing the careers of women in the corporate sector and in medicine. While every 'sponsor' is a mentor; not every mentor can/will sponsor every mentee – and it should not be expected.

How can organisations facilitate mentoring?

Quality mentoring is central to the support and training of a diverse, well-educated scientific workforce. The culture of any research organisation impacts on the morale of its students and staff. Dr Jennifer de Vries (www.jendevries.com) argues that viewing mentoring through a 'bifocal lens' (where organisational culture inherently fosters the professional development of its staff) increases productivity and yields a better return on investment. The NIH has developed mentoring guidelines and the Howard Hughes Medical Institute supported the Entering Mentoring seminar developed by the University of Wisconsin-Madison, US. All group leaders attend this as part of their introduction to scientific teaching, and it is widely shared. Training investigators to mentor minority groups has also been recommended (Jeste et al. *Am. J. Public Health* 2009). In Australia, Monash University has a successful Alumni–Student Mentoring Program while the Murdoch Childrens Research Institute encourages informal, 'organic' interactions through annual poster symposia, regular seminars and social events.

Is mentoring worth it? The inherent value of mentoring becomes clear when as individuals and as organisations, we place both ourselves and our emerging scientific leaders in the best position to thrive and excel in education, research and innovation, to benefit Australia's future health and economy.

Marguerite V. Evans-Galea is an investigator at the Bruce Lefroy Centre for Genetic Health Research, Murdoch Childrens Research Institute, Victoria, and is the Founding Chair, Australian Early-Mid Career Researcher Forum, Australian Academy of Science, and Co-Founder, Women in Science Australia. **Charles A. Galea** is a researcher at the Monash Institute of Pharmaceutical Sciences, Monash University, Victoria.

Leone Spiccia receives Helmholtz International Fellow Award

Professor Leone Spiccia FRACI CChem from the School of Chemistry at Monash University was recently awarded the Helmholtz International Fellow Award. He is one of only eight scientists globally to receive this prestigious fellowship.

The fellowships are awarded by the Helmholtz Association, one of Germany's largest scientific organisations, with almost 36 000 employees and an annual budget of approximately €3.8 billion.

The Association, which carries out top-level research to identify and explore the major challenges facing society, science and the economy, launched the prestigious awards to recognise excellent research and facilitate international research collaborations.

Each fellow is invited to conduct research at one or more Helmholtz Centres in Germany. Professor Spiccia said he was delighted to be selected for such a prestigious fellowship.

'It is a tremendous honour to be chosen for such an award, and I was ecstatic to receive the news. I plan to use the generous support to return to Germany next year to continue working on two major research projects,' Professor Spiccia said.

'I've seen first hand the excellent research facilities and equipment on offer at the Helmhotz Centres. They are among the best in the world so I have no doubt this will enhance the quality of our research and greatly accelerate our progress.'

Professor Spiccia, who was the only chemist to receive the award this year, will spend four months next year collaborating with colleagues at the Helmholtz-Zentrum Berlin (HZB) and the Helmholtz-Zentrum Dresden-Rossendorf (HZDR).

The first project will see Professor Spiccia conduct research on novel materials capable of efficiently converting sunlight into energy in collaboration with Professor Emad Aziz, Professor Klaus Lips and Dr Alexander Schnegg at HZB, while in the second area he will work on novel nanomaterials for cancer diagnosis and therapy together with Dr Holger Stephan and Professor Jörg Steinbach at HZDR.

A chemist with over 30 years experience, Professor Spiccia combines chemistry with aspects of biology, biochemistry, medical science, nanomaterials science and engineering, environmental science, earth science and physics in research that covers a range of fundamental, applied and commercial projects.

Professor Spiccia has received a number of accolades for his work in recent years including the RACI Inorganic Division Burrows Award in 2013, the RACI H.G. Smith Medal in 2012 and an Alexander von Humboldt Research Award in 2010.

MONASH UNIVERSITY

Milton Hearn receives ACS Award in Chromatography

Credit: Steve Morton

Professor Milton Hearn FRACI CChem has been awarded the 2015 American Chemical Society Award in Chromatography.

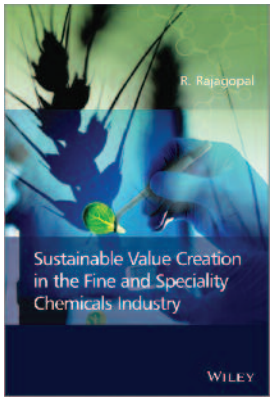
Professor Hearn, Associate Director (Industry) of Monash University's Green Chemical Futures and lead scientist of the Victorian Centre for Sustainable Chemical Manufacturing, received the award in recognition of his outstanding contributions to the fields of chromatography and related sciences.

Professor Hearn has authored more than 600 original scientific papers and has made many other contributions to the chemical and biotechnology industry and the public within Australia and overseas, for which he has received a Centennial Medal of the Commonwealth of Australia and inter alia the American Chemical Society Green Chemistry Institute's Distinguished Lecturer Award (2013). Professor Hearn has previously received RACI's Leighton Memorial Medal, the Green Chemistry Challenge Medal, the R.K. Murphy Medal, the Analytical Chemistry Medal, the Applied Research Medal and the H.G. Smith Medal, and an Alexander von Humboldt Forschungspreis and numerous other national and international medals and awards for his pioneering work at the forefront of the separation sciences, analytical chemistry and biotechnology.

Most recently, Professor Hearn and his team, formerly at the University's Centre for Green Chemistry, developed a new process to extract natural products, such as polyphenols and phytosterols, from plant waste rather than manufacturing them from a petrochemical base. These products are increasingly being used as nutraceutical ingredients in a number of processed foods, and in pharmaceutical and cosmetic products, because of their potential anti-ageing and health-promoting effects. Professor Hearn said the new extraction process adds value to what is otherwise agricultural waste.

The 2015 American Chemical Society Award in Chromatography award, sponsored by Sigma-Aldrich/Supelco, will be presented to Professor Hearn at the Society's National Meeting in Denver, Colorado, on 24 March 2015.

MONASH UNIVERSITY



Sustainable value creation in the fine and specialty chemicals industry

Rajagopal R., Wiley, 2014, hard cover, 312 pp., ISBN 9781118539675, $189.95

Global 'mega trends', including climate change, urbanisation, food security and technological convergence, are exerting varying degrees of influence on the fine and specialty chemicals industry. Increasing energy and raw material costs, resource squeeze, regulatory pressures, shrinking margins and customer preference for safer, less environmentally harmful products are also shaping the contemporary sector landscape. The imperative for sustained and resilient value creation in the fine and specialty chemical (F&SC) industry is rapidly established in the initial few pages of R. Rajagopal's *Sustainable value creation in the fine and specialty chemicals industry*.

