chemistry in Australia
June 2016

Big questions in chemistry: the new VCE study design

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chemistry in Australia

June 2016

cover story

Senior chemistry: Victoria's new study design

An engaging and challenging new study design for VCE Chemistry has arrived.

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Congresses and corporate governance

Hello members. You are reading a column from the CEO rather than the President because, unfortunately, Paul Bernhardt was severely injured in a cycling accident in mid-April. At the time of writing, it is a mere week after the accident and Paul is seriously ill in hospital. Hopefully, by the time you read the magazine he will be well on the way to recovery, but the rehabilitation physio work is going to be long and arduous. I'm sure you join with me to wish him a speedy recovery.

The first thing I would like to touch upon is the Centenary Congress (23–28 July 2017 in Melbourne). We received a huge boost for the event at the end of March when we managed to secure the 17th Asian Chemical Congress (ACC) as one of our Congress partners after their original host, Japan, dropped out.

This is a triple bonus because:

- a competing congress is no longer running in the same region at the same time as ours, freeing up a large number of possible delegates
- we have gained an event that has regularly attracted over 1200 delegates at its last three congresses
- the event will attract a large number of additional abstracts from quality Asian chemists, which will greatly enhance our Congress' program.

All RACI divisions have put their hands up to run meetings, so we will not be running a separate event for the ACC but will utilise the divisional meeting programs for the content for the ACC delegates.

With six specialised topic partner events and 14 divisional meetings, we will have something for every brand of chemists, so there is no reason for you not to attend. We are expecting at least 3500 delegates (3501 if you go), so it's going to be a massive event.

The plan is that abstracts will be opening early June so get out there and put a couple in!

Visit the website at www.racicongress.com to get the latest news.

I'd like to move onto a corporate governance issue.

Every year, Board positions come up for renewal and this year we have the very important positions of President Elect and Treasurer up for grabs. Obviously, the current President elect, Peter Junk, moves up the ladder to President so the position will be vacant, while the current Treasurer, David Edmonds, has indicated that he's stepping down after four years, so his position will also be vacant. In addition to these two office-bearer vacancies, an Ordinary Board member position is also up for election.

The Board sets the direction for the organisation and, for good governance, it's vital we get quality people at the helm. In the recent past the membership (you) has been apathetic in this area, underlined by the fact that from 2010 to 2014, of the 18 positions up for renewal only two had to go through an election process. Last year was spectacularly different! For the two Ordinary Board member positions, there were six nominations, and for the Honorary General Secretary position, there were two nominations. All of the nominated people were high-quality candidates, which was absolutely fantastic; however, there was still a downside: of the 4000 eligible voters only 600 put their hands up.

Good governance requires a robust election process to ensure the best people lead the organisation, so this year let's have a plethora of nominations and then have all members consider the suitability of the applicants and cast their vote.

More information on director's duties can be found together with a nomination form at www.raci.org.au/theraci/corporate-governance/board-elections-2016.

In closing, let's hope that Paul's recuperation process has progressed to a point where he will be able to write his own column next month.

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RACI honorary 50-year life members

The New South Wales Branch held the President's Dinner and Awards Night on 7 April 2016. Cecil Bannon, Peter Field and I received honorary life membership for 50 years of membership. Such an occasion is a good excuse to reflect on the history of the educational institution that allowed me access to RACI membership. The Sydney Institute of TAFE (aka Sydney Technical College, traceable to 1833 with the Sydney Mechanics Institute) 'spawned' two universities: the University of New South Wales (1949) and University of Technology Sydney (1969). Both these universities had name changes, with UNSW commencing life as 'The New South Wales University of Technology' and UTS known as NSWIT in earlier years. When I enrolled as an undergraduate in 1960, UNSW was known as 'The New South Wales University of Technology' although some historians claim this name change occurred in 1958. My memory is the name changed in 1961, also the same year of the last trams to UNSW Kensington facility.

I believe the 1960 student intake was the last enrolled in a combined BSc (Applied Chemistry) and ASTC (Associate of Sydney Technical College = Applied Chemistry Diploma awarded by STC). Sydney Technical College's high international rating as a teaching/research institute assisted in the dual universities (UNSW and UTS) spin-offs. UNSW went on to established colleges at Newcastle (1951) and Wollongong (1961), which eventually became independent universities.

In any event, the final outcome is great news as all these institutions are success stories with impressive records of delivering educational and economic benefits to current and future generations. Thank you STC/TAFE/UNSW and RACI for your contributions to my education.

I would like to hear from other ASTC graduates to arrange an annual lunch. Maybe with other RACI honorary 50-year life members we could be invited to attend and contribute to the Annual Fellow Lunch.

Robert Ryan FRACI CChem

As your RACI member magazine, *Chemistry in Australia* is the perfect place to voice your ideas and opinions, and to discuss chemistry issues and recently published articles.

Send your contributions (approx. 400 words) to the Editor at editor@raci.org.au.

Swansea University to reintroduce chemistry degrees

Swansea University is to re-introduce chemistry degrees from 2017, after a 12-year gap, following discussions with the Royal Society of Chemistry.

New chemistry BSc and MChem programs focus on teaching excellence, student experience and employability. Based in the College of Science, the programs will have strong links to engineering and medicine.

Students will be able to take up placements with companies in the field, as well as having the option of spending a year in industry, like many other College of Science students.

Postgraduate opportunities within the chemical sciences already exist in the University's Medical School and College of Engineering. Further opportunities will now be created in the new Chemistry Department.

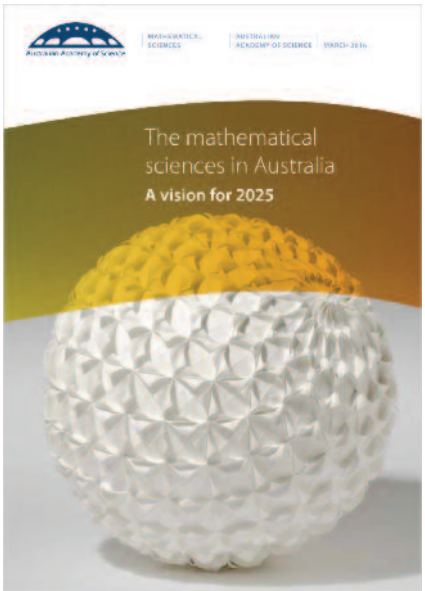
Chemistry degrees were withdrawn at Swansea University in 2004, at a time when science and technology subjects had fallen in popularity. The demand for chemistry degrees is now increasing, with undergraduate enrolment in the subject up 4% nationally in the last two years.

The College of Science at Swansea, which will be the home for chemistry, is also growing rapidly: with undergraduate applications rising 15% overall in 2015–16 on top of a 20% increase in 2014–15.

Swansea University Vice Chancellor Professor Richard B. Davies said: 'The University has changed and the world has changed since 2004. Swansea University is in a far stronger position. We are now in the top 25 universities for research in the UK … The wider context has also changed, with higher demand for chemistry and other science subjects, including from overseas students.'

Swansea University

Uni maths bar set too low: mathematicians



Mid-level maths should be made a prerequisite for students looking to enrol in science, engineering or commerce degrees according to a new 10-year plan for mathematics in Australia launched in March by the Federal education minister (bit.ly/1Xq4XhD).

Currently only 14% of Australian universities require science students to have studied intermediate mathematics in year 12.

The plan, developed by the National Committee for Mathematical Sciences, makes a dozen key recommendations, including increasing professional development for out-of-field maths teachers and a new national mathematics research centre to link industry and research. It also highlights an urgent need to address the low participation of women and rural Australians in the mathematical sciences.

Professor Nalini Joshi, chair of the National Committee, said that improving the mathematics skills of the next generation is vital for future workforce demands.

'We are in the era of big data but what good is data without the ability to interpret and analyse it? We need people who have the skills to take that raw information and turn it into something useful,' Joshi said.

National Committee member and Director of the Australian Mathematical Sciences Institute Professor Geoff Prince said the plan was developed to outline the challenges and opportunities for the future of maths in Australia.

'This plan is a clear vision for governments, universities and industry to shape mathematical sciences over the next 10 years, starting now. Fundamental to that vision is education. We know that 75% of the fastest growing occupations will need science, technology, engineering and mathematics (STEM) skills, and that maths is at the heart of this skill set. If we're not preparing our teachers and students the way we should, Australia will be left behind by the rest of the world,' Prince said.

The ten-year plan was developed after extensive consultation with mathematical scientists in schools, universities, government agencies and industry.

Australian Academy of Science

Can beetroot juice give elite athletes an edge?

Nitrate-rich beetroot juice might enhance performance among top athletes according to a joint study from the University of Western Australia, the Western Australian Institute of Sport and the Australian Institute of Sport.

Dr Peter Peeling from UWA's School of Sport Science, Exercise and Health was one of the scientists who looked at the influence beetroot supplements had on physiological and performance outcomes in elite kayakers.

The research saw six national-level male and five international-level female kayakers take part in a two-part study at the Western Australian Institute of Sport and the National Regatta Centre in Penrith.

'We looked at the difference that the use of a commercially available 70-millitre beetroot shot made to the time-trial performance and paddling economy of the athletes involved,' Peeling said.

'In laboratory-based four-minute ergometer tests, the beetroot supplement had a small effect on the distance covered, but was effective in improving the task economy of the male kayakers. When we used a greater volume of beetroot juice (140 millilitre) among our female participants during a field-based 500-metre kayaking time-trial, we found there was a meaningful performance improvement of 1.7%.'

'Given that the margin between gold and silver medals in the Men's K1-1000m and the Women's K1-500m races at the 2012 London Olympic Games was 0.3% and 1.0% respectively, the relatively small performance changes that we recorded are clearly relevant.'

Dr Peter Peeling with a sample of the beetroot supplement.

Peeling said the nitrate in beetroot juice has been shown to improve 'the efficiency of processes that occur in the mitochondria … This means ATP … can be spared during muscular activity, resulting in a decreased oxygen cost for a given task.'

'If you can find a way of reducing the oxygen cost of a given activity, you might improve the ability to withstand the exercise intensity for a greater period of time, or you find a greater level of output for the original oxygen cost.' he said.

'Beetroot juice is also known to improve explosive power and activate fast-twitch muscle fibres, although current literature is yet to establish why.'

The study, published in the *International Journal of Sport Nutrition and Exercise Metabolism* (doi: 10.1123/ijsnem.2014-0110), found the use of beetroot shots by high-level athletes should be trialled on an individual basis with the load and dosage tailored for the desired outcome.

'However, the use of this natural vegetable supplement in sport has become increasingly popular, and seeing an athlete with red beetroot stained lips at an endurance event is no longer unusual,' Peeling said.

University of Western Australia

New approach to rapidly identify 'legal highs'

Professor Steven Bell, Justice Minister David Ford and Louise Jones.
Simon Graham/Harrison Photography

Chemists from Queen's University, Ireland, have developed a new approach that allows for rapid screening and identification of 'legal highs' or novel psychoactive substances.

Published in *Analyst* (doi: 10.1039/C5AN02326B), the new approach will enable statutory agencies to identify the actual substances contained within the legal highs more quickly, thereby enabling more prompt public health messages to be issued out to communities.

In addition, as well as allowing agencies to build a comprehensive and 'live' picture of which drugs are currently in circulation, it is envisaged that the new rapid identification approach will also help speed up related criminal prosecutions.

'Legal highs' are substances used like illegal drugs, and have been responsible for a growing number of deaths in the UK over the last decade. Known as 'legal highs' because when first produced they were not covered by existing drugs legislation, they face a total ban since the UK government's new Psychoactive Substances Act came into force in April. The ban covers (with the exception of a number of listed compounds such as alcohol and caffeine) 'any substance intended for human consumption that is capable of producing a psychoactive effect'.

Devised by Professor Steven Bell and PhD researcher Louise Jones in Queen's School of Chemistry and Chemical Engineering, the new approach combines rapid infrared and Raman spectroscopy screening for known drugs with in-depth analysis of new compounds. The samples can then be searched against a library of known compounds. They are then either identified as known compounds or marked as new variants.

In the Queen's study, 75% of more than 200 previously seized samples could be identified immediately. In the future, it is hoped that this will allow for laboratory facilities to be freed up for in-depth investigation of unidentified compounds. The next stage of the work will be to begin work on live casework samples.

Queen's University Belfast

Where do STEM qualifications lead?

Australians with qualifications in science, technology, engineering and mathematics (STEM) are working across the economy in many roles from winemakers to financial analysts, according to a new report from the Office of the Chief Scientist.

Australia's Chief Scientist Dr Alan Finkel said Australia's STEM Workforce is the first comprehensive analysis of the STEM-qualified population and is a valuable resource for students, parents, teachers and policymakers. The report is based on data from the 2011 Census, the most recent comprehensive and detailed data set of this type of information. The report will serve as a benchmark for future studies.

'This report provides a wealth of information on where STEM qualifications – from both the university and the vocational education and training (VET) sectors – may take you, what jobs you may have and what salary you may earn,' Finkel said.

'Studying STEM opens up countless job options and this report shows that Australians are taking diverse career paths.'

The report investigates the workforce destinations of people with qualifications in STEM fields, looking at the demographics, industries, occupations and salaries that students studying for those qualifications can expect in the workforce.

The report found that fewer than one-third of STEM university graduates were female, with physics and astronomy and engineering having even lower proportions of female graduates. Biological sciences and environmental studies graduates were evenly split between the genders. In the VET sector, only 9% of those with STEM qualifications were women.

Finkel said that even more worrying than the gender imbalance in some STEM fields, was the pay gap between men and women in all STEM fields revealed in the report. These differences cannot be fully explained by having children or by the increased proportion of women working part-time.

The analysis also found that gaining a doctorate is a sound investment, with more STEM PhD graduates in the top income bracket than their Bachelor-qualified counterparts. However, these same STEM PhD holders are less likely to own their own business or to work in the private sector.

Finkel said that preparing students for a variety of jobs and industries was vital to sustaining the future workforce.

'This report shows that STEM-qualified Australians are working across the economy. It is critical that qualifications at all levels prepare students for the breadth of roles and industries they might pursue.'

The full report is available at chiefscientist.gov.au.

Office of the Chief Scientist

Ocean acidification stops shrimp chorus

Snapping shrimps, the loudest invertebrates in the ocean, may be silenced under increasing ocean acidification, a University of Adelaide study has found.

Published in March in *Proceedings of the Royal Society B* (doi: 10.1098/rspb.2015.3046), the researchers report that under levels of CO_2 predicted to be found in oceans by the end of the century, the sound of snapping shrimps would be reduced substantially.

This is expected to have profound consequences for many species that rely on sound cues for information about the location and quality of resources (food, shelter, partners and potential predators).

'Coastal reefs are far from being quiet environments – they are filled with loud crackling sounds,' says Tullio Rossi, PhD candidate in the University's School of Biological Sciences.

'Shrimp "choruses" can be heard kilometres offshore and are important because they can aid the navigation of baby fish to their homes. But ocean acidification is jeopardising this process.'

Snapping shrimp species *Alpheus randalli* (right) with a gobi (*Amblyeleotris yanoi*).

Wikicommons/Steve Childs

The snapping shrimp is the most common and noisiest of the sound-producing marine animals in coastal ecosystems. They can produce sounds of up to 210 decibels through the formation of bubbles by the rapid closing action of their snapping claw, used as a warning sign to scare off predators and in their own hunting.

Rossi, working with supervisor Associate Professor Ivan Nagelkerken and co-supervisor Professor Sean Connell in the University's Southern Seas Ecology Laboratories, measured the sound produced by shrimp in field recordings at natural CO_2 volcanic vents at three different ocean locations and under laboratory conditions. They found substantial reductions in both the levels of sound produced and the frequency of snaps.

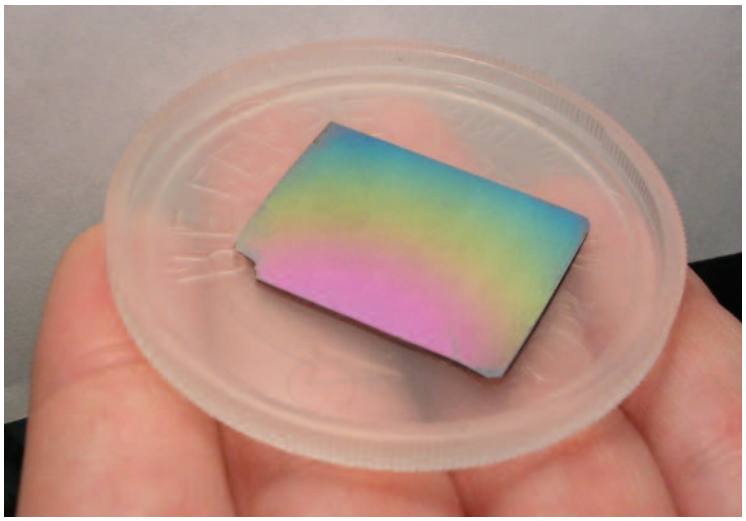
'Our results suggest that this is caused by a change of behaviour rather than any physical impairment of the claw,' said Nagelkerken.

'This outcome is quite disturbing. Sound is one of the most reliable directional cues in the ocean because it can carry up to thousands of kilometres with little change, whereas visual cues and scents are affected by light, water clarity and turbulence.

'If human carbon emissions continue unabated, the resulting ocean acidification will turn our currently lively, noisy reefs into relatively silent habitats. And given the important role of natural sounds for animals in marine ecosystems, that's not good news for the health of our oceans.'

University of Adelaide

Controlling molecules in glass



This sample of organic glass, made in University of Wisconsin-Madison chemistry Professor Mark Ediger's laboratory, has been 'pre-aged,' meaning it deforms more slowly than most glasses.
Mark Ediger

For 30 years University of Wisconsin-Madison professor of chemistry and glass expert Mark Ediger has been exploring the fundamental properties of organic glass while inventing ways to control the placement of molecules and slow the degradation of a substance that does not have the rigidity of a crystal.

Glass is a non-crystalline, solid material built of molecules or atoms packed together in countless different arrangements. Crystals only tolerate one packing arrangement between neighbours. The science of 'silicate' glass – the stuff of light bulbs, beer bottles and windows and made largely from sand – is already highly advanced. Many other glasses, however, exist at the cutting edge of modern science. The glasses that interest Ediger, for example, are made from organic molecules.

Glasses are more versatile than crystals, Ediger said. 'For any given organic molecule, you only have a few crystal structures to pick from; you are out of luck if one of them does not have the properties you want. But molecules in glass are really flexible about their local environment and who they are willing to hang out with, so for organic molecules, there are an infinite number of glasses we can make. Some glasses might, for example, resist water uptake or be exceptionally hard or resist degradation by light.'

As in most glasses, the light-making molecules in an organic light-emitting diode (OLED) are oriented more or less at random, 'but you want those molecules positioned so the light is aimed toward your eye,' he says. Advanced production techniques to control the orientation of OLED molecules would increase efficiency and extend mobile phone battery life. The slight but continual movement of molecules in glass will eventually degrade performance in the hundred-million-odd OLEDs made to illuminate mobile phone displays every year; more stable glasses would extend the display lifetime.

Ediger acknowledges that this sounds like taming a rebellious group of molecules. 'If we tame them completely, we get a crystal, which we don't want, but we have found a middle way to produce materials that are in many respects better than traditional glass, but are not crystals.'

Crystals have their uses – the silicon crystal is the basis for computer chips, for example – but glass is better if you want to see through a window or use light for digital communication. 'An optical fibre has to be able to carry a signal what – 60 miles – without being scattered by the boundaries between crystals,' Ediger said. 'There's no way you could do that with crystals.'

In 2007, in *Science*, Ediger and colleagues published a key advance in the quest for a middle ground between the rigid repetition of a crystal and the amorphous anarchy of a glass. The article described organic glass made by depositing a vapour of organic molecules on a cold plate in a vacuum chamber. 'Initially we did not know what we were making, we just knew that it was bizarre, unexpected,' he said.

The new material did not behave as expected under neutron irradiation. 'We raised the temperature to something we figured would start the molecules moving, but we had to raise the temperature another 25°C before the molecules started to move. It turned out we had made a form of glass in which the molecules were so much better packed that they did not move until we reached a much higher temperature.'

Ediger had stumbled upon a way to 'pre-age' glass and sidestep the seemingly inevitable degradation caused by slight atomic rearrangements over time. 'Our contribution was showing that there is this interesting space between traditional glass and crystals,' he says. 'You are putting order in, but if you put in too much order, it becomes a crystal, and you have gone too far.'

Ediger eventually worked out that the cold-plate deposition process allowed the molecules to settle into a 'comfortable' position, 'and then get buried by another molecule' that locked them in place.

The cross-pollination between theory and practicalities continues in Ediger's lab, as graduate student Yue Qiu uses vacuum deposition to prepare a new set of compounds that could be useful for OLEDs. 'Yue's work answers a fundamental question and also can be useful in practice,' Ediger says. 'OLEDs deteriorate over time, so cellphone displays get dimmer, and Yue's work might eliminate that.'

Qiu 'is also asking an important fundamental question that applies very broadly to many aspects of glass technology,' Ediger says. 'How do you pack the molecules in a glass so tightly that light cannot cause the molecules to rearrange? You could improve cellphone displays by trial and error, but that would be a long process. If we can identify the principles, we could cut years from that.'

University of Wisconsin

Sniffing out a dangerous vapour

Alkane fuel is a key ingredient in combustible material such as petrol, aeroplane fuel, oil – even a homemade bomb. Yet it's difficult to detect and there are no portable scanners available that can sniff out the odourless and colourless vapour.

But University of Utah engineers have developed a new type of fibre material for a handheld scanner that can detect small traces of alkane fuel vapour, a valuable advancement that could be an early-warning signal for leaks in an oil pipeline or an airliner, or for locating a terrorist's explosive.

Their discovery was published in March *ACS Sensors* (doi: 10.1021/acssensors.6b00018). The team is led by University of Utah materials science and engineering professor Ling Zang.

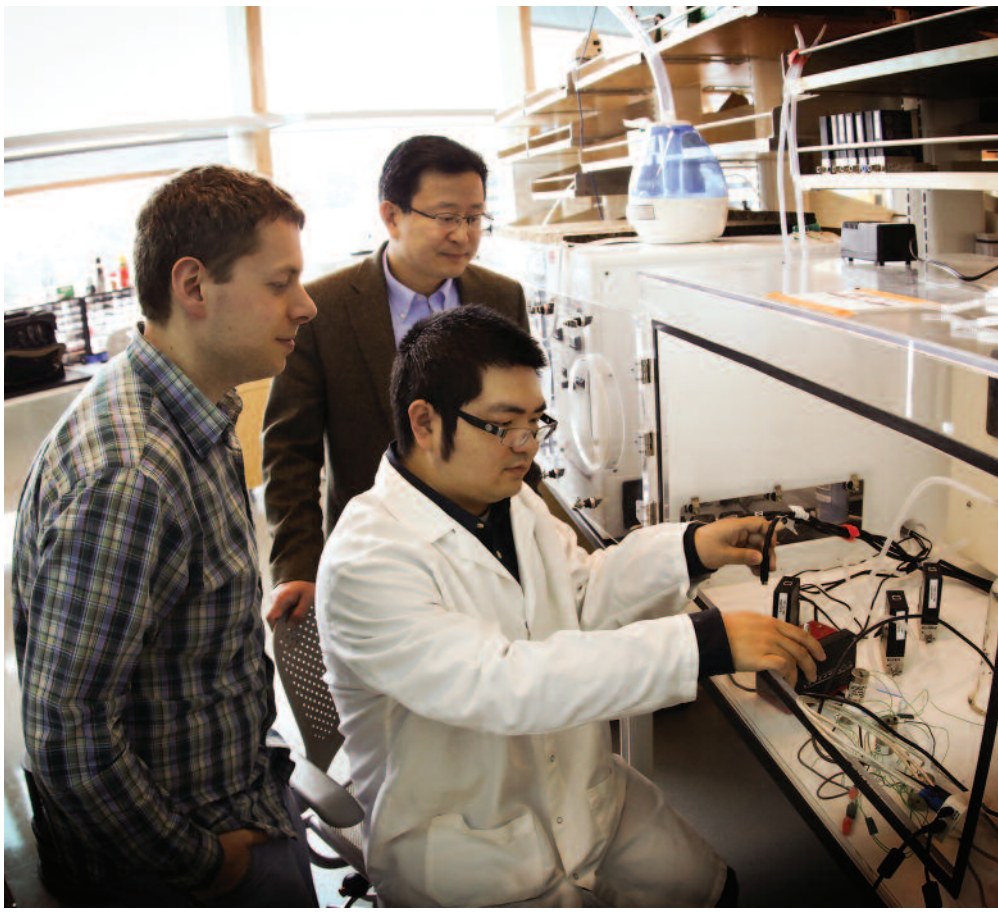
Currently, there are no small, portable chemical sensors to detect alkane fuel vapour because it is not chemically reactive. The conventional way to detect it is with a large oven-sized instrument in a lab.

'It's not mobile and very heavy,' Zang said of the larger instrument. 'There's no way it can be used in the field. Imagine trying to detect the leak from a gas valve or on the pipelines. You ought to have something portable.'

So Zang's team developed a type of fibre composite that involves two nanofibres transferring electrons from one to the other.

'These are two materials that interact well together by having electrons transferring from one to another,' said Ben Bunes, a postdoctoral fellow in the University of Utah's materials science and engineering department. 'When an alkane is present, it sticks in between the two materials, blocking the electron transfer between the two nanofibres.'

That kind of interaction would then signal the detector that the alkane vapour is present. Vaporsens, a University of Utah spin-off company, has designed a prototype of the handheld detector with an array of 16 sensor materials that will be able to identify a broad range of chemicals, including explosives. This new composite material will be incorporated into the sensor array to include the detection of alkanes. Vaporsens plans to introduce the device on the market in about a year and a half, said Zang, who is the company's chief science officer.



Ben Bunes (left), Ling Zang and Chen Wang (in lab coat), all researchers from the University of Utah's material sciences and engineering department, demonstrate a new prototype detector that can sense explosive materials and toxic gases. The research team developed a new material for the detector that can sense alkane fuel, a key ingredient in such combustibles as gasoline, airplane fuel and homemade bombs.

Dan Hixson/University of Utah College of Engineering

Such a small sensor device that can detect alkane vapour will benefit three main categories: oil pipelines, aeroplane fuel tanks and security.

If leaks from pipelines are not detected early enough, the resulting leaked oil could contaminate the local environment and water sources. Typically, only large leaks in pipelines can be detected if there is a drop in pressure. Zang's portable sensor – when placed along the pipeline – could detect much smaller leaks before they become bigger.

Fuel for aircraft is stored in removable 'bladders' made of flexible fabric. The only way a leak can be detected is by seeing the dyed fuel seeping from the plane and then removing the bladder to inspect it. Zang's sensors could be placed around the bladder to warn a pilot if a leak is occurring in real time and where it is located.

The scanner will be designed to locate the presence of explosives such as bombs at airports or in other buildings. Many explosives use fuel oils like diesel as one of its major components. These fuel oils are forms of alkane.

University of Utah

Chinese traditional medicines: do you know what you are buying?

iStockphoto/marilyna

Chinese medicines are manufactured and distributed all over the world. Many people perceive them as natural, even benign and with few side effects, but regulation of human medicines fluctuates widely in different countries. Are they really as safe as we think? Previous studies have found conflicting evidence of the presence of hazardous chemicals such as arsenic and mercury in Chinese medicines. Now a new research paper recently published by Dr Etsuko Furuta (Ochanomizu University, Japan) and Professor Nobuaki Sato, (Tohoku University, Sendai, Japan) in *Toxicological & Environmental Chemistry* (doi: 10.1080/02772248.2015.1135927), raises questions about what controls should be implemented regarding the use, importation and production of Chinese medicines.

Furuta and Sato have published analyses of the chemical make-up of 32 Chinese medicines; 21 samples were purchased online and the rest were purchased from Japanese markets and pharmaceutical companies. The authors employed two non-dissolving methodologies to test the medicines: instrumental neutron activation analysis (INAA) to examine the concentrations of any hazardous elements present, and X-ray diffraction (XRD) to determine chemical structures of elements present in high concentrations. The results from these tests showed the presence of As and Hg in all samples. Additionally, the results showed that medicines with identical names but different places of production had considerably inconsistent concentrations of these hazardous elements. These tests also revealed that the use of INAA and XRD together yielded the most accurate results for quantitative and structural analysis. XRD alone failed to detect low levels of As and Hg in some samples but without it the chemical structure of elements present could not be determined; this a key indicating factor for user safety, putting results of previous, less thorough, examinations in doubt.

Most of the Chinese medicines purchased had no ingredient sheet, which would make product evaluation difficult for the customer. However, those that did have an ingredient sheet were not always right; tests revealed the presence of unlisted hazardous ores and again widely varying concentrations of others or different ingredients in identically named medicines. Furuta and Sato point out that raised levels of Hg are likely due to environmental contaminants, yet another indicator for the need for stricter regulation of Chinese medicines and their use.

This study reveals a very unclear picture of safety in Chinese medicines. Despite their historically unregulated use, the authors urge for tighter controls on importation, better information on their chemical structures, and thorough consultation with a doctor before regular use. Their conclusion is clear: 'a long-term continuous consumption of these herbs should be avoided.'

Taylor & Francis

X-ray technology helps map indigenous artefacts

Researchers from Flinders University in South Australia have managed to use advanced X-ray technology from the Australian Synchrotron Facility in Melbourne to analyse Aboriginal artefacts without the need for sample extraction.

Old European-style portrait artworks have been analysed by X-ray fluorescence microscopy, but the new research allows for more delicate artefacts such as bark paintings to be examined while remaining intact.

Flinders University researcher Dr Rachel Popelka-Filcoff MRACI CChem said although the technique had been used in European-style canvas paintings, this was the first time it was used on Indigenous objects.

'The compilation of these data into elemental maps allows further insights into the composition, application and layering of natural pigment on the Xscale, and further cultural interpretation of the objects, as well as expanding the capability of the (synchrotron beamline) technique towards complex analytical problems.'

Using the XFM beamline at the Australian Synchrotron in Melbourne, Popelka-Filcoff joined South Australian Museum and University of South Australia researchers in analysing two different Australian Indigenous objects, a boomerang and bark painting from the museum's Australian Aboriginal Culture Collection.

'The findings from across Australia will help to reconstruct ancient exchange routes, provenance of Indigenous art and objects, and other unprecedented analysis to help conservation and authentication studies,' Popelka-Filcoff said.

'We have been looking at the bulk analysis of these pigments from known sources, but there hasn't really been any work done on the really fine paintings. The technology had not really been there to examine them.