To counter various structural, market and technology inhibitors, businesses in the F&SC sector devised and deployed a range of measures, including strategic alliances, mergers and acquisitions, divestments ('spin offs'), cost and product rationalisation, leveraging emerging technologies (e.g. in biotech, catalysis, micro reactors), exploring renewable feedstocks, and greater, more innovative R&D. Rajagopal anticipates that such approaches will continue to play out over the following years as F&SC companies seek to diversify their product and services portfolios and sustain value. Rajagopal intersperses the text with many pertinent examples of where and how high-profile F&SC companies have adopted such tactics to blunt market volatilities or accelerate access to markets but ultimately help create a more sustainable business.

In this initial chapter, Rajagopal also sketches out some of the F&SC sector's broad features, including global sales, number of segments (e.g. surfactants, lubricants, coatings), geographic distribution, market trends and company profiles and capabilities. The sector's evolution, particularly since the 1980s, is also outlined. Where large, multifaceted companies dominated, niche players now generate growth with focused portfolios. As Western markets matured and slowed, the F&SC sectors migrated pointedly east for growth. Most F&SC companies with high brand recognition are now well represented in Eastern economies.

In Chapter 2, Rajagopal expands on the F&SC industry's evolution towards more sustainable practices, emphasising the ongoing need for more uniform and robust (audit) standards for Western companies that build manufacturing capacity in developing economies with below-par infrastructure and compliance arrangements. Rajagopal's Figure 2.1 (p. 31) neatly captures key elements of the sector's sustainability journey, from cleaner production (e.g. low-waste processes) to more genuine sustainable practices (e.g. resource management). Why and how the F&SC sectors adopted these elements is again illustrated via the experiences of prominent chemical companies. Elements covered include green chemistry, sustainable value creation tools, regulatory regime (e.g. REACH*), supply chain management, tools/metrics (e.g. life cycle analysis), innovation (e.g. renewable feedstocks) and technology. Rajagopal also provides some hints as to how such elements may play out in the sector's future.

Rajagopal's focus in Chapter 3 is green chemistry and technology (GCT). Again, he provides some historical context as it applies to the F&SC sector and argues that GCT will be at the heart of a sustainable business model. Figure 3.2 (p. 61) encapsulates key GCT (operational) components elaborated by the author throughout this chapter. Process design (e.g. synthetic redesign), intensification (e.g. membrane reactors), reaction media (e.g. supercritical fluids) and enabling technologies (e.g. nanotechnology) are among many featured components. Once more, Rajagopal selects either familiar F&SC companies or their products to demonstrate the sustainability advantages of GCT. Pfizer's redesign of sertraline synthesis to a single-step process, dispensing with hazardous solvents (e.g. THF) and reducing energy and raw material use is one notable example. Another commercially noteworthy example is Merck's manufacture (via biocatalysis) of the statin Simvastatin. Again, toxic and hazardous reagents were eliminated (benefiting process safety) and fewer steps enhanced efficiency.

Chapter 4, though brief, is devoted to strategies for optimising resource use; that is, approaches to optimise the 'value' (e.g. through transformation, transfer) of raw materials, energy, water, mass and heat, among others. While the focus is on waste prevention, the F&SC industry is still characterised by methods to recover and reclaim by-products, most notably solvents. Rajagopal highlights a number of these techniques, particularly for water. He also includes some interesting examples of how wastes (e.g. food and agri residues) can be extracted or converted to commercially viable products.

Chapter 5 concerns the F&SC sector's foray into and experiences with bio-based materials, largely as a result of technological advances (e.g. biotech, molecular engineering), better biorefinery models and greater recognition of the real and considerable negative economic, social and environmental consequences caused by climate change, environmental degradation and depletion of natural resources. More and more F&SC companies have come to appreciate the potential for sustainable value creation bio-based materials offer, their renewable nature and vast raw input base being the most obvious advantages. Traditional 'petrochemical' businesses and other, newer ventures continue to make meaningful investments in bio-based industry. Typical approaches include product substitution (like for like), adopting strategic alliances and investing in specialised technology platforms (e.g. synthetic

*See D. Blackwell's review of *REACH compliance: the great challenge for globally acting enterprises*, April issue, p. 30.

biology). Rajagopal nominates a variety of chemical precursor 'poster children', such as the acids succinic, acrylic and adipic to illustrate how F&SC companies are developing biosynthetic pathways to supersede, compliment or replace conventional petrochemical routes. He also provides a number of interesting examples of promising (in sustainability terms) F&SCs from (bio)sector categories, such as biosurfactants, bioadhesives and biopoloymers.

While bio-based industry shows great promise for F&SC companies, Rajagopal is quick to identify and articulate a myriad of challenges that confront a sector in its infancy. Competition from a well-established, scaled and globally integrated petrochemical sector with mature and proven technologies remains dominant. Other notable challenges include feedstock security (the 'food versus fuel versus feed' dilemma), quality and consistency, nascent government policies and incentives, scale-up, market acceptance (and preparedness to pay a premium for bio-based products) and access to capital. Rajagopal rounds out this chapter by outlining what he feels are the critical issues that need to be overcome to help bio-based industry flourish.

Chapter 6 delves more deeply into the nature of sustainability practices of sector categories, including crop protection, pharmaceuticals, oleochemicals and surfactants, personal and cosmetic care, coatings, adhesives, lubricants and colourants. Historical context is given, drivers for change, trends and emerging issues.

By Chapter 7 Rajagopal has come full circle, again posing the question 'Why sustainable value creation?' To some extent, this chapter is a little redundant, as the case for and methods of pursuing sustainable value creation have already been well prosecuted during previous chapters. Admittedly, there is some new or expanded material (e.g. innovation, human capital, consumer power) so don't skip over this chapter entirely.

In many ways *Sustainable value creation in the fine and specialty chemicals industry* describes business strategies, measures, tools and techniques that any generic company may apply to create and sustain long-term value and business prosperity. For Rajagopal, commercial longevity for F&SC companies demands vibrant R&D programs, innovation in all aspects of business, social and ethical responsibility and behaviour, resource optimisation, safer processes, high performance and more benign products. Anyone with a professional interest in sustainable value creation in the chemical industry should enjoy this book. For those within the F&SC sector keen for sustainability guidance, the text is laced with a heavy dose of valuable references (though I never did discover a reference to Brussels sprouts, a leaf of which is featured on the cover page). It also performs quite well as a demonstration of the F&SC industry's evolution, capabilities, priorities and pursuit of sustained value creation.