Dr Rachel Popelka-Filcoff with some of the artefacts.

'At the Synchrotron we are able to do things with a spot size of about five microns or less. We can create an elemental map of the pigments on the object that gives us an idea of the composition and structure of the pigments, how they were applied and the thickness.

'There is no need for a vacuum, no need to take physical samples, and we get a wealth of information.'

The high sensitivity x-ray fluorescence detector allows for a low radiation dose, returning larger amounts of data than other traditional X-ray methods.

'One of the reasons we are so excited to have this published is because it's not just important in understanding indigenous cultures in Australia, but to understand indigenous cultures worldwide,' Popelka-Filcoff said.

The latest findings have been published by the Royal Society of Chemistry in *Analyst* (doi: 10.1039/C5AN02065D).

Flinders University

Geochem team to research dinosaur extinction impact crater

Curtin University WA-Organic and Isotope Geochemistry researchers will play a key role in an international project that will see scientists drill into the 180-kilometre-wide Chicxulub Impact Crater associated with the dinosaur extinction event. The researchers aim to understand how life recovered and repopulated Earth following the catastrophic asteroid impact event 66 million years ago.

Associate Professor Marco Coolen, geomicrobiologist and ancient DNA expert, will be the only representative from Australia to visit the drilling location in Mexico to obtain samples for the team's research.

The drilling project aims to reach 1500 metres below the ocean floor into the crater's 'peak ring'. The samples will be frozen and shipped to Curtin University for further analysis by the WA-Organic and Isotope Geochemistry team and the John de Laeter Centre.

John Curtin Distinguished Professor Kliti Grice FRACI CChem, a molecular fossil and stable isotopic expert of mass extinctions, said the team will be applying an innovative approach to combine geological, biological and geochemical tools to study the environmental factors accompanying life during and after the impact event.

'It is estimated that close to the impact, greater than 50% of species became extinct, including calcifying plankton, whereas non-calcifying organisms recovered from the event,' Grice said.

'Research associated with this end-Cretaceous event is the most closely related to the rise of our current CO_2 concentrations, which saw the levels rise at least approximately four times more than present levels,' Grice said.

Curtin University Associate Professor Fred Jourdan, a geologist and expert on argon dating and the causes of mass extinctions, explained that this end-Cretaceous period extinction event is currently the only one that can be associated with an asteroid impact event and volcanic activity 66 million years ago.

'Other extinctions are associated solely with voluminous volcanic activity, which affected the biogeochemical cycles and microbial communities in the ancient seas,' Jourdan said.

Curtin University

Scientists discover how medicinal plant makes anti-cancer compound

New research led by Professor Cathie Martin of the John Innes Centre, UK, has revealed how a plant used in traditional Chinese medicine produces compounds that may help to treat cancer and liver diseases.

***Scutellaria baicalensis* may help to treat cancer and liver diseases.**
Qing Zhao, Chinese Academy of Sciences

The Chinese skullcap, *Scutellaria baicalensis* – otherwise known in Chinese medicine as Huang-Qin – is traditionally used as a treatment for fever, liver and lung complaints.

Previous research on cultured cells has shown that flavones found in the roots of this plant not only have beneficial anti-viral and anti-oxidant effects, but they can also kill human cancers while leaving healthy cells untouched. In live animal models, these flavones have also halted tumour growth, offering hope that they may one day lead to effective cancer treatments, or even cures.

As a group of compounds, the flavones are relatively well understood. But the beneficial flavones found in Huang-Qin roots, such as wogonin and baicalin, are different: a missing hydroxyl group in their chemical structure left scientists scratching their heads as to how they were made in the plant.

Professor Cathie Martin, lead author of the paper published in *Science Advances* (doi: 10.1126/sciadv.1501780), explained: 'Many flavones are synthesised using a compound called naringenin as a building block. But naringenin has this –OH group attached to it, and there is no known enzyme that will remove it to produce the flavones we find in Huang-Qin roots.'

Working in collaboration with Chinese scientists, Martin and her team explored the possibility that Huang-Qin's root-specific flavones (RSFs) were made by a different biochemical pathway. Step by step, the scientists unravelled the mechanism involving new enzymes that make RSFs using a different building block called chrysin.

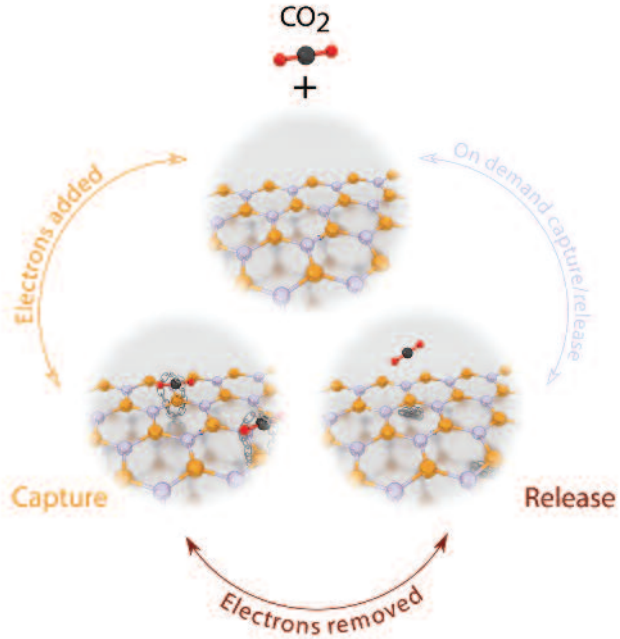
'We believe that this biosynthetic pathway has evolved relatively recently in *Scutellaria* roots, diverging from the classical pathway that produces flavones in leaves and flowers, specifically to produce chrysin and its derived flavones,' said Martin.

'Understanding the pathway should help us to produce these special flavones in large quantities, which will enable further research into their potential medicinal uses. It is wonderful to have collaborated with Chinese scientists on these traditional medicinal plants. Interest in traditional remedies has increased dramatically in China since Tu Youyou was awarded the Nobel Prize for Medicine in 2015 for her work on artemisinin. It's exciting to consider that the plants which have been used as traditional Chinese remedies for thousands of years may lead to effective modern medicines.'

John Innes Centre

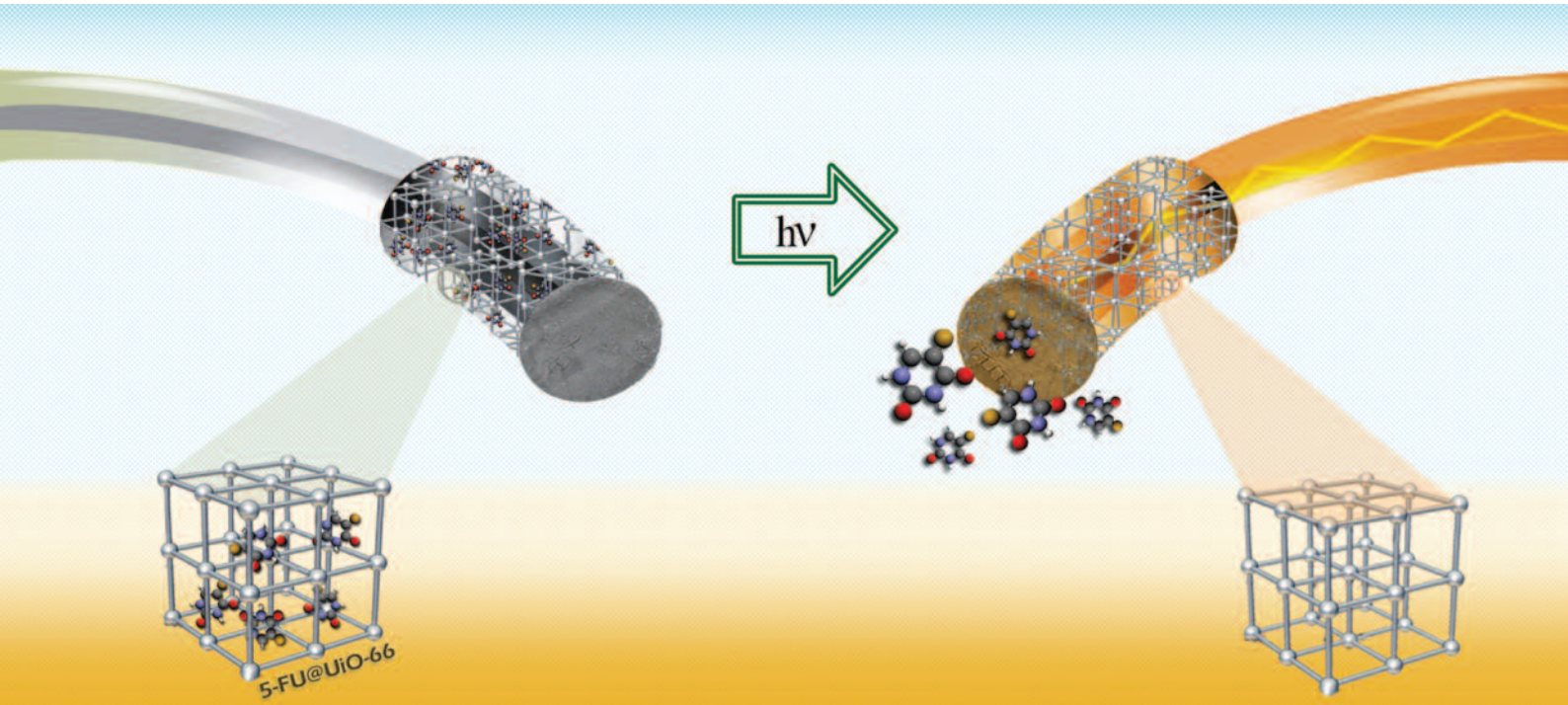
CO_2 capture and H_2 storage: solving Goldilocks' dilemma

Current materials for capturing carbon from power plant exhaust tend to bind CO_2 too effectively. This causes problems when the carbon needs to be released again for sequestration or recycling. The same problem exists for hydrogen-storage materials, which should ideally load hydrogen quickly at the pump and then release it on demand for the automobile's fuel cell. The material will not load quickly if H_2 binding is too weak, but it will not release on demand if the binding is too strong. Professor Sean Smith and the team at the Integrated Materials Design Centre (IMDC) at the University of New South Wales run first-principles materials simulations to reveal new approaches for carbon capture and hydrogen storage. The IMDC team has recently identified several conductive materials that adopt stronger binding with CO_2 and with H_2 when electrically charged (Tan X., Kou L., Tahini H.A., Smith S.C. *Sci. Rep*. 2015, **5**, 17636; *ChemSusChem* 2015, **8**, 3626–31). When the materials are neutral there is very weak binding; but if the charge is modulated, they can bind and release CO_2 and H_2 quite effectively. The IMDC team is running calculations to predict the binding strength and voltage response profiles in order to find a new way around the thermochemical 'Goldilocks problem'.

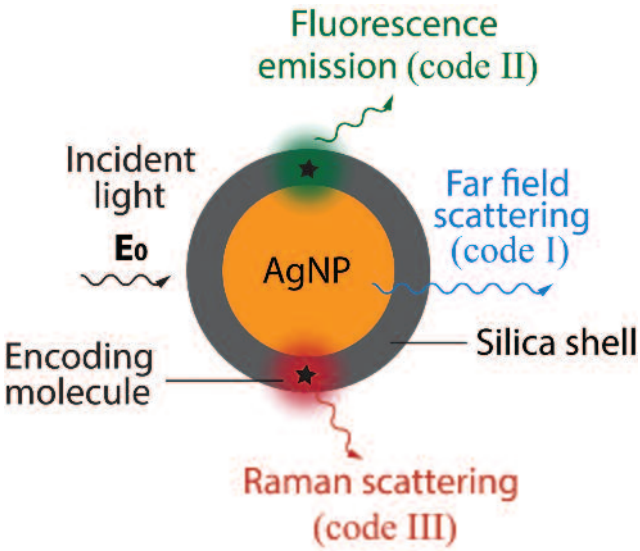


Light-triggered drug delivery

Physical delivery of anticancer drugs to controlled anatomic locations can complement advances being made in chemo-selective therapies. To this end, Dr Matthew Hill and co-workers at CSIRO, Institut de Ciència de Materials de Barcelona, Monash University and Victoria University have developed a metal–organic framework (MOF)-based drug-delivery device (Nazari M., Rubio-Martinez M., Tobias G., Barrio J.P., Babarao R., Nazari F., Konstas K., Muir B.W., Collins S.F., Hill A.J., Duke M.C., Hill M. R. *Adv. Funct. Mater.* 2016, doi: 10.1002/adfm.201505260). To make the device, the surface of an optical fibre catheter was plasma etched, which allowed it to be coated with a thin layer of the MOF UiO-66. The anticancer drug 5-fluorouracil (5-FU) was then sublimated and stored within the MOF pores. Delivery of light of an appropriate wavelength through the fibre catheter was found to trigger the release of 5-FU on demand, offering a new route to localised drug administration. The system exhibits great potential, delivering sufficient drug to treat a tumour from less than 1 mm of optical fibre.



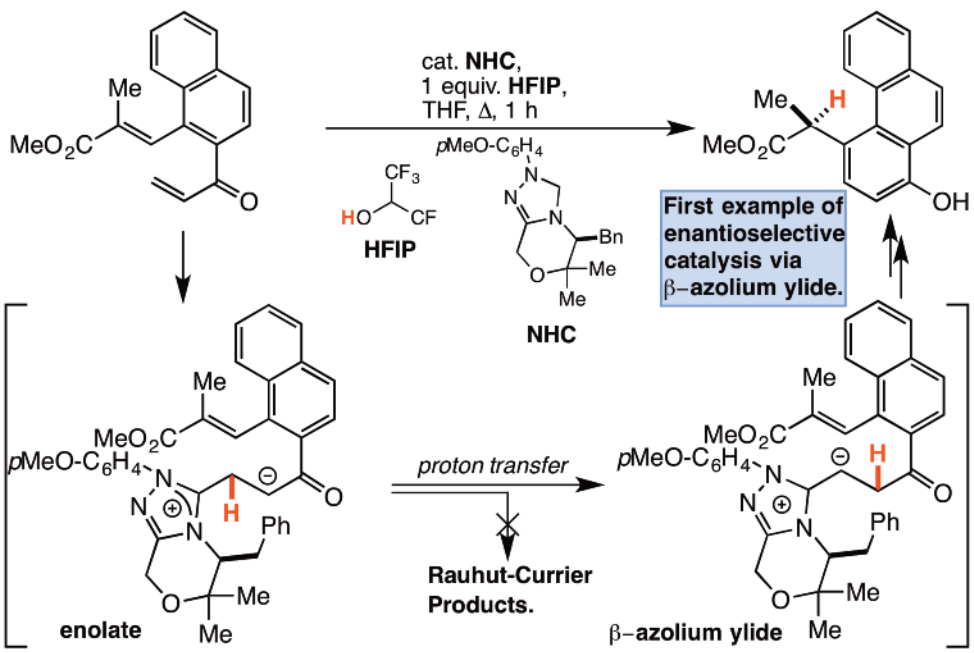
Unclonable plasmonic security labels



Optical multiplexing plays a key role in applications such as optical data storage, anti-counterfeiting, bioimaging and molecular sensing. Conventional optical information carriers usually support only one optical phenomenon, either fluorescence (e.g. dyes, quantum dots and up-conversion nanoparticles) or light scattering (e.g. photonic crystals). In contrast, plasmonic (metal) nanoparticles that exploit electronic resonance with optical radiation are able to interact with light in multiple fashions. This leads to the generation of multiple optical signals, such as far-field scattering, fluorescence and Raman scattering. In collaboration with researchers at Monash University, the group of Professor Justin Gooding at the University of New South Wales has recently developed a low-cost, non-destructive, unclonable anti-counterfeiting strategy that takes advantage of smartphone-readable multiplex plasmonic nanoparticles as information carriers (Zheng Y., Jiang C., Ng S.H., Lu Y., Han F., Bach U., Gooding J.J. *Adv. Mater.* 2016, **28**, 2330–6). The security labels were fabricated by shadow-mask-lithography-assisted self-assembly using multifunctional fluorescein-embedded silver@silica core–shell nanoparticles as building blocks. The multiple optical signals emitted by the nanoparticles can be assigned as spectral codes for security and anti-counterfeiting applications. The produced security labels look the same from batch to batch on the macroscopic level; however, at the nanoscopic level, they are quite different from each other. This makes the security labels unique and unclonable.

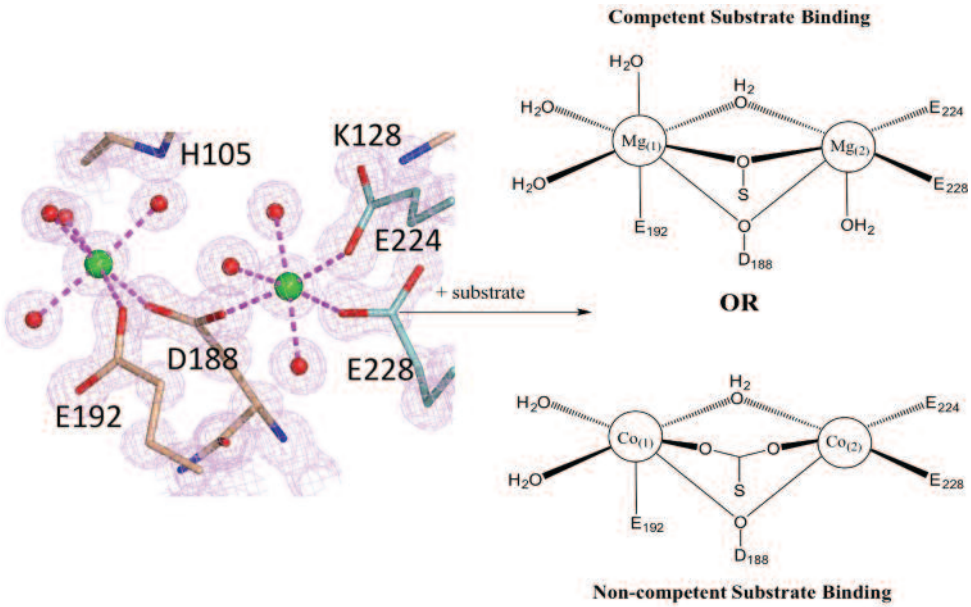
Proto(n)-type: first enantioselective catalysis via the β-azolium ylide

Studies by Associate Professor David Lupton at Monash University have focused on N-heterocyclic carbene (NHC) organocatalysis, particularly as it relates to the generation of novel reactivity patterns with acyl azoliums. NHC organocatalysis has flourished in the last 20 years, moving beyond the Breslow intermediate to encompass a diverse range of reactive intermediates now. While many have received significant attention, others, such as the β-azolium ylide, have largely been overlooked. Though reported 10 years ago, this intermediate has for the most part been ignored in reaction discovery. Research by Associate Professor David Lupton and Yuji Nakano has recently led to the discovery of the first enantioselective reaction proceeding via the β-azolium ylides. The transformation provides 2-aryl propionates from enones, in up to a 91:9 enantiomeric ratio and 96% yield, while showing robustness and good generality (Nakano Y., Lupton D.W. *Angew. Chem. Int. Ed.* 2016, **55**, 3135–9). Remarkably, initial formation of an enolate does not provide Rauhut–Currier products, but is instead followed by proton transfer to provide the β-azolium ylide. Examination of the impact of alcohol-containing additives has demonstrated that a series of proton transfer events are integral to the enantioselectivity of the reaction.



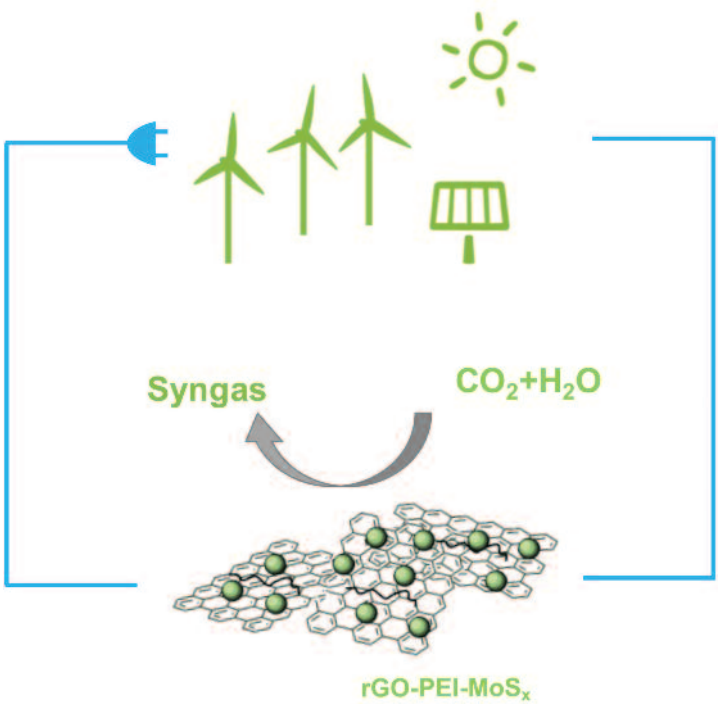
Novel target to treat tuberculosis

The alarming increase in drug resistance by *Mycobacterium tuberculosis* is a major threat to global health. Ketol-acid reductoisomerase (KARI) is an essential NADPH-dependent enzyme in the branched-chain amino-acid biosynthesis pathway of plants and microorganisms, including *M. tuberculosis*, and catalyses the concerted isomerisation and reduction of substrates such as 2-acetolactate. KARI is not present in humans and is thus an ideal new target to combat tuberculosis. The groups of Professors Gerhard Schenk and Luke Guddat at the University of Queensland have recently solved the crystal structure of KARI from *M. tuberculosis* to 1.0 Å (Lv Y., Kandale A., Wun S.J., McGeary R.P., Williams S.J., Kobe B., Sieber V., Schembri M.A., Schenk G., Guddat L.W. *FEBS J.* 2016, **283**, 1184–96, and demonstrated that only Mg^{2+} can promote catalysis, whereas the substrate binds in a non-competent mode in the presence of other metal ions (e.g. Co^{2+}), thus inhibiting the reaction (Tadrowski S., Pedroso M., Sieber V., Larrabee J., Guddat L.W., Schenk G. *Chem. Eur. J.* 2016, doi: 10.1002/chem.201600620). These observations pave the way to develop urgently needed new drug leads to deal with a major global disease.

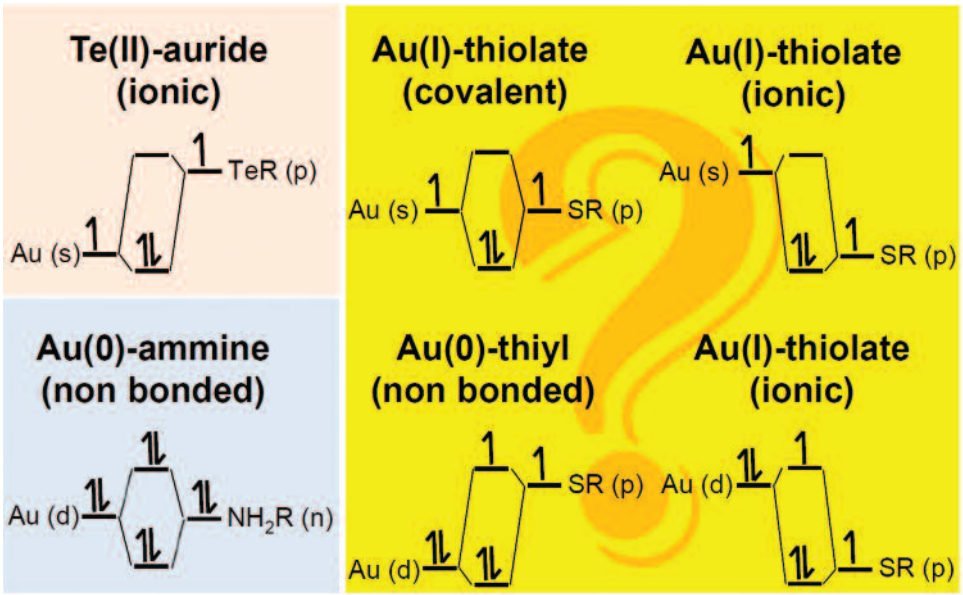


Renewable fuels from CO_2 using cheap efficient catalysts

Despite tremendous efforts being made to implement renewable energy sources, there remains a need in the long term to generate liquid fuels sustainably for applications such as transportation. Electrochemical reduction of captured CO_2 to produce fuels using renewable energy as a power source could potentially provide a solution to this problem. However, current electrocatalysts for this reaction generally suffer from high cost, low energetic efficiency and/or poor product selectivity. On the contrary, in nature, molybdenum- or tungsten-containing formate dehydrogenases (FDH) can efficiently and selectively catalyse electrochemical reduction of CO_2 to formate. Inspired by the structure of the active sites in FDH, researchers from Monash University have synthesised a novel and cheap electrocatalyst consisting of amorphous molybdenum sulfide (MoS_x) immobilised on a polyethylenimine (PEI)-modified reduced graphene oxide (rGO). The catalyst can efficiently convert CO_2 into a hydrogen/CO mixture similar to syngas (Li F., Zhao S.-F, Chen L., Khan A., MacFarlane D.R., Zhang J. *Energy Environ. Sci.* 2016, **9**, 216–23). Syngas in this form can be used to form methanol directly. This promising rGO-PEI-MoS_x composite catalyst may pave a new way towards efficient CO_2 reduction catalysis based on inexpensive noble-metal-free materials.

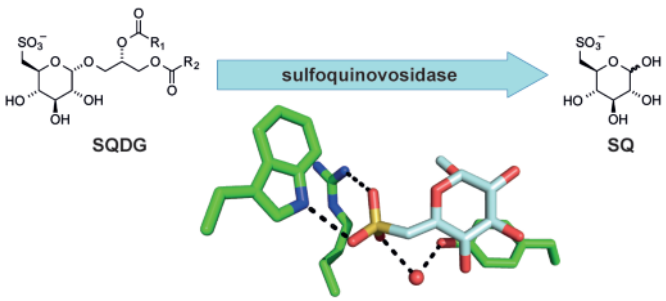


How sulfur binds to gold



Alternative descriptions of chemical bonding are often mere questions of semantics, but recent work by Professors Jeffrey Reimers and Noel Hush and co-workers at Shanghai University, University of Technology Sydney, the University of Sydney, and the Danish Technical University shows that understanding bonding is critical to understanding the synthesis of sulfur-bound self-assembled monolayers on gold or gold nanoparticles (Reimers J.R., Ford M.J., Halder A., Ulstrup J., Hush N.S. *Proc. Natl Acad. Sci. USA* 2016, **113**, E1424–33). The Au–S bonding has been assumed to be of the Au^{I}-thiolate form found in many small molecules, but reaction conditions optimised to make such products lead instead to surface etching. However, gold surfaces are noble and cannot bond this way using their s electrons. Instead they interact with sulfur through their filled d band via strong van der Waals interactions, binding as Au^{0}-thiyl. Reactions that exploit this bonding result in surface protection rather than etching. This work establishes the first broad understanding of Au–S chemical reactivity, leading to the discovery of a key intermediate species in the Brust–Schiffrin synthesis, the most common method used now to make gold nanoparticles. It also shows that Au-S bonding fits smoothly into periodic-table variations and explains its 'anomalous' surface spectroscopy.

Sweet discovery in leafy greens

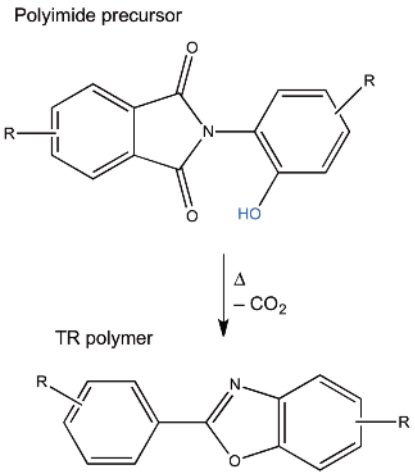


Ten billion tonnes of the sulfur-containing sugar sulfoquinovose (SQ) are produced annually by photosynthetic organisms. The amount of sulfur in this sugar rivals that used in the total annual biosynthesis of the essential amino acids cysteine and methionine. As such, SQ plays a critical part in the cycling of sulfur in the biosphere. The major form of SQ is a sulfolipid called sulfoquinovosyl diacylglyceride (SQDG). The research groups of Professor Spencer Williams at the University of Melbourne and Dr Ethan Goddard-Borger at the Walter and Eliza Hall Medical Institute, and colleagues in the UK, have reported the discovery of the first enzyme (a sulfoquinovosidase or SQase) dedicated to releasing SQ from SQDG (Speciale G., Jin Y., Davies G.J., Williams S.J., Goddard-Borger E.D. *Nat. Chem. Biol.* 2016, **12**, 215–7). SQases are glycosidases, and release SQ so that it can undergo sulfoglycolysis, a catabolic process supporting primary metabolism that produces ATP and pyruvate. The work defined the characteristic features of SQases, and bioinformatics was used to reveal the widespread occurrence of SQases across the tree of life. It is speculated that consumption of leafy green vegetables in the diet, which are rich in SQDG, may promote the growth of beneficial gut bacteria, such as *E. coli*, which express SQase and are capable of sulfoglycolysis.

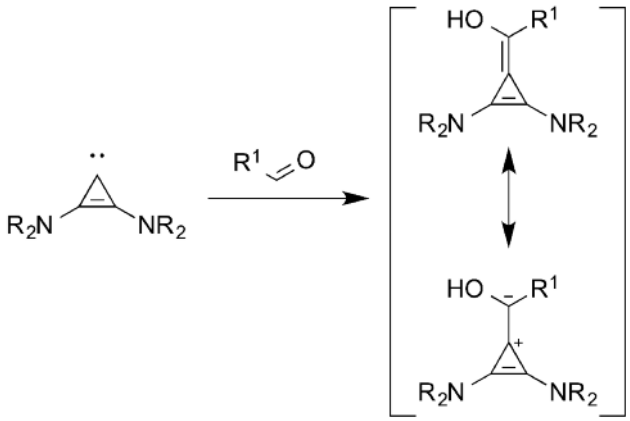
Compiled by **David Huang** MRACI CChem (david.huang@adelaide.edu.au). This section showcases the very best research carried out primarily in Australia. RACI members whose recent work has been published in high impact journals (e.g. *Nature*, *J. Am. Chem. Soc.*, *Angew. Chem. Int. Ed.*) are encouraged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

Highlights of the June issue

Two reviews and a focus article are highlights of the June issue of *Aust. J. Chem*. Colin A. Scholes of the Department of Chemical and Biomedical Engineering, University of Melbourne, provides a comprehensive overview of thermally rearranged poly(benzoxazole) (TRPBO) copolymer membranes for high-performance gas separation. Their superior mechanical properties together with chemical resistance promise considerable application in industrial gas separation. The underlying chemistry for their preparation and separation performance is described.