Damien Blackwell MRACI CChem

John Wiley & Sons books are now available to RACI members at a 20% discount. Log in to the members area of the RACI website, register on the Wiley Landing Page, in the Members Benefits area, search and buy. Your 20% discount will be applied to your purchase at the end of the process.

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Remember November, our non-chemist issue!

The November issue will be free online. So pass on your weblink when it arrives by email, for colleagues, friends and family to enjoy.

Non-formal education: scouting, schooling and teacher training

At a recent camp, primary-school-age Scouts were cooking just one piece of bacon on the part of the pan that was directly over the stove flame. Since that procedure would be too slow to cook breakfast for 16 campers, this led to a discussion of the conduction of heat throughout a metal pan, as well as conduction and radiation of heat through thin pieces of bacon. The happy ending was that multiple pieces of bacon were cooked simultaneously, in several layers, using the entire pan, and all got a hot breakfast quickly.

In another example, participants on a caving trip discussed the dissolution of calcium carbonate, and the change in concentration as water evaporated, leading to saturation, precipitation and the formation of stalactites and stalagmites. There are many other examples of science and chemistry education in this non-formal educational setting. The use of GPS units for geocaching is a de facto lesson on Cartesian coordinates. Lighting campfires is an opportunity to learn about the three essential features for combustion: fuel, air (oxidant) and heat. The use of a hillbilly hot water service illustrates convection, as hotter water rises to the outlet at the top of the system. Setting the guy ropes on a tent is an application of rope tension and force vectors.

The Scouting Movement is a non-formal educational organisation, which is defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as having organised educational activity outside the established formal system, that is intended to deliver a defined set of learning objectives to an identifiable group of learners. Although the Movement seeks primarily to train youth to be better citizens, the above examples illustrate why more than half of American Scouts believe that scouting has improved their performance in science, reading and mathematics. Scouting is an established part of the curriculum or co-curriculum in many countries in Asia, the Pacific and Africa. In Canada, the Schools and Scouting Program continues to complement curriculum requirements in science, physical education, fine arts, social studies and environmental and outdoor education.

The Catholic Regional College Sydenham in the western suburbs of Melbourne hosts a Venturer Scout Unit for 14–17 year olds. The Venturers can even use their normal Scouting activities to complete the requirements of a Vocational Education and Training (VET) Certificate II in Business, which can count directly towards the year 12 Victorian Certificate of Education (VCE) and the Victorian Certificate of Applied Learning (VCAL). With additional work, Venturers can also complete Certificate II in Outdoor Recreation.

Hazel Glen College is a new P–12 government school as part of the Doreen South Education Precinct located at Doreen, 30 kilometres north of Melbourne. The Precinct will also include a P–12 Catholic College and an Early Learning Centre, and when at

full capacity will cater for up to 4300 students. The primary school opened in early 2014, and the secondary school is currently under construction and will open in 2015. A new Scout Multipurpose Facility is being built within the College with joint funding from Scouts Victoria and the Victorian Department of Transport Planning and Local Infrastructure (DTPLI) through a Growth Area Infrastructure Grant, auspiced by DTPLI on behalf of Whittlesea City Council. The Victorian Department of Education and Early Childhood Development are providing the land. Scouts Victoria will manage the Facility, which will be used for school and community purposes during the day, including out-of-school-hours care, and as a purpose-built scout hall in the evenings. The Facility will be available for scout and community use over the weekends and school holiday periods.

Scouting can also help train future teachers. Adult volunteer scouting leaders plan and run a mixture of recreational and educational activities for youth, interact with parents, and manage budgets and resources, all skills that future teachers need to acquire. In the Quality Teacher Program, a new program started by Scouts Victoria with the support of the state government, education students become scout leaders. In addition to their teaching specialties, these teachers of the future would gain additional qualifications and experience, valued by the education sector. Budding early-childhood and primary teachers would work with 6–10-year-old Joey Scouts or Cub Scouts. Secondary teachers would work with 10–17-year-old Scouts or Venturer Scouts. Venturer-leader teachers would be planning and delivering accredited VCE and VCAL learning for at least 80 hours per year as part of the scouting program, in addition to their scheduled teaching rounds in schools.

Education is not confined to a school, TAFE or university classroom; learning occurs all around us, in a variety of educational settings. Educators and future teachers must be prepared to recognise and utilise opportunities as they arise.

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A growing industry that could use some chemistry

Chemists are often confused by the common usage of terms such as 'chemical free' and 'organic'. For example, when my shampoo bottle is labelled as 'chemical free', I often wonder if it is a miraculous bottle housing a perfect vacuum. Similarly, the adjective 'organic' in organic agriculture does not mean that a farmer can use any matter with carbon atoms as a chemist might presuppose. The term 'organic' is ironically used, among other things, to denote the absence of certain organic molecules such as herbicides, insecticides and fungicides.

The molecules that are not used in organic agriculture also happen to represent some of the greatest innovations in chemistry, including the Haber process for the production of ammonia, which allowed the development of modern fertilisers, Gerhard Schrader's invention of organophosphates as insecticides, John Franz's synthesis of glyphosate, and many others.

Modern intensive or industrial agriculture is characterised by the high use of inputs such as capital and energy and the heavy use of pesticides and chemical fertilisers relative to land area. This is in contrast to traditional agriculture in which the inputs per unit of land are much lower. Modern organic agriculture differs from both intensive and traditional agriculture in that it promotes techniques such as crop rotation, bio-fertilisers, green manure, compost and biological pest control. Generally speaking, the use of any synthesised chemicals is not permitted in organic agriculture. Indeed, many other inputs are banned, such as antibiotics, genetically modified organisms, human sewage and synthetic nanomaterials.

The bias in most organic agriculture systems is to revert to inputs that were familiar in the traditional and pre-industrial era. The strict control of inputs is based on the principle that even trace amounts of synthetic chemicals or biochemicals that are used in intensive agriculture could end up in humans after consumption of the food products. Further, it is considered that the human body is so complex that it is virtually impossible to prove that any unnatural additive, even at trace levels, is harmless. There are plenty of examples where chemicals once thought to be harmless to humans are now banned, based on experimental or statistical evidence of harm.

Despite the reversion to pre-industrial inputs, modern organic agriculture is far more advanced than pre-industrial traditional agriculture. This is because modern organic agriculture is based on the scientific development of agriculture methods that enhance biodiversity, biological cycles and soil biological activity through the use of technology and farm management processes that were unknown to our farming ancestors.