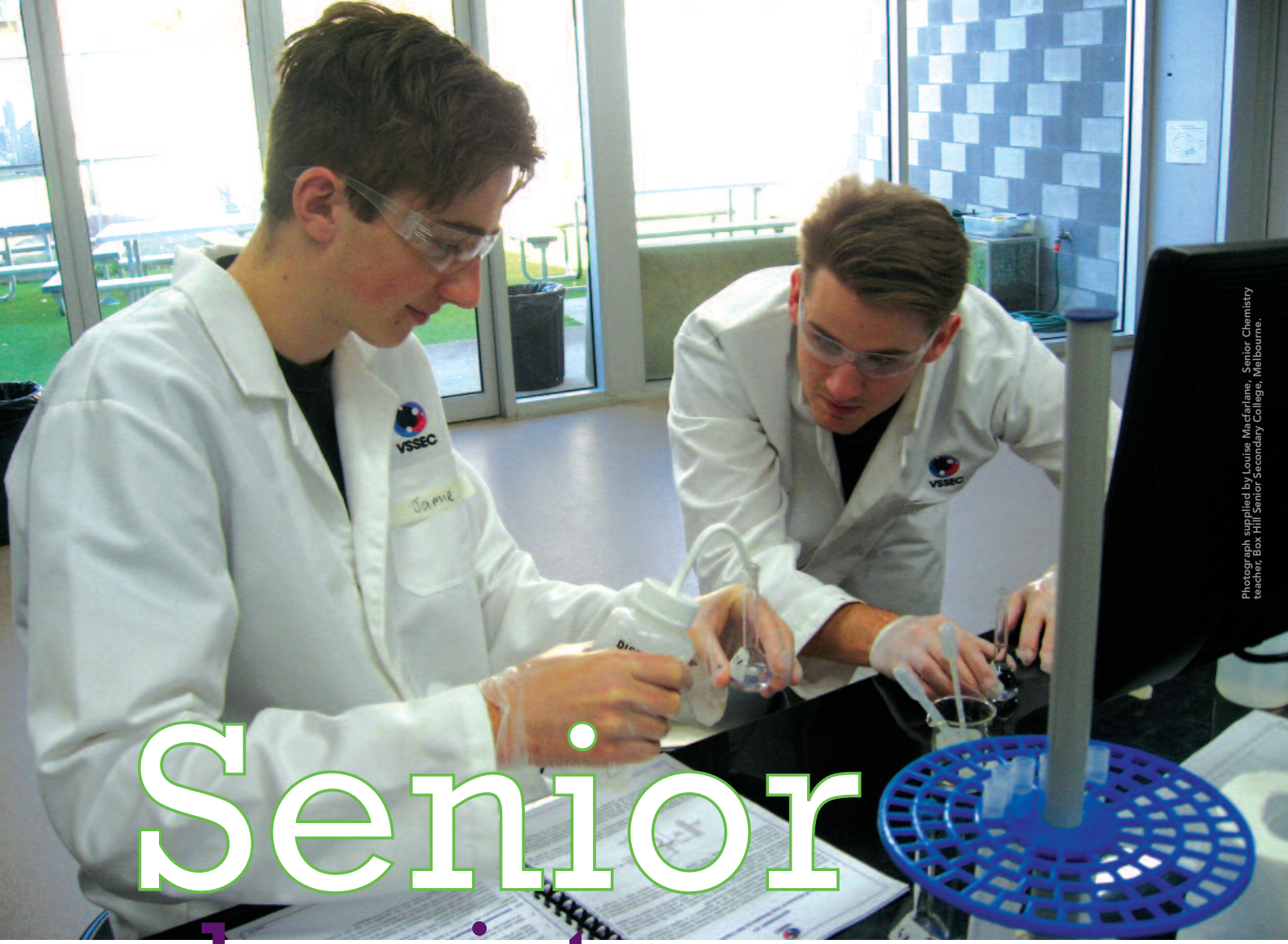
The C–S cross-coupling reaction of aryl halides with thiols or sulfur is an important synthetic transformation reaction in chemistry and medicine. The review by Lotfi Shiri and colleagues at the Department of Chemistry, Ilam University, Iran, is a detailed description of the use of metal-based nanocatalysts in such reactions. A focus is provided on three separate metallic catalysts, Cu, Pd, Ni and In, Fe304, and copper ferrite nanoparticles. A clear overview of the recovery and reuse of these nanocatalysts is also provided.



On the subject of organic catalysts, Reece Crocker of the School of Chemistry, University of Sydney, provides a research focus on the use of bis(amino)cycloproenylidenes (BACs) as alternatives to the more commonly employed N-heterocyclic carbenes. BACs were originally developed as organometallic ligands and, despite lacking satisfactory stereochemistry induction from their chirality, are now acknowledged to be highly promising organocatalysts with important applications to organic chemistry.

The issue is complemented by 10 research articles, including a contribution by Angel Ramos-Organillo and colleagues at the University of Colima, Mexico, describing the preparation of new silicon-containing amide and esters derived from ibuprofen. The amide analogues showed significantly improved ability to bind to nuclear transcription factor κβ (which is directly associated with the mechanism of onset of inflammation) and yet showed no increase in toxicity. The results suggested these new compounds may be suitable lead molecules for the development of novel therapeutics against inflammation.

George Koutsantonis FRSC, FRACI CChem and **John D. Wade** FRSC, FRACI CChem, Co-Editors-in-Chief, *Australian Journal of Chemistry*



Photograph supplied by Louise Macfarlane, Senior Chemistry teacher, Box Hill Senior Secondary College, Melbourne.

Senior chemistry Victoria's new study design

An engaging and challenging new study design for VCE Chemistry has arrived.

BY **JENNY SHARWOOD**

At no time has it been more important for the future of Australia for us to inspire and empower students to be innovative, creative and critical thinkers, informed participants in solving the major issues of our time, responsible and contributing citizens and highly skilled researchers, scientists and applied scientists, mathematicians, technology experts, academics, engineers, skilled workers, educators and communicators. This is why Australia's Chief Scientist, Dr Alan Finkel, and his predecessor, Professor Ian Chubb, the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering, and many other leading scientists and educators are doing all they can to increase enrolments in STEM subjects across Australia.

This year an exciting new VCE Chemistry study design has been introduced in Victoria. It is the product of ongoing research, analysis and evaluation of chemistry study designs and examinations across the world and across Australia and aims to achieve international best practice.

In Victoria, enrolments in VCE Chemistry continue to increase, with

an almost 50 : 50 gender ratio. This revised study design also aims to inspire students to continue to enrol in Chemistry, a key STEM subject, in their senior years, so that they have many options for their future studies and careers. To that end, the study design was developed in conjunction with wide consultations with many experts in the field, including researchers in chemistry and chemistry education, industry leaders, as well as chemistry lecturers and teachers.

Key study design features

A focus on student independent learning, scientific inquiry and communication underpins the structural and assessment changes in the new VCE Chemistry study design.

The key features of the new study design are:

- its thematic approach, with each of the four semesters based on a different and very relevant theme that is meaningful to students
- the embedding of science as a human endeavour across the key knowledge and key skills
- its focus on the development of science investigation skills, thinking skills and science communication skills, including, where possible, student-designed investigations, site tours and field trips
- opportunities for students to apply and further develop their skills in independent learning, and to direct their own learning through their self-selection of areas of interest for investigation, including generation and analysis of both primary and secondary data
- its introduction to key quantitative concepts and skills through practical, meaningful contexts, such as its introduction to stoichiometry through the context of gravimetric and volumetric analysis of water, and to gas laws, gas stoichiometry and thermochemistry through the context of the combustion of fuels
- opportunities to build research skills and critical thinking skills through investigations of a number of major current chemical issues, including, where possible, meeting experts in the field
- opportunities to investigate modern developments in chemistry, such as nanochemistry, synchrotron applications, designer materials and fuel cells.

Compared with other states and territories, Victoria's new study design maintains the higher proportion of quantitative application work that is traditionally taught in Victoria. The study design also still includes a range of analytical techniques, including volumetric, gravimetric and instrumental analysis. A new feature is the inclusion of instrumental analysis in the new Unit 2, when students investigate water quality. Students use colorimetry and/or UV–visible spectroscopy and also analyse results from AAS and HPLC analyses.

Through the study of instrumental analysis across Units 2–4, students gain a 'taste' of real-world, current chemical endeavour. In fact, many teachers take their students to analytical laboratories so they can observe and even participate in instrumental analyses, which makes this area of work all the more meaningful and relevant for students and enables them to learn about the scientific approach to investigations from practising chemists and to appreciate its importance.

The four themes of the study design, one per unit, are each presented as a challenging 'big' question in order to promote scientific inquiry. Each unit is divided into areas of study, which also are presented as key questions (see p. 23).

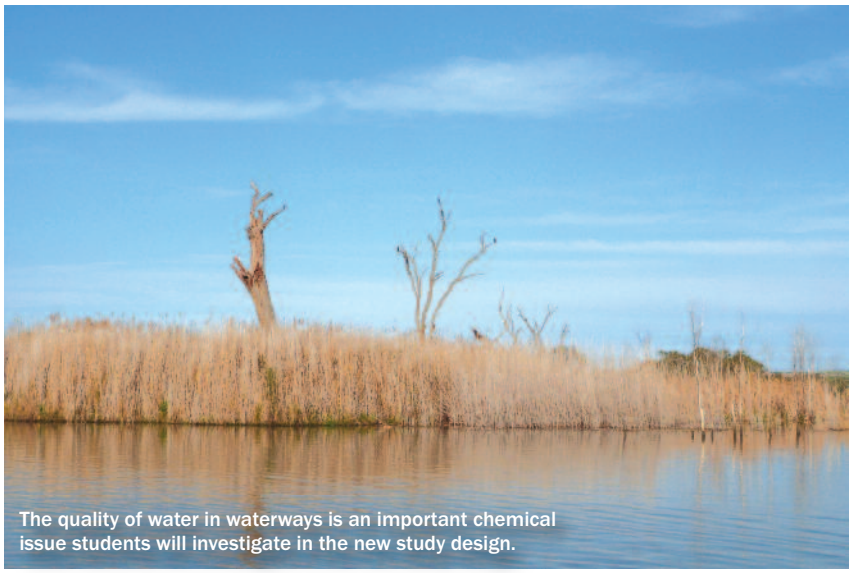
Anecdotally, Victorian students and teachers report that they really enjoy the challenge of quantitative and analytical chemistry, especially the challenge of deducing an unknown organic structure from MS, IR and NMR analyses, because it is like solving a puzzle.

Building science investigation skills

Units 1 and 2 each consist of three areas of study. In the first two areas of study, students not only build their key knowledge and understanding of that thematic content, but also develop and apply a range of thinking skills and science skills in the process. The third area of study requires students to undertake extended scientific investigations. In Unit 1 this may include practical laboratory investigations as well as research using a range of resources. In Unit 2 students undertake an extended practical laboratory investigation, which may include a field trip to take water samples, and/or a site tour.

Units 3 and 4 each consist of two areas of study in which students build their key knowledge and understanding, as well as undertake laboratory investigations. As they hone their science skills and thinking skills, students gain more experience in analysing and evaluating experimental findings and experimental designs and in suggesting how they can be improved. These skills are applied in an additional area of study that is undertaken at a time of the year selected by the classroom teacher.

... Victoria's new study design maintains the higher proportion of quantitative application work that is traditionally taught in Victoria.



The quality of water in waterways is an important chemical issue students will investigate in the new study design.

In this area of study, students design and perform their own extended laboratory investigations and report on them in the form of a scientific poster. While the experiment may be designed and performed in partnership with another student, each student must independently process their results, draw their own conclusions and analyse and evaluate their findings and suggest how the experimental design can be improved and extended.

This work and other assessment tasks performed by the students over the year will contribute 40% towards a student's final VCE Chemistry study score. An external examination, held in November, covers the knowledge and skills developed across Units 3 and 4 and will contribute 60% towards a student's final VCE Chemistry study score.

Investigation of issues related to chemistry

Issues related to chemistry that can be considered in this study design include safety issues that might be involved in the use of nanoparticles, chemical manufacturing and waste management, water pollution, ocean acidification, non-renewable versus renewable energy resources, and the use of natural and artificial sweeteners in food.

Students are expected to investigate particular issues, critically examine the arguments and supporting evidence presented in the media and other resources, draw their own conclusions and communicate their findings.

Supporting and inspiring teachers and students

A program of implementation workshops as well as information sessions held at teacher conferences, which have been run by the Victorian Curriculum and Assessment Authority, as well as support material, has helped teachers prepare for the wide-ranging changes in this new study design. As a result, the new study design has been well received by most teachers.

Chemistry teachers with whom I have spoken have made comments such as 'I like the thematic approach. It makes chemistry relevant and meaningful and the course more cohesive' and 'I am really pleased that food chemistry is there'. Others have said that they thought that the greater emphasis on scientific skills will help students build stronger laboratory skills and understandings, and that they are very relieved that instrumental analysis has been retained. Those who were initially cautious about the idea of reporting an investigation by means of a scientific poster and have attended workshops on this new aspect of the curriculum can now see that it will foster some very worthwhile and widely used skills.

I believe that the new study design will really engage and challenge students and teachers alike. I look forward to hearing their feedback as they experience it for themselves.

But chemistry teachers will need as much support as possible. Here the RACI can make a significant contribution, particularly in the areas of site tours, analytical laboratories, chemistry updates and updated training in science investigation and laboratory skills. The Victorian Chemical Education Group would be most interested to hear from RACI members who may be able to help in this regard.

In the meantime, the Victorian Chemical Education Group, in partnership with the Victorian Branch, are offering VCE chemistry students and teachers a range of opportunities to build their interest in and enthusiasm for chemistry. These include the Titration Stakes, the Hartung Youth Lectures, the exciting new 'Chemistry is Everywhere – Bubble Mania' program, the essay and art competitions and the Australian National Chemistry Quiz, which is now entered by students from many other countries as well as from across Australia.

Further information

The new VCE Chemistry study design can be found at:

- www.vcaa.vic.edu.au/Pages/vce/studies/chemistry/chemunits1and2.aspx
- www.vcaa.vic.edu.au/Pages/vce/studies/chemistry/chemindex.aspx

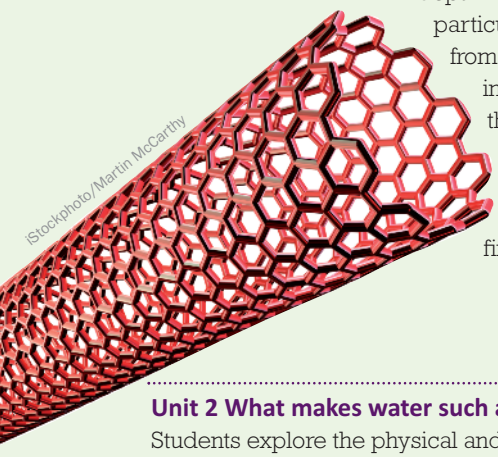
Units 1 and 2 of this new VCE Chemistry study design (usually studied in Year 11) are being implemented this year. Units 3 and 4 (usually studied in Year 12) will be implemented in 2017.

Jenny Sharwood MRACI CChem is a retired VCE chemistry teacher and was a member of the VCE Chemistry Review Panel. She continues to be a chemistry and education writer, is actively involved in the RACI Australian National Chemistry Quiz and has rejoined the RACI Victorian Chemistry Education Group this year.

VCE Chemistry: the four themes

Unit 1 How can the diversity of materials be explained?

Students investigate the properties of a range of materials from ionic compounds and metals to polymers and nanomaterials, and the reasons for those properties. In the process, they investigate the structure of the atom, the modern periodic table, and the relationship between structure and bonding and properties. They also investigate how materials may be modified to better suit particular purposes and are introduced to mole theory and the relative sizes and masses of particles. This culminates in an in-depth investigation of one particular aspect of materials from a range of options, including the application of the principles of green chemistry to chemical manufacturing, and communication of the findings.



iStockphoto/Martin McCarthy

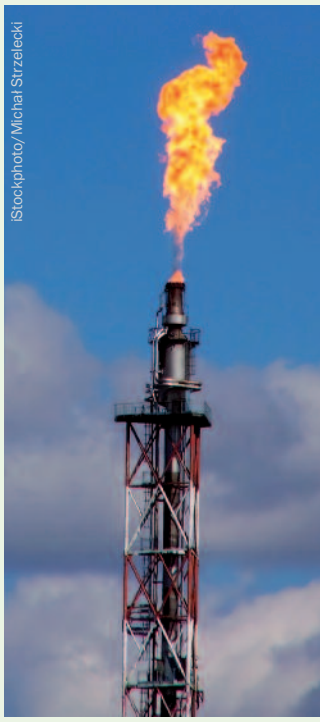
Unit 2 What makes water such a unique chemical?

Students explore the physical and chemical properties of water and explain them in terms of its structure and bonding. They investigate solutions and solubility, pH and reactions in water including acid–base, redox and precipitation reactions. They are introduced to stoichiometry and solution concentration. This leads to a study of various analytical techniques for determining the concentrations of salts, acids and bases and organic contaminants in water, including acid–base titrations, gravimetric analysis and instrumental analysis. With this foundation behind them, students then design and conduct their own investigation of some aspect of water quality.

iStockphoto/kot2626

Unit 3 How can chemical processes be designed to optimise efficiency?

Students explore the combustion of fossil fuels and biofuels, and are introduced to the principles of thermochemistry in this context. They compare these energy resources in terms of factors such as energy efficiency, renewability and impact on the environment. Students also investigate galvanic cells, fuel cells and electrolytic cells and examine and compare their designs and operating principles. They use the electrochemical series to explain and predict the processes occurring in the cells, and apply Faraday's laws. They investigate the application of rate and equilibrium principles behind the selection of optimum conditions for the manufacture of industrial chemicals, and study and apply the equilibrium law and Le Chatelier's principle.



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Unit 4 How are organic compounds categorised, analysed and used?

Students investigate the carbon atom and the reason for the versatility of the design of carbon compounds. They study the structures, systematic names and reactions of key organic families, and predict the products of and also design reaction pathways that are used to synthesise particular organic compounds. They perform volumetric analyses to determine the concentration of organic compounds, and use data from the instrumental analysis of an unknown organic compound (MS, IR and NMR) to deduce its structure. Students then study various food biomolecules in terms of their structures and the reactions used to build them up and break them down. Calorimetry is used to investigate the energy content of various foods.

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The weevil *Cyrtobagous salviniae* on a leaf of the weed *Salvinia molesta*.
Matthew Purcell

Biological control

A case for multidisciplinary research

BY **DEIDRE TRONSON**

Biological control of pest plants involves biology, ecology and a dose of chemistry.

Invasive plants or weeds are usually from 'somewhere else'. These plants are kept in check in their natural environment by being in balance with the soil and weather systems, and also because they are a food source for a range of insects, other animals and microorganisms. Looking in particular at insect–plant relationships, ecologists find that some are very specific, which indicates to me that some herbivores might use chemical signals to detect which plants are the right ones for them.

There are many 'unknown unknowns' of the biological control of pest plant species; but as a result of ongoing research, there are now a few 'knowns'. This article is based on interviews with two researchers in the area of biological control of Australian plants.

Matthew Purcell is the team leader of Biological Control in the Managing Invasive Species Impacts program at CSIRO, and also Director of the US Department of Agriculture, Agricultural Research Service (USDA ARS) Australian Biological Control Laboratory. He is elucidating some complex biology and ecology involved in biological control of pest plants. Dr R. Andrew Hayes, Forest Health Research Fellow at the Forest Industries Research Centre, University

of the Sunshine Coast, undertakes research into the chemical signals (called semiochemistry or infochemistry) that enable plants and other organisms to interact with each other.

I know both these researchers from previous lives, and didn't know that they both work at the Ecosciences Precinct at Dutton Park, Queensland (opened in 2010), which is a large multidisciplinary research centre with over 1000 people working in it from two state government departments, CSIRO, and a few universities.

Matthew Purcell became involved in monitoring our own little biological control agent here at the Centre of the Universe (Werombi, New South Wales). In the mid-1980s, CSIRO researchers introduced the weevil *Cyrtobagous salviniae* to help control an infestation of the water weed *Salvinia molesta* on large farm dams. The larvae and adults of the weevils nibble at the growing points of the weed, which then – eventually – dies and sinks. Both the weed and its predators come from Brazil, but it was only due to perseverance after a couple of false identifications that researchers found exactly the right species of *Cyrtobagous* weevils to control the plant.

The *Salvinia* weed is a problem in many tropical and warm temperate areas all over the world, including Florida, where the same species of weevil has been imported, and usually effects some biological control. However, it is too cold for the Brazilian or Floridian weevils to control the plant in Texas. Matthew and his US collaborators have recently found that 'our' weevils, having been breeding for 30 years in the coolest climatic extreme of their range, have genetically adapted to the cold, so the ongoing plan is to find how to breed cold-adapted weevils (Obeysekara P.T., Knutson A., Mukherjee A., Heinz K.M. *Environ. Entomol.* 2015, vol. 44(6), pp. 1590–8, doi: http://dx.doi.org/10.1093/ee/nvv123).

Matthew defines biological control as 'reuniting invasive insects and plants with their native parasites and herbivores'. His research for the past 30 years has been focused on identifying the many, many insects that naturally keep some Australian plants in balance with their home environment and he has successfully used some of these insects to control

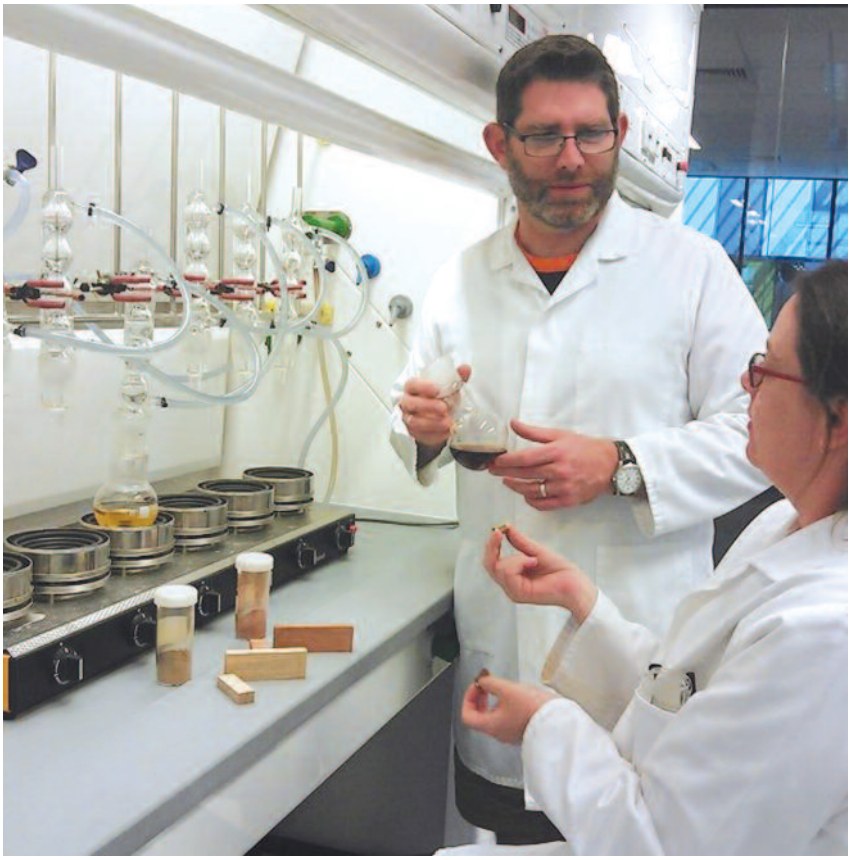
Matthew defines biological control as 'reuniting invasive insects and plants with their native parasites and herbivores'.

Matthew Purcell at the farm dam at Werombi, NSW, collecting the water weed *Salvinia molesta* on which the weevil *Cyrtobagous salviniae* feeds. He really wants the weevils, but they are tiny and hard to see, and for travel to the lab they are best kept on some of the weed. These weevils are adapted to the cold, and will be sent to labs in Texas, US, to compare their genetics with those from other places.

several Australian plants that have run rampant in the US.

One particular menace that once covered 500 000 acres in Florida (including the Everglades) is the Queensland paperbark *Melaleuca quinquenervia*. After a long process of dedicated research, Matthew and his team used the melaleuca weevil, psyllid and stem gallfly to control the invasion as part of an integrated management system approach that also used some chemical control and mechanical removal. As a result of this, flowering has been reduced by 95%, and 85% of saplings that do grow can be removed in some areas (although this is very difficult in the Everglades, which is a 'river of grass' with crumbling underlying limestone). Matthew says he is fortunate to have stayed with his project and seen its development from finding his first potential biological control agent to seeing the unwanted melaleuca in Florida being reduced from 28 000 trees per acre to a manageable and sustainable 4000 trees per acre 15–20 years later. Not many people get to see an overview like that in a field of research.

This is the largest of his many projects in Florida. His successes are due partly to rigorous and painstaking science, coupled with the support of researchers and employers who can take the long view. But success is also partly due to Matthew's personal enthusiasm and passion. When he was a new graduate, he 'visited everywhere and anywhere to get paid or unpaid experience in science'. He received an offer for an interview for a six-month fill-in job at CSIRO, and 'zoomed straight up there and fronted the counter immediately'. Impressed with his enthusiasm, CSIRO hired him. During that time, a US scientist was looking for someone based in Brisbane to search for Australian insects as biological control agents for Australian plants that were pests in Florida. Matthew is still there, doing that 'temporary' job, 30 years later.



Andrew Hayes in the laboratory with Timber Durability Scientist Lesley Francis discussing wood extracts.

What has surprised him in his work with insects is the impact of genetics. His team has found that not all insects of one species will be equally as effective in controlling the plant hosts. New techniques and methodologies are enabling genetics researchers to find more knowns where once were only unknowns.

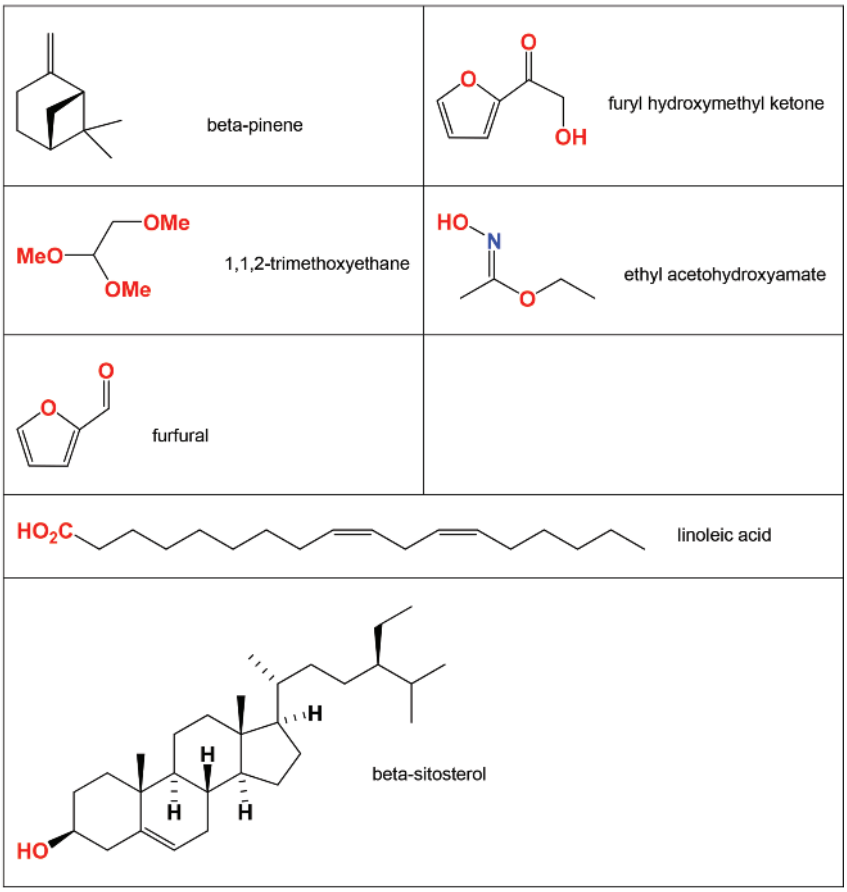
Although Matthew told me he did not know of any research into potential chemical communications between insects and plants in his particular project areas, I suspected there might be someone doing some related chemical studies, somewhere. And there is: my own investigations in this area turned up another familiar name.

I first met Dr R. Andrew Hayes when he was a biology PhD student at the (then) University of Western Sydney, Hawkesbury campus looking at the chemical composition of the odours that rabbits use in their chin gland secretions to control their social structure. In the same multidisciplinary lab, joining the same queue for the only GC-MS, I was investigating the odours of banksias (see October 2015 issue, pp. 38–9).

Andrew told me: 'I haven't stopped studying smell ever since.' He has studied odour and genetic relationships in captive and wild lemurs, the faecal odours of native rats and the implications in their predator–prey interactions, and the chemical ecology of the cane toad.

Andrew moved to Queensland for a postdoc position, adamant he would only stay two years. Thirteen years later, he vows: 'we won't be moving any time soon!' Queensland must have something the rest of the world doesn't know about.

The Forest Industries Research Centre where he now works aims to support the forest and timber industries of Queensland and the rest of Australia,



Range of chemical structures from the inner bark (secondary phloem) of the important forestry tree *Corymbia variegata* and its hybrid with *C. torelliana*, as a first step in determining if some of these compounds influence the attack by the beetle *Phoracantha solida* which attacks some of the hybrids more often than the parent.

with the ultimate goal of improving primary productivity, but also of reducing pesticide load in the environment. Although the chemistry projects Andrew is working on do not relate directly to Matthew's projects, some are complementary to them.

For example, one of the Centre's current projects involves research with partners in Laos, Cambodia, Vietnam and Thailand in a project funded by the Australian Centre for International Agricultural Research (ACIAR). The project aims to identify biocontrol agents for Australian-introduced eucalypt pests in plantations in the Mekong basin. Another project, in collaboration with the NSW Department of Primary Industry, hopes to identify pheromone-trapping for the fruit-spotting bug *Ambypelta nitida*, which, although an Australian native species, is a pest in some tropical crops such as macadamia and avocado. Andrew indicated that this research has shown mixed results so far, and the team is trying to tweak the integrated chemical and biological systems to make a more effective control strategy.