The primary sciences behind organic agriculture are quite diverse and include plant propagation, organic crop production, the structure and improvement of soils, nutrient and water supply technologies, organic crop pest and pathogen

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… although the great agricultural inventions of chemistry are shunned in organic agriculture, this industry still needs chemistry in its quest for continual improvements.

management, crop science and crop physiology. But behind all these practices there lurks chemistry! So although the great agricultural inventions of chemistry are shunned in organic agriculture, this industry still needs chemistry in its quest for continual improvements.

Reviews have shown that organic farming has yields of 50–100% of those typical for intensive farming, depending on the crop and location. Relative costs are also higher but will drop as yields improve and also as energy costs continue to impact upon intensive agriculture. In addition, the upside for organic agriculture is that it is also more environmentally friendly than intensive agriculture. The general consensus is that improved soil inputs, new breeding research, and producing varieties and breeds better adapted to the unique conditions of local organic systems, and more scientific organic agriculture practices will continue to enable significant increases in yields and reductions in costs. This optimism is based on the relative lack of research and development in this area, which suggests that the current organic yields and costs are far from their full potential.

Another way of looking at this opportunity is that organic agriculture is, when viewed through a technology lens, at its infancy. For some crops the yields and costs of organic farming are almost at parity with intensive farming without the benefit of more than 100 years of scientific and technological research and development. This would imply that there are substantial opportunities for researchers in this area and that, as in all new industries, now is the time to seek research breakthroughs in organic agriculture that will have greatest impact. By comparison, research into intensive agriculture is well along the Pareto curve (a probability distribution curve) and the returns on research efforts will probably be less lucrative.

In Australia, organic agriculture is already a $655 million industry, growing at around 12% per year, and will be a $1 billion industry by 2018. Organic produce also has emerged for the first time as a significant export earner, particularly organic meat sold to the US. And yet organic agriculture provides only 1% of all income to farmers in Australia, so there is plenty of room for growth.

Given the potential for growth in this industry, there is surprisingly little scientific research in the area of organic agriculture in Australia. Most useful would be multidisciplinary research aimed at improving agricultural yields and bio-inputs, and also at reducing costs and energy inputs. Chemistry will undoubtedly be central to any such efforts.

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The air you can see

Half of the world's population now lives in cities. This shift has been driven by demographic changes, notably due to industrialisation of the economies of developing nations. The trend will continue – a recent government decision in China will allow 60% of the population to live in cities. The environmental issues affecting cities, and how those issues are managed, now directly impact on the lives of most humans.

Kerbside electricity 'bowser', Helsinki

Air quality is typically the first environmental impact to be discussed when cities are concerned. Bob Hope once quipped, 'I'm from Los Angeles; I don't trust air I can't see', and Los Angeles provides a good example of how combustion of fossil fuels for transport, industry and energy production can result in poor air quality. Increasingly, industrial sources contribute a lower proportion of air emissions and motor vehicles powered by internal combustion engines contribute an increasing proportion. There are at least two solutions to this problem: reduce the reliance of automobiles on fossil fuels or reduce motor vehicle use.

Many major car companies produce hybrid cars, which use a combination of batteries and internal combustion engine to provide the motive power. In city traffic, the battery provides most of the energy and the engine does not produce emissions when the vehicle is not moving. However, hybrids have their limitations, and purely electric vehicles are now on the market. The advances in battery technology that have facilitated hybrid vehicles have enabled the rebirth of the pure electric car. Battery recharging is important, and the infrastructure for this needs to develop in the same way that the availability of petroleum fuels has over decades. In the early 1900s, electric cars were common, but the reticulated power supply to allow recharging was not. The internal combustion engine was easier to re-fuel. All it needed was a five-gallon drum and a funnel.

General Motors Holden has a recharging facility for its Volt model outside its Fishermans Bend facility in Melbourne, which is a little off the beaten track. The ultimate target is the sort of kerbside facility to be found outside Helsinki Energy's main office building in central Helsinki.

To reduce motor vehicle usage in cities and still move large numbers of people, good public transport is required. European cities with limited space, and a high population density, favour efficient and highly developed public transport systems. I've recently had the chance to experience public transport in a number of Eastern European cities, and it works well, frequently built around an underground rail system (Metro). Some large cities, such as Moscow, still have significant traffic issues, but the Metro does carry large numbers of people, through effective networks that have multiple interchange points. This contrasts with Australian public transport systems, which tend to be radial, designed to move people to a single centre. Smaller cities such as Prague and Helsinki also use tram networks effectively, again with multiple interchange points, unlike Melbourne's radial system. All of this means that there is not the degree of air pollution one might expect were there the same reliance on car transport to move large numbers of people as in Australian cities.

However, electric-powered public transport relies on a power supply, the largest proportion of which, worldwide, is produced with fossil fuels. Australian cities have generally removed power stations, particularly coal-fired power stations, from urban areas. Beijing, on the other hand, still has many coal-fired power stations, although the Xinhua news agency has recently reported that the city authorities will ban coal burning in its six main districts by 2020. In Russia, power stations serve the dual purpose of electricity generation and producing reticulated hot water. By necessity, they need to be close to the urban areas, often surrounded by them. These are largely gas-powered these days, and have a lower impact on air quality.

However, the compactness that favours public transport can also present other problems for a city. Singapore recognised that surface public transport could not move the numbers of people required, simply because there was not enough land space to go around. Hence, its MRT system was built underground, and has a range of circular and cross-city lines, making it easy even for tourists to get around. Singapore is also creating land area, as it reclaims low-lying and swampy areas from the sea. No doubt, some of the rock and soil used to do this comes from tunnel excavations as the MRT network is expanded.

There are many other environmental issues that cities face as they grow. Availability of water, access to fresh food, and safe soil on which to build, will also be on the minds of city planners, builders and residents. Increased awareness of one issue (such as air quality) may turn into greater awareness of others.

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Wine and terroir

'Terroir' is a term that one frequently comes across in the wine literature. A concept that is almost an article of faith to some grapegrowers and winemakers, it is used extensively by wine marketers and its existence is often questioned as being without a scientific basis. Simply put, terroir is the combination of vineyard site and soil that determines the characteristics of grapes and the wines made from them. My colleague, Dr Dejan Tesic, has noted that there is a considerable degree of 'vagueness' in the use of terroir in the viticulture literature (*Aust. J. Grape Wine Res.* 2001, vol. 8, pp. 15–26). Factors ascribed to determining a site's terroir include the soil, subsoil and water table depth. To this, we can add the site's altitude, slope and perspective. The climate and especially the mesoclimate are important, both of which can be influenced by 'climate-modifying bodies' such as wind breaks and large bodies of water. In a somewhat more extreme understanding, a spiritual aspect may be added.

The concept of terroir gained significance for me while I was working and teaching in the Loire region of France, particularly in Anjou. The vineyard holdings are small and the soil and site aspect change quickly. Thus, the Chenin Blanc or Cabernet Franc wines made by the same winemaker from vineyards less than one kilometre apart can show differences in acidity, fruit intensity and, for the Cabernet Franc wines, tannin structure.

Perhaps the concept of terroir reaches its peak in Burgundy. Here the soil and aspect, particularly the slope, change very quickly. The vineyards are small, thanks to complex French inheritance laws (for example, the Clos de Vougeot is just over 50 hectares and has 82 owners), and each parcel of land tends to produce its own unique characters. The better wines, and certainly the most expensive ones, come from the vineyards on the upper and upper middle part of the slope, while the lower category 'village' wines are produced from grapes grown at the bottom.

What is so often overlooked, especially by the marketers, is that terroir can really only apply to wines that are made from the single vineyard for which the terroir is claimed. Blending of wines from grapes grown in different vineyards can only reflect the more general attributes of a region, rather than specific terroirs. And of course, blending between varieties creates another issue altogether. In Anjou, as I mentioned above, there are single varietal wines. Similarly in Burgundy, the 'terroir wines' are single varietal wines from Chardonnay and Pinot Noir.

In Bordeaux, the situation is quite different. For red wines, five varieties may be used – Cabernet Sauvignon, Cabernet Franc, Merlot, Malbec and Petit Verdot – although most wines would use perhaps two or at most three varieties. Blends are created to bring out the best from each parcel of grapes and the blend percentages may vary from year to year. So, the marketers can then argue that each wine offers 'a unique blend of terroirs'.

The terroir influence on grapes is best reflected in the finished wine when there is minimal winemaker influence. For example, in Burgundy, many alcoholic fermentations are not inoculated; rather, the natural yeasts from the grape are used. The same also applies to the malolactic fermentation. Some time ago, a colleague of mine, when visiting a top producer in Burgundy, asked if active dried yeast was used to inoculate the ferment. With a look of disgust, the response was 'If I want to drink Coca-Cola, I would go to Australia … or Bordeaux'!

Here in Australia, our international market success has been based significantly on our capacity to blend wines across regions and varieties. We have used geographic indications as a means of describing regionality. The list of current geographic indications can be found at bit.ly/1lfcHzu. There are restrictions regarding the use of geographic indications when labelling wine.

So, where is the science up to regarding a more formal understanding of terroir? There is still a long way to go, but progress is being made. Dejan Tesic (see previous citation and *Aust. J. Grape Wine Res.* 2001, vol. 8, pp. 27–35) developed a site index for Cabernet Sauvignon in the Hawke's Bay region in New Zealand. This led to the proposal for several terroirs in the region (see bit.ly/1zB4FJH and go to the 1996–1999 section).

After many years of wine research, I remain convinced that analytical chemistry will find a way to answer many unsolved wine questions. And now we are starting to get some good data on terroir. Chloé Roullier-Gall of Université de Bourgogne in Dijon, France, has been carrying out a longitudinal study of wines from three areas in Burgundy for her doctorate. Fourier transform ion cyclotron resonance–mass spectrometry was used in an untargeted 'chemodiversity' analysis of grapes and wines. Fascinatingly, vintage effect was the dominant discriminating factor in the grapes and young wines. However, with age, the terroir differentiation between the three areas became apparent. The paper in *Food Chemistry* (2014, vol. 152, pp. 100–7) is a great read. There will be more on this theme at the 2015 *In Vino Analytica Scientia* conference (http://eventi.fmach.it/IVAS2015).

Finally, for those who are really switched on to terroir, there are now terroir wine bars and even terroir restaurants. The latter serve wine and food supposedly from the same terroir, the argument being, I suppose, that the terroir influence on grapes also influences the animals that graze there. It is something of a challenge though if one is seeking a fish course.

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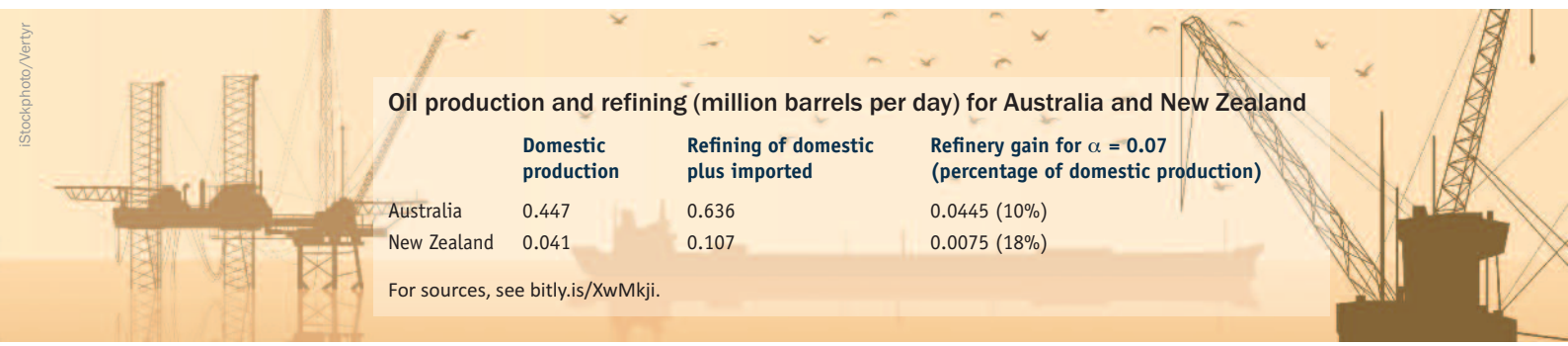
Refinery gain in Australia and New Zealand

In my day as a student, physical chemistry lecturers and authors would recount the anecdote of the corrupt barman who diluted a litre of scotch with 100 cm^3 of water and expected to get 1.1 litres of diluted scotch, thereby dishonestly raising his profit. If he'd studied chemistry, he would have been aware that this is unsound because volumes unlike weights do not sum in that simple way. Precise knowledge of the diluted volume of the scotch requires that the partial molar volume of the alcohol content be taken into account. The extent to which the final volume differed from that falsely calculated by summation can easily be determined experimentally. A cathetometer could be used to measure the height of the meniscus before and after dilution. Knowledge of those heights and of the vessel diameter would, by very simple mensuration, give a value for the volume change ΔV for the mixing and it would be negative. The scotch after mixing with water would not go quite as far as the rascally barman had intended.