... one of the Centre's current projects ... aims to identify biocontrol agents for Australian-introduced eucalypt pests in plantations in the Mekong basin.

Although a proud biologist and ecologist, Andrew is always willing to look outside the square and use a range of ideas and methodologies from other disciplines. His long and continuing research in using chemistry to solve biological and ecological problems is impressive, as indicated by the title of one of his papers: '*Corymbia* phloem phenolics, tannins and terpenoids: interactions with a cerambycid borer' (Hayes R.A., Piggott A.M., Smith T.E., Nahrung H.F. *Chemoecology* 2014, vol. 24, pp. 95-103).

The coda to this story relates to the importance of enthusiasm, which both Andrew and Matthew have in abundance. I recently visited the Everglades in Florida, where no one mentioned melaleuca as being a problem, although they all talked about introduced Burmese pythons decimating the raccoon population. Our enthusiastic and knowledgeable young tour guide told us he started out as an English major who entered a competition to write a promotional article about the Everglades. The short-listed candidates were taken on an introductory camping tour of the national park, and our guide was 'hooked' to such an extent that he changed his major to environmental science. His passion was contagious, something that helped secure him his current permanent job as a ranger at the Everglades.

Deidre Tronson FRACI CChem used to be a mad scientist, but is now the Good Little Banksia Lady who, in retirement, is an enthusiastic member of Scientists and Mathematicians in Schools at a local primary school. She has proudly raised three science graduates. She has had separate careers in research and teaching, culminating in a position as part-time senior lecturer at the University of Western Sydney, Hawkesbury campus.

A	cd	K	kg	m	mol	s
ampere	candela	kelvin	kilogram	metre	mole	second

Quantum leap

Redefining SI

BY **DAVE SAMMUT**

Several units in the *Système international d'unités*, including the kilogram, are under review in the lead-up to the proposed 'new SI' in 2018.

The arcane science of metrology is on the cusp of a quantum leap, a bold redefinition of four of the seven SI base units, in the aftermath of which we will find our lives radically unchanged.

The *Système international d'unités* (SI) has its roots in imperial France. In the late 1700s, King Louis XVI ordered investigations into a new, standardised system of weights and measures to crack down on rampant fraud. Louis' expert committee proposed measures based on nature – such as the triple point of water for temperature, and a fixed volume of water for mass. Before the revolution, the 'grave' was proposed as the mass of litre of water, but in 1799 this was updated to the 'gramme' – the mass of 1 cm^3 of water at 4°C.

However, a pea-sized volume of water (for extremely large values of 'pea') was not a practical unit, so the kilogram gained traction as a standard unit, embodied as a physical object.

Following the Metre Convention of 1875, 17 member countries agreed to a standardised system, and the modern SI system was born. Since 1889, the International Prototype of the Kilogram (IPK) has been stored at the *Bureau International des Poids et Mesures* (BIPM) near Paris, under the auspices of the *Conférence Générale des Poids et Mesures* (CGPM).

One of 40 identical artefacts carefully manufactured by British firm Johnson Matthey as a 39 mm cylinder (approximate length and diameter) of platinum (90%) and iridium (10%) and then selected by lot, this IPK is periodically brought out and checked

against the national prototypes that have been distributed to member states around the world. Of the original 40 manufactured, there remain six national prototypes, eight working standards and two additional copies for special units.

And here lies the key problem with physical constants. More than just the logistical problems of access, transport and measurement, by definition a physical constant should be both universal in nature and constant in time. But successive measurements have shown a drift in some of the national prototype kilograms against the IPK of up to 50–60 μg (6×10^{-8} relative uncertainty).

Either the IPK is losing mass (possibly through the diffusion of gas encapsulated during manufacture, or loss of atoms on handling), or the national prototypes are gaining mass (such as through mercury vapour adsorption or carbonaceous contamination). Either way, the IPK is by definition a kilogram, so the rest of the world is getting heavier, and that can't be allowed to continue (see box, p. 31).

At its 23rd meeting in 2007, the CGPM mandated a committee of 18 eminent scientists, the *Comité International des Poids et Mesures* (CIPM) to investigate the use of natural constants to replace the IPK. The CGPM has eliminated the International Prototype Metre (1960) and the definition of the second based on the period of rotation of the Earth (1956, 1967), leaving the kilogram as the only base SI unit still anchored to a physical artefact.

Two alternative methods of defining the kilogram in terms of natural constants have been proposed. CIPM's preferred method (amidst strenuous ongoing debate) is to define the kilogram in terms of Planck's constant (see box), specifically by setting the numerical value of h to exactly $6.62606x \times 10^{-34}$ joule second (where the numbers making x have yet to be determined).

The science of the arguments gets complex pretty quickly, but to paraphrase BIPM's very cogent explanation: the natural constant h is composed as the product of two components, its numerical value $\{h\}$ and its unit $[h]$, so that in this case:

$h = \{h\}[h] = 6.62606 \ldots \times 10^{-34}\,\mathrm{kg\,m^2/s}$

The factors $\{h\}$ and $[h]$ can be chosen in different ways such that the constant itself, h, remains unchanged. Until now, the unit $[h]$ has been dependent on the fixed definition of the kilogram, making the numerical value $\{h\}$ a measured variable. Under CIPM's preferred approach, the numerical value $\{h\}$ will be fixed, in turn yielding the definition of the unit $[h]$. The metre and second are both defined by natural constants, and this in turn yields a new definition for the kilogram.

The current definition fixes the mass of the IPK at 1 kg with zero uncertainty, which in turn means that the current best measurements of Planck's constant have a relative uncertainty of 4.4×10^{-8}. By fixing the value of Planck's constant (with zero uncertainty), the IPK itself may no longer have a mass of 1 kg, but will assume the relative error of 4.4×10^{-8}.

In practice this means that the kilogram can be experimentally measured on a watt balance, which compares electrical power and mechanical power. In simple terms, a conducting wire carrying an electric current (I) perpendicular to a magnetic field of known strength will experience a force of known strength. In a watt balance, the current is varied to precisely counteract the weight (at known local gravity, g) of a standard mass (m).

By moving the wire through the magnetic field at known speed (in a separate 'calibration mode'), a potential difference (U) is generated across the ends of the wire, which can be used to remove the effect of the magnetic field strength and the length of wire, such that:

$UI = mgv$

Planck's constant

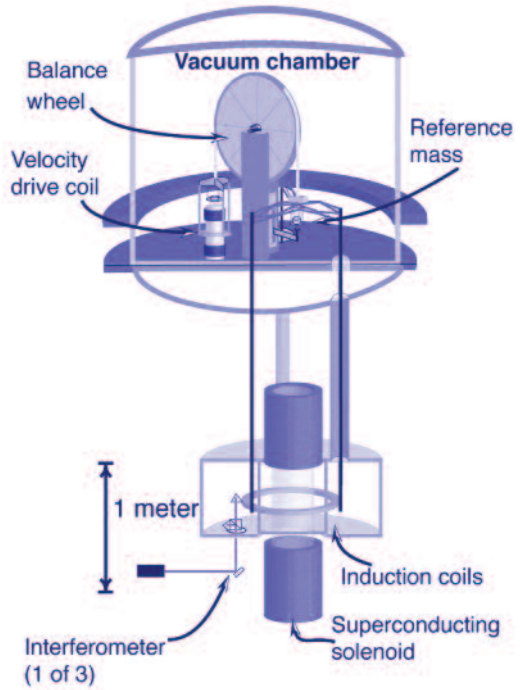
The duality of light has been an enduring paradox for physics. As early as 1801, Young's two-slit experiment demonstrated that light is a wave. Maxwell's equations and Faraday's discoveries reinforced this view. But then came Max Planck and Albert Einstein.

In 1900, Planck – using only mathematical foundations – showed that light must be emitted and absorbed in discrete amounts if it is to correctly describe black body radiation (the fact that hot objects emit light at different wavelengths depending on temperature). Einstein followed this in 1905, using Planck's initial equations to explain the photoelectric effect, and thereby clearly showing that light was composed of discrete particles – photons. Einstein showed that the energy of a photon was related to its frequency by Planck's constant:

$$E = h\upsilon = \frac{hc}{\lambda}$$

In 1954, Einstein said of Planck's work: 'This discovery became the basis of all twentieth-century research in physics and has almost entirely conditioned its development ever since. Without this discovery it would not have been possible to establish a workable theory of molecules and atoms and the energy processes that govern their transformations.'

With extremely accurate measurements available for U, I, g and v, it is expected that the watt balance can be used to generate extremely accurate measurements of the kilogram. As example, the US's National Institute of Standards and Technology's (NIST) newest prototype watt balance, NIST-4, was commissioned in 2015, and is expected to measure the kilogram/Planck's constant with an



In the NIST watt balance experiment, a kilogram test mass is placed on a balance pan that is connected to a coil of copper wire, which surrounds a superconducting electromagnet. If electric current is sent through the coil, then just as in an electric motor, electromagnetic forces are produced to balance the weight of the test mass. The apparatus also can move the coil vertically, and, like an electric generator, that induces a voltage. The velocity and voltage of the coil also are measured. These four measurements determine the relationship between mechanical and electrical power, which can be combined with other basic properties of nature to redefine the kilogram.
R. Steiner/NIST

Crystals of silicon-28 can be machined into spheres with a defined mass of 1 kilogram. Using this, the spatial parameters of the silicon's crystal lattice and the mass of an individual silicon atom, Avogadro's number can be determined. NIST

The Avogadro Project ... uses perfectly spherical balls of ultra-pure (99.9995%) silicon-28.

uncertainty of 3×10^{-8} – half the current uncertainty from the IPK.

The alternative method for measurement has included CSIRO and the National Measurement Institute facility at Lindfield, Sydney. The Avogadro Project, as it has come to be known, uses perfectly spherical balls of ultra-pure (99.9995%) silicon-28. Each 'super sphere' costs about US$3.2 million, and is handcrafted by a master lens-maker. CSIRO's Australian Centre for Precision Optics has claimed that the spheres have total out-of-roundness' of only 35 nanometres.

The crystalline balls have a predictable pattern of atomic spacing that can be measured by X-ray crystallography. With only one dimension to be measured (via highly precise optical interferometers), and with nanometre precision in the milling (so that if the approximately 94 mm spheres were blown up to the size of the Earth, the difference between the highest peak and the lowest trough would be 3–5 metres), the number of atoms in the spheres can be determined with extremely high precision.

According to NIST, the best measurement to date has the same level of uncertainty as the best watt balance measurements: 3×10^{-8}. This then provides an excellent second method of verifying the measurements from the watt balance approach. As stated by NIST: 'The watt balance and Avogadro Project measurements are not so much competing with as complementing each other to define the kilogram. In fact, metrologists are counting on a large amount of agreement between the two experiments for a first-shot redefinition. The two strategies can act as checks against one another, which would give scientists more confidence that each new definition is a reliable replacement for ''the big K'' [the affectionate term for the IPK].'

One of the consequences of the Avogadro Project approach is that it would link the definition of the kilogram to the mole, which is also under CGPM review. The current definition of the mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12.

The proposed revision fixes the value of Avogadro's constant at $6.02214x \times 10^{23}$ mol^{-1}, which would in turn affect the definition of the dalton and the atomic mass unit (which would be dropped as an SI unit altogether), with minor differences emerging between the last two.

CIPM has advised that the criteria for acceptance of kilogram measurements should be that three separate experiments using the watt balance and silicon sphere should yield values having uncertainty of no more than 5×10^{-8}, with at least one value better than 2×10^{-8}.

Master optician Achim Leistner measuring the roundness of a precision silicon sphere that was manufactured at CSIRO. CSIRO

Redefining the kilogram in terms of a fundamental natural constant will ensure its long-term stability and reliability. After years of detailed argument, it is now proposed that a new approach will be adopted at the 25th CGPM meeting in 2018. This is to be termed the 'new SI'.

And at the end of all of that effort, what will have changed in our laboratories and day-to-day lives? Well … nothing, actually. While the changes will affect certain high-precision industries such as telecommunications, and will become more important as our technologies develop, the methods used now to calibrate 'at the coal face' will remain unchanged.

From my limited perspective, the kilogram will no longer be an object that I will never see outside a photo, and instead will be derived from a concept based on an arcane theory by a bloke who had something against cats. Call it a quantum leap in my lack of understanding.

Dave Sammut FRACI CChem is principal of DCS Technical, a boutique scientific consultancy, providing services to the Australian and international minerals, waste recycling and general scientific industries.

Matters of substance

As I dolefully contemplate my bathroom scales of a morning, I find that the subject of mass is of fundamental importance to me. The problem started when our son was born. Did you know how you weigh less in the morning than when you go to bed at night? After staying up all night with a screaming baby, this stopped happening for me. I started to get fatter. So I went on my first diet ever. Like a good scientist, I applied the scientific method to my experiment:

Aim: *To avoid having to purchase new pants.*

Method: *Measurements taken at t = 0. Ingest nothing but healthy food for several weeks. Measurements repeated.*

Results: *System changes observed and recorded.*

Conclusion: *Judging by what I lost during the test, the 'will to live' weighs approximately 2 kg.*

iStockphoto/urfinguss

RACI Organic Division Awards

The RACI Division of Organic Chemistry is calling for nominations for the following awards. Nominations should be submitted to Dr John Tsanaktsidis (john.tsanaktsidis@csiro.au), Chair of the Organic Chemistry Division, by 30 June 2016. For more information, visit www.raci.org.au/events-awards/organic-chemistry.

The Athel Beckwith Lectureship

John Morris GROUP Generously supported by the John Morris Group

The Organic Division has established an annual funded lectureship to allow outstanding, recently appointed, organic chemists to travel around Australia and present the results of their research work. The objective is to provide the lecturer with the opportunity to achieve broader recognition and exposure at an early stage in their career. Reasonable travel and accommodation expenses up to a maximum of $3500 will be provided.

The Mander Best PhD Thesis in Organic Chemistry Award

DAVIES COLLISON CAVE INTELLECTUAL PROPERTY Generously supported by Davies Collison Cave

The Mander Best PhD Thesis in Organic Chemistry Award recognises the best PhD thesis in the field of organic chemistry for outstanding achievement and communication. The recipient will receive a cash prize of $1000, generously provided by Davies Collison Cave.

Student Bursaries for Conference Travel

CSIRO Generously supported by CSIRO Manufacturing

Up to 10 student bursaries (of up to $500) are available to assist current RACI student members, who have been a member for at least one year, with attendance at organic chemistry related conferences within Australia.

RACI Board elections

Nominations are open for the following positions on the RACI Board.

- President elect
- Treasurer
- Ordinary board member

Forms are available at www.raci.org.au/theraci/corporate-governance/board-elections-2016

Nominations close 20 August and elections will be held the first week in October.

Kliti Grice honoured with Gibb Maitland Medal

Internationally recognised organic geochemist and chemist Professor Kliti Grice FRACI CChem has been awarded the Geological Society of Australia's (GSA) 2016 Gibb Maitland Medal.

Grice, a John Curtin Distinguished Professor in the Department of Chemistry, Curtin University, and the founding director of the WA-Organic and Isotope Geochemistry Centre at Curtin, received the award in recognition of her work in organic and isotope geochemistry and its applications to fundamental geology, and for her substantial and sustained contributions to the petroleum and minerals resources sector in Western Australia and internationally.