The table shows production and refining figures for Australia and New Zealand. The figure for domestic oil in Australia is for 2013 and is significantly down on the previous year's production. Australian oil production has been decreasing since about 2000. The figures for New Zealand show how far from being self-sufficient in oil that country is. The refining figure for New Zealand is for the Marsden Point refinery, the only refinery in New Zealand. The difference between what it produces by way of automotive and aviation fuels and the actual requirement for such fuels is met by imported refined product.

Obviously, if a country produced as much oil as it needed and refined, the increase would be the same as the refinery gain, about 7% of the amount produced. Because Australia and New Zealand each refine more oil than they produce, that is pushed up to 10% of the production for Australia and to 18% of the production for New Zealand. If these two countries were to express their production in the same way that Taiwan (not uniquely) does, there would be these significant rises, which apply when oil is received and distributed after refining on a barrels basis. Conservation of mass requires that when quantities are expressed on a weight basis, as they would be if measured with a Coriolis meter, refinery gain is nil.



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Oil production and refining (million barrels per day) for Australia and New Zealand

	Domestic production	Refining of domestic plus imported	Refinery gain for α = 0.07 (percentage of domestic production)
Australia	0.447	0.636	0.0445 (10%)
New Zealand	0.041	0.107	0.0075 (18%)

For sources, see bitly.is/XwMkji.

… separation of liquids resulting in a positive ΔV is the reason why a barrel of oil when refined gives products with total volume about 1.07 barrels.

This effect in reverse – separation of liquids resulting in a positive ΔV – is the reason why a barrel of oil when refined gives products with total volume about 1.07 barrels. This effect is called refinery gain and is important in hydrocarbon supply. This column is concerned not so much with refinery gain per se but with its incorporation into oil production figures and statistics. Having recently examined this for two OPEC countries, Saudi Arabia and Angola (*OPEC: its role and influence since 1960*, Ventus Publishing, Fredericksburg, 2014), here I will do the same for Australia and New Zealand.

According to the US Energy Information Administration (www.eia.gov), in 2012, Taiwan produced an average of 22 000 barrels of oil per day and almost all of this was refinery processing gains. It would appear that for any country, the refinery gain adds to the crude oil production figure by $\alpha \times$ amount refined, where α is the extent of refinery gain, usually about 0.07 as indicated, and the amount refined (units barrels per day) includes refining of domestic and imported oil.

Japan has very little crude oil but enormous refining capacity. Refined products are both used domestically and exported. Such products are gasoline, jet fuel and diesel. In 2012, Japan refined 3.4 million barrels per day of crude oil, the refinery gain from which would have been roughly 0.24 million barrels per day. This is half an order of magnitude higher than the crude oil production of Bahrain, which in 2012 stood at 0.048 million barrels per day (www.eia.gov).

J.C. Jones FRACI CChem worked in Australia during 1978–95, latterly at the University of New South Wales. He was at the University of Aberdeen until April 2014, and then spent a short period at the Kazakh–British Technical University in Almaty, Kazakhstan, a link he expects to continue.

Green and gold

The investigation of the constituents of terrestrial plants was the backbone of natural products chemistry in Australia for many years, although there was always some work being done on animal products, especially those of marine origin. There were major sites of investigation, too: mainly university chemistry departments and CSIR/CSIRO laboratories.

James Matthew Petrie was born in Scotland about 1873. He studied at Heriot-Watt College in Edinburgh, but came to Australia in the 1890s to work as an assayer at the Mint. He married in Sydney in 1898. In 1895–6, he was a junior demonstrator in Chemistry at the University of Sydney, and then 1898–1901 a lecturer in Chemistry at Sydney Technical College. I assume that he was also studying part time, because he graduated with first class honours in chemistry from the University of Sydney in 1900. In 1904, he was awarded a research scholarship in chemistry, and his DSc was awarded in 1905 for a thesis on the mineral oil from the torbanite of New South Wales. This was the oil resulting from destructive distillation of the hydrocarbon-rich rock that was mined at locations typified by Glen Davis and Joadja Creek.

In 1907, Petrie was awarded the Caird Scholarship; in this year he also became a Linnean Macleay Fellow in Biochemistry. Subsequently, he gave his address as the Physiology Department or the Physiological Laboratory, where he undertook research on Australian plants with a special focus on their medicinal properties. He took a particular interest in plant toxins and published a series of investigations into the occurrence of hydrocyanic acid in plants. The HCN is present as sugar cyanohydrins containing the functional group >C(OH)CN and can be released by enzymic hydrolysis. Part of Petrie's interest was in grasses that might be stock poisons, but he went over the top when he examined 152 species from the Sydney botanic garden, each on four occasions spaced through the year. Very few had appreciable concentrations of cyanide.

The paper that first caught my eye was published in the *Biochemical Journal* in 1924 and entitled 'The yellow pigments of Australian acacias'. Petrie examined the golden blooms of four species – *A. discolor*, *A. linifolia*, *A. decurrens* and *A. longifolia*. Most of the work was done on the first of these, from which he showed that free flavones were absent but the yellow colour resided in a glycoside that he precipitated by lead acetate. From 1200 grams of fresh flowers, he obtained 2.4 grams of crude yellow pigment, which he purified by conversion to its acetate (m.p. 179°C). This was hydrolysed to form the flavone as yellow needles with melting point 274°C. Zeisel analysis (reaction with HI) showed that no methoxy groups were present. The sugar from the original glycoside was identified as the methyl pentose rhamnose. The osazone derived from Petrie's sugar had melting point 188°C, in accord with literature values of Emil Fischer and Emil Votocek. The formation of an oxonium salt from the flavone and sulfuric acid enabled the molecular weight to be determined as 286 by titration of the acid freed by hydrolysis of the salt. Taken together, the data pointed to kaempferol, 5,7,4'-trihydroxyflavonol, as the flavone, which was present in the plants as its rhamnoside. The same compound was isolated from the other three *Acacia* species. Kaempferol is a common constituent of plants, especially those valued as 'green medicine' but also including tea and most green vegetables.

Shortly before he died, Petrie became the Bosch Fellow in Cancer Research at the University of Sydney. Funds raised by an appeal enabled research on the effect of X-rays and radioactive emanations to be undertaken and so Petrie changed research fields once again. His career was cut short, however, by his death in 1927 at age 54. An obituarist noted that he had 'borne bravely great physical disabilities' but did not say what they were.

Part of Petrie's interest was in grasses that might be stock poisons, but he went over the top when he examined 152 species from the Sydney botanic garden ...

To complete the biographical part of this story, I can add that Mrs Petrie had a Bachelor of Arts degree, and their elder son, Arthur H.K. Petrie, completed a BSc at Sydney with first class honours in Botany, following which he worked as a senior demonstrator in Botany at the University of Melbourne and earned his MSc degree in 1926. In the following year, he was awarded an 1851 scholarship, which enabled him to study at Cambridge where he completed his PhD before returning to the Melbourne department. In 1931, he left there to take up an appointment at the Waite Agricultural Research Institute in Adelaide.

Petrie Jnr's research interests had been in the ecology of Australian rainforests, at first in the Blue Mountains and then in the dividing range to the east of Melbourne. He was also co-author of a book about the vegetation of the high plains. In Adelaide, however, he turned to plants of agricultural importance, more to do with plant physiology than ecology, and in 1936–7, he spent another year at Cambridge. His attention was directed by CSIR to the growing of tobacco in Australia and the impact of soils and climate, but the work was incomplete when he died in 1942 at age 38.

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.

Speed dating chemists in NSW

A key metric for the services provided to our members is the quality of RACI events – how well targeted they are to the audience, and how they are carried off. In July, the Young Chemists and Analytical Chemistry Groups in New South Wales collaborated to put together a 'speed dating' networking event that excelled in both respects.

Hosted at 3M in Sydney, and sponsored by Evolve Scientific Recruitment, the event was a planned effort to reach out to young chemists, to find ways of creating specific value suited to their particular needs. It included a guided tour of 3M's Innovation Centre at North Ryde, followed by a talk from Tania Notaras FRACI CChem (pictured networking with some young chemists) on her experience of building up Australia's largest private laboratory company, refreshments, and then small-group discussions with experienced RACI members.

In short, it was an excellent function. George Zavras and Danny Wong did a great job of organisation, including having all of the attendees already pre-grouped by coloured name tags so that breaking up and coming together happened smoothly. The event was fully subscribed, and the conversations were active and engaged.

The most particularly striking responses from a survey of participants were in the areas of greatest interest to young chemists. When asked what type of event they would be most likely to attend in future, just short of 100% of respondents identified networking events, and over 75% expressed interest in mentoring events.

This exactly mirrors my own experience with young chemists. In my presentation to young members about making the transition into the workforce, I emphasise the critical importance that networks play in any career – not just in finding employment, but also in creating value throughout your career. Through networks, you can identify new business opportunities, find ways to collaborate, and sometimes even

make joint discoveries. Networking is very much a case of '1 + 1 = 3 … for extremely large values of 1'.

However, as our longer-serving members will remember, it can be extremely daunting as a young chemist to attend an RACI event. The room is filled with people actively engaged in conversations among members who already know each other well, who are older, and more established and distinguished in their careers. Even I, a comparatively gregarious fellow (small 'f') found this incredibly intimidating at the beginning of my career.

It is therefore incumbent on established members not just to welcome these newer participants, but to actively engage them in our conversations and make sure that they are also getting the full value of their participation. Our organisation cannot thrive without the active engagement, participation and ultimately retention of our young members.

As noted, mentoring was the other major area for which young chemists expressed interest. Marguerite Evans-Galea and Charles Galea write in this issue (p. 26) about the theory and practice of mentoring. I have run my own ad-hoc mentoring program for the past few years, and found the process to be eminently rewarding.

As an industrial chemist, my mentoring program is focused on commercial careers. I try to start with chemists around third year, and then support them through to their first career role. I offer guidance on practical issues – developing skills and experiences useful to their resumé; guidance on how to select an honours project; proofreading honours theses; interview skills and improved job applications; as well as hosting my mentees to networking events and facilitating their introduction to networks.

I believe that this is one of the most tangible forms of support that I can offer the next generation of chemists. And given the strong expression of interest in mentoring at the Speed Dating event, I am keen to gauge the interest among my RACI colleagues for a wider and more formal mentoring program. I welcome anyone who might be interested (either as a mentor or mentee) to contact me.

I offer my fulsome congratulations to the NSW Young Chemists Group for their energy and enthusiasm, and to the NSW Analytical Chemists for their work in supporting this collaboration. Working together, we have every opportunity before us to grow and fortify our society for the long term.

Dave Sammut MRACI CChem

Speed dating Q&A

How does a PhD affect my employment prospects? This is a regional issue. Unlike in the US, in Australia it is not common for chemists to move smoothly between industry and academia. While a PhD can significantly enhance an academic career, there is a risk in Australia that it will be perceived as having three negatives: competing candidates of the same age without PhDs have three years more industrial experience; candidates with PhDs will expect higher pay, faster advancement and higher status; and candidates with PhDs will expect to be able to publish their ongoing research, which is not necessarily what companies want. Of course, none of these needs be true. The best advice for any job candidate is to be aware of the potential negative assumptions about your status, and to take concrete steps to address these. Make sure that you include industrial applications and linkages in your PhD work. Emphasise the commercial outcomes of your work. Be clear and realistic about your expectations. And, most importantly, use your networks to identify the opportunities where your training will be most marketable.

What are employers looking for? In general terms, bachelor degrees produce a fairly generic set of candidates – more or less the same basic skills and (limited) experience. At the graduate level, employers most commonly look to personality, 'fit' with their organisation, and examples of demonstrated behaviours that will be useful to them. When I want to hire a researcher, my favoured candidates are ones who demonstrate the behaviour by researching my company and my chemistry before they apply.

What qualifications make me more employable? Statistically, double degrees enhance employability. The greatest value in modern commerce comes from bridging between specialised skill sets. Even if you are not studying a full double degree, consider taking a few business-oriented subjects (accounting, economics and/or finance) as part of your studies so that you are at least passingly familiar with the concepts and terminology. After this, the extracurricular activities you undertake are also important. What skills and behaviours do they demonstrate?

What if I am an international student? Unfortunately, most employers cannot afford to sponsor workers to come to Australia, and that includes students. At the graduate level, there are too many candidates who already hold work rights, and the skill sets required are too generic, for a company to be able to prove (as they must) that a foreign worker is required. As an international student, you must get on the 'front foot' to organise your visa if your want to work in Australia at the completion of your studies. Having done so, you stand every bit as good a chance as an Australian-born graduate – sometimes even more so. In some cases, there can be an assumption that someone born overseas will work harder to 'make it' in Australia, and will be more loyal to their employer. Also, language skills are critical. Skills can be taught, but the ability to communicate with your team is one of the major factors in your ability to create value for your employer.

events

7th Asian Biological Inorganic Chemistry Conference (AsBIC-7)
30 November – 5 December 2014, Gold Coast, Qld
www.asbic7.org

11th Australasian Aluminium Smelting Technology Conference
6–11 December 2014, Dubai, United Arab Emirates
http://11aastc.com

RACI National Congress
7–12 December 2014, Adelaide, SA
www.raci.org.au/events-awards/raci-national-congress-2014
Early Bird registration closes 1 August 2014

Advanced Materials & Nanotechnology (AMN7)
8–12 February 2015, Nelson, New Zealand
www.amn-7.com

35th Australasian Polymer Symposium
13–15 July 2015, Gold Coast, Qld
www.35aps.org.au

IUPAC 2015
48th General Assembly 6–13 August 2015,
45th World Chemistry Congress 9–14 August 2015,
Busan, Korea
www.iupac2015.org

Pacifichem 2015
15–20 December 2015, Honolulu, Hawaii
www.pacifichem.org

RACI events are shown in blue.

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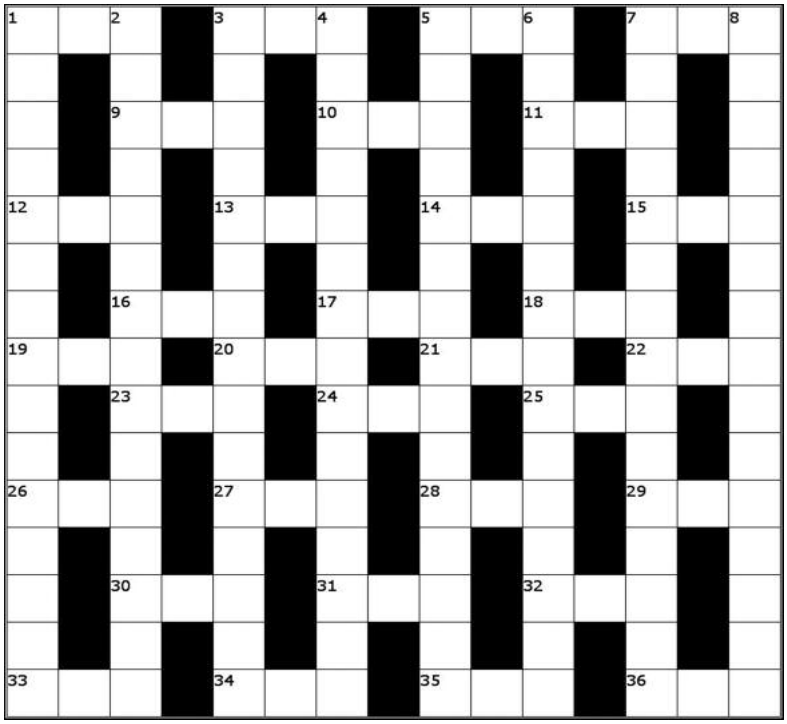
Coming up

Non-chemists rule in November!

So, what do chemists actually *do*?
Chemistry in comic strips and at the cinema
Swap screen time for science 'make and do'
Cigarette butts: a toxic problem
Questacon's director on cool chemistry events
Top chemistry reading

cryptic chemistry



Across

1 Concentration = 1561. (3)
3 Looks at small things in base metal studies. (3)
5 Fight sequence. (3)
7 Pop a Diode Array Detector. (3)
9 A viscous organic black liquid over an animal. (3)
10 & 35 Across Blunt tin carried out. (6)
11 First linear acetylenic carbon resin secreted by insects. (3)
12, 19 Across and 22 Across Fix up toenail liquid. (6,3)
13 First and last, nothing compounds derived from H_2N_2. (3)
14 Electrochemistry reference made up of two elements. (3)
15 Parcel stacks. (3)
16 First lady came the day before. (3)
17 Transport 205. (3)
18 & 29 Across Laser rotation held back maritime explorer. (6)
19 See 12 Across.
20 Electron energy of I. (3)
21 A lot of water is used in cellulose acetate production. (3)
22 See 12 Across.
23 Prussic acid finishes fourth Antarctic expedition. (3)
24 Present position. (3)
25 Three elements of a Bateman Pulsed Column. (3)
26 Where Peter Allen goes for a Spanish flower. (3)
27 Bank backed Auntie. (3)
28 Three: sound attempt. (3)
29 See 18 Across.
30 Assesses research quality on a curve? (3)
31 & 34 Across React directly expelling iodine and carbon and leave to dehydrate. (3,3)
32 Colour produced by one element encasing another. (3)
33 Spy sensed 21 Across. (3)
34 See 31 Across.
35 See 10 Across.
36 Electron transport chain and other things. (3)

Down

1 Pinhole rots ship made from compounds of stoichiometry $[X_2PN]_n$. (15)
2 CH_3S^- meant the heat oil burnt. (15)
3 Send each furnace new form of Raman scattering with amplified signals. (7-8)
4 Cis-cyclo-pair/mol change on a very small scale. (15)
5 Perhaps the result of benzene reacted with an electrophile leads to rust – but signed it off! (4-11)
6 Healthy table dishes became very much in place. (4-11)
7 Corrode in bleach to make CCl_2. (15)
8 Deny milt is chair form of cacodylic. (15)

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

RACI National Congress

The RACI Congress will be held shortly in Adelaide. It will be the largest gathering of Australian Chemists since 2005 and you are invited to be part of the exciting event. Over 100 plenary, keynote and invited speakers have been drawn from around the world and represent some of the most important work in chemical community (see website for a complete list of speakers www.racicongress.com/speakers).

Well over 850 abstracts have been received and represent work in many important areas of chemistry as well as cross disciplinary activities. The meeting will provide a great environment to meet colleagues, discuss current work and trends and explore new opportunities. There will also be a significant exhibition showing the latest equipment and technology.

Congress Venue – Adelaide

RACI 2014 will be held at the multi award winning Adelaide Convention Centre, on the waterfront of the River Torrens near the heart of the city.
Adelaide is a picturesque coastal city that's easy to get to, easy to get around, easy on the pocket, and 'green'. The Convention Centre offers first-class facilities to delegates, partners and visitors, and is a short walk from accommodation, restaurants and the central business district of Adelaide.

To register please visit the website: www.racicongress.com/registration

Contact Us

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raci
National Congress
7-12 December 2014
Adelaide | Australia
Building strong bonds

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Royal Australian Chemical Institute