Grice, who has held two Australian Research Council (ARC) QEII fellowships and a Discovery Outstanding Research Award at Professorial level, has been responsible for a number of major international scientific breakthroughs.

Her research has significantly contributed to knowledge around the causes and recovery of four of the five largest mass extinction events on Earth, with special relevance to Western Australian geology and exploration of critical resources.

She has also developed and applied sophisticated analytical biomarker and compound specific isotopes (C, H, N and S) from 'living' stromatolites – ancient sediments, petroleum and mineral systems including but not limited to the Devonian of the Canning Basin, Permian/Triassic of the Perth Basin, and Triassic/Jurassic of the North West Shelf to very ancient Precambrian petroleum basins.

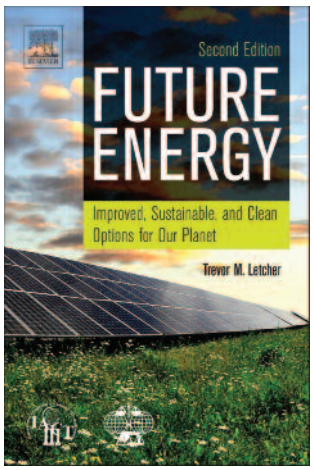
More recently, Grice has focused on organic geochemistry in Australia's mineral deposits, including gold, lead, zinc, silver, copper and uranium, through her leadership of the CSIRO Minerals System cluster. Her team's research on the role of biomarkers, biomolecules and microbial-mediated processes has also led to novel and international groundbreaking evolutionary theories associated with exceptional preservation of fossils within ancient concretions.

'Concretions act as molecular time capsules of species that evolved or became extinct over major events including ocean anoxic events,' Grice said.

Grice and her team will shortly begin work analysing samples expected to emerge from the current international expedition that is drilling into the Chixculub impact crater in Mexico – the crater linked to the extinction of the dinosaurs at the end-Cretaceous (see p. 14). She is also chief investigator of the oceans and climate theme of a major International Ocean Discovery Program submission between Geoscience Australia and the Japan Agency for Marine-Earth Science and Technology, which is investigating the end-Cretaceous event in Australia.

In accepting the award, Grice said: 'Much of the research work would not be achieved without a collegial and collaborative team approach from inspiring and truly passionate interdisciplinary researchers who collaborate and profit from each other to achieve the highest goals.'

Curtin University



Future energy: improved, sustainable and clean options for our planet

Letcher T.M. (Ed.), Elsevier, 2014, hardcover, ISBN 9780080994246, 716 pp approx., $129.95

Future energy: improved, sustainable and clean options for our planet (2nd edition) is an absolutely superb book. Everyone who has any interest at all in our climate-change-wracked planet will benefit from reading it and it ought to be compulsory reading for members of parliament and national leaders, planners and other bureaucrats associated with energy supply and energy source development and national development. Then, perhaps we might hear less asinine bleating from many of our representatives – lawyers and narcissists almost to a man (and woman), but, alas not scientists – who judge wind farms and other new energy options on their personal aesthetic perceptions, or on which particular lobby group offers the best political capital, rather than on any rigorous assessment of the technological problems confronting our world and the potential solutions on offer. They understand the aesthetics. They understand the politics. But many do not seem to appreciate the scientific and technological implications. This authoritative work would certainly wise them up, as assuredly it will all of us.

Editor Trevor Letcher, formerly of the chemistry department of the University of KwaZulu-Natal, Durban, South Africa (but now living in Somerset, England) has assembled some 55 significantly expert authors to contribute to this 31-chapter book. In every sense it is a heavyweight book; the book is physically daunting at 716 pages, and the authors too have daunting pedigrees and achievements. Each chapter is stand alone and extensively referenced, but the entire book assembles as a remarkably harmonious, complete and well-rounded entirety. Obviously, a great amount of editorial effort has gone into achieving this and the clear vision and guiding hand of the editor is absolutely commendable. So often these multi-author works seem to wind up as a series of peripherally related papers, simply stapled together, prettied-up and, like the curate's egg, good in parts. Well, I can tell you that this book is much, much, better than that. The oeuvre (indulge me!) is all good. And with its extensive colour illustrations, it is good fodder for curates and others alike.

The first edition of this book was copyrighted in 2008. With this second edition, the book has grown from 20 chapters to 31. That tends to happen with second editions. It's sort of like inflation – it just seems to happen. However, it is also an indication of the developments and discoveries in the technology and the widening global scientific and political interest in future energy sources and supply systems. We can then, perhaps, take heart. The messages of global warming are getting through, at least in some quarters. People are thinking about future global energy scenarios and the potential for various energy sources to contribute to that future in ways that tend towards minimal environmental harm. New technologies are being developed and assessed, maybe not as fast as we'd like, but the picture is not totally one of future doom and gloom.

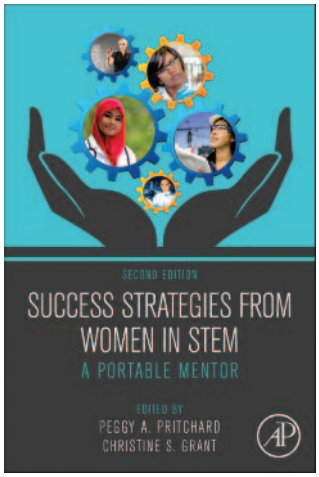
Essentially, the book explores current and developing sources of energy from various perspectives including explanation of the technology of their exploitation; where they sit as contributors to national/international and, where appropriate, domestic energy supply at the moment; what their future prospects are together with discussion of what strengths, limitations, challenges and opportunities they offer; as well as what their environmental and societal impacts are likely to be. Early chapters are devoted to conventional energy sources, coal and oil and nuclear power, including fusion as a source of energy. Novel and emerging energy sources for transport, which consumes nearly one-third of global energy use, are canvassed over the ensuing sections, including an excellent chapter on lithium ion batteries and future technology emerging in battery technology. Renewable sources are extensively discussed, as are more speculative options currently under development.

The final section of the book provides an excellent review of environmental impacts and what the future might look like as the world moves gradually (too gradually?) towards novel, more sustainable and less problematic sources of energy. I'd like to stress that this book is in no ways trying to push barrows or ram ideas down your throat. The book says of each energy source: this is what it is, this is how it works, this is where the technology is at, these are its beauty spots and these are its warts, this is an assessment of its present and future capacity, and here is how it might contribute to energy futures.

Finally, I will share one snippet that has stuck in my mind. You could meet all your energy requirements for your entire life with the energy from a modest piece of uranium-235, about the size of a golf ball. Now, I haven't checked the calculation (depends how long you're planning on living and under what conditions I suppose), but given there are about seven billion or so of us, that's one almighty big pile of golf balls! Oh, and if you had seven billion golf balls, what is the most efficient way to stack them? Ignore criticality in the first instance, else the need for future energy might simply … well … evaporate in an ultimate cataclysmic explosion! Better to stick to stacking oranges, methinks.

I was tremendously impressed by this book. It is a big book, in every sense, and far-from-light reading, but absolutely worth the effort.

R. John Casey FRACI CChem



Success strategies from women in STEM: a portable mentor

Pritchard P.A., Grant C.S. (Eds), Elsevier, paperback, ISBN 9780123971814, $52.95

Success strategies from women in STEM: a portable mentor (2nd edition) is a comprehensive read. The book includes sage advice for all career stages from beginning to retirement.

Five hundred and nineteen pages comprise 13 chapters in this explicit handbook covering topics such as career management, networking, mentoring, mental toughness, time stress, personal style, communicating science, strategically using social media, negotiating with emotional intelligence, a call to leadership, climbing the ladder, balancing professional and personal life and transitions. Allow an hour at a time to fully absorb the content of a specific chapter. Vignettes tell of authentic experiences, and references made within the chapter and at the end of the chapter are worth following up. The book is useful regardless of your gender or indeed whether you work in a STEM occupation or not.

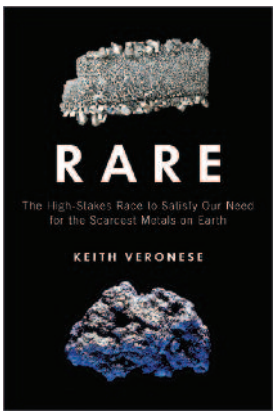
No matter the stage of your career, there are reminders throughout the book about what you should be doing and how to go about achieving what it is you desire. For example, career management can be broken down into four simple steps (Chapter 1), or in networking (Chapter 2) advice on how to prepare your 30-second introduction of yourself, or seven tips to maintain your LinkedIn profile provides practical recommendations. In communicating science (Chapter 7) email etiquette is covered, use of Arial font is recommended and a website for choice of colour palettes for PowerPoint presentations appears. Regardless of such recommendations, every organisation will likely have its own 'branding' and font choice. As an example, where I work fonts Bommer Slab and Gotham Book have been selected for all media presentations. Chapter 9 about negotiating with emotional intelligence is a stand-alone and worthy read. These examples provide just a snapshot of the content within.

Sixteen female authors with backgrounds in science (physical/organic chemistry, biochemistry (virology), biology (ecology), pharmacology, engineering (chemical/biochemical, mechanical, geomatics) and psychology and the arts have compiled the book. Of note, there is no representative from the pure mathematics field. While most work in universities, three of the contributors work in management in large companies. All authors attained PhDs, save for three who have acquired Masters degrees or Bachelors' degrees in more than one field of interest. Six writers hail from Canada, nine from the mainly eastern side of the US and one from Australia (Queensland).

These passionate women have devoted the time in already demanding and busy lives to create this helpful reference material.

I highly recommend *Success strategies from women in STEM: a portable mentor* as a practical and valuable handbook to have in your library.

Alison McKenzie



Rare: the high stakes race to satisfy our need for the scarcest metals on Earth

Veronese K., Prometheus Books, 2015, ISBN 9781616149727 (hardback), 9781616149734 (ebook), 270 pp., $49.99

Rare: the high stakes race to satisfy our need for the scarcest metals on Earth provides fascinating insights into the world of rare metals: where they come from,; what they are used for, who controls the supply chains, what the recycling prospects look like, and where we might look to finding future supplies of scarce metals. Author Keith Veronese is a scientific writer with a strong background in chemistry. He has written a fine book, which is readily intelligible to any interested adult, irrespective of scientific literacy.

Some metals are very rare indeed. Estimates are there is only about 500 grams of promethium on Earth. As Veronese put it, this is about enough to 'fill the palm of a kindergartner's hand'. (Now, there's a unit you won't find in your conversion tables!) If there were enough of it, it would make useful atomic batteries.

The book is brim full of interesting bits of information. For example, the London murder of the Russian defector Litvinenko, using polonium-210, is discussed along with speculation that Yasser Arafat may have received the same treatment. Thallium was a widely used rat poison until recent times and was equally efficacious for knocking over the odd spouse or in-law. The antidote is fairly straightforward: a few glassfuls (Ah! Now there's another odd unit!) of Prussian Blue solution. The only possible drawback is bright blue motions, which, while exciting, is unlikely to kill you.

Thulium would be a good contender for use in brachytherapy. Palladium can be used in dentistry, for crowns and the like, so that instead of being 'as flash as a rat with a gold tooth' one could have a gleaming silvery smile. Even tungsten has been known to be buried deep within gold bars to fool the unwary. If you have a flash of inspiration about recovering gold from seawater, then I'm terribly sorry to disillusion you. Between the world wars, Hitler put Fritz Haber on this task as a way of getting money to pay war reparation debts. It didn't work. And then, we all know about square-planar platinum compounds for

If you fancy getting into the business of recovering gold and other rare metals from your old computer ... Veronese tells you how you can do it in the garage.

chemotherapy, but did you know it is also used in breast implants to help the implant hold its shape?

If you fancy getting into the business of recovering gold and other rare metals from your old computer (well, really, you'd need a decent heap of scrap computers), Veronese tells you how you can do it in the garage. My only comment is that although it is possible, you would be extremely foolhardy and breaking just about every environmental and OHS law you can imagine. Alas, of course exactly these horrors accompany much of the computer recycling/recovery operations in the Third World. If you are interested, Veronese refers to the classic 1940s book by Caroline M. Hoke, *Refining precious metal wastes: a handbook for the jeweller, dentist and small refiner*. This book is still obtainable. You can download it free, but be warned. The version I first tried to download brought with it a plethora of Trojan horses and sundry other nasties.

So, what are we to do when we get really, really short of the rare metals that, let's face it, are pretty essential to our lifestyles and wellbeing? Veronese discusses ways some of them could be recovered from spent nuclear fuel rods. There are very real difficulties in doing this and in getting a product that is totally free of radioactive contamination. Other options canvassed include mining on the Moon, Mars or nearby space rocks. Possibly, these activities are somewhat speculative. What seems to me rather less speculative, and quite depressing really, is the possibility of mining on the Antarctic Continent. Currently, the Antarctic Treaty forbids mining. What it doesn't forbid is geological mapping and surveying of the continent. I am pessimistic for the longer-term future of the beautiful wild world to our south, particularly when the treaty comes up for renegotiation.

All in all, this is a very informative and enjoyable book. It is well written and easy to read and there is much to be learned from it. It is highly recommended reading for anybody interested in the rare and obscure metals that underpin modern life.

R. John Casey FRACI CChem

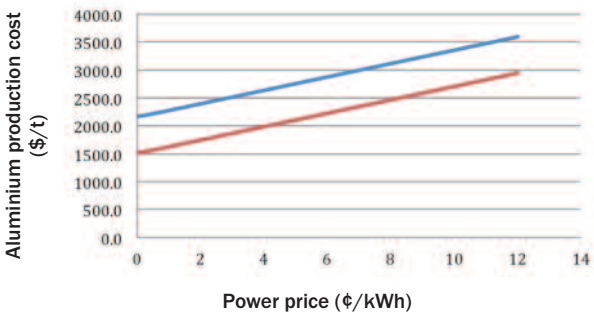
Steel, aluminium, LNG – on rocky ground

At the time of writing there is a major concern surrounding the viability of the Arrium steelworks at Whyalla in South Australia. This operation, which is based around a blast furnace and coke oven, is small by world standards. The steelworks produces mainly unsophisticated products such as rails, wire and construction steel. This is supplemented by several electric arc furnace operations in Victoria and New South Wales. In recent years, a major part of the company profits has come from iron ore export from the nearby Middleback range.

The collapse of commodity prices for both iron ore and steel has exposed Arrium to apparently unsustainable levels of debt. Problems seem to be exacerbated by dumping of steel from the large integrated steel mills in Asia (particularly China, South Korea and Taiwan).

Because of the impact of the steelworks closure on the township of Whyalla, there is considerable pressure on the Commonwealth and state governments to financially support the company. Blast furnace operations are innately carbon emission intensive, so the reintroduction of carbon charges would inevitably lead to demands for further government subsidy to maintain viability.

It is about a year now since I reported on the production cost of aluminium in Australia and its strong dependence on the power price (see April 2015 issue, pp. 36–7). The key features are illustrated in the graph.



The graph illustrates the relationship between aluminium production cost and power price (US dollars), aluminium metal production being highly electricity intensive. The top line is the cost for a greenfield smelter and the lower line represents the cash cost for production of metal.

Since the earlier article, we have witnessed a significant fall in the price of oil; this lowers the production cost of aluminium by reducing the price of anode carbon, which is a major cost input. This is reflected in the graph – it now shows that the cash cost is approximately $1500/t compared to the earlier $2000/t. Unfortunately, there has been a concomitant fall in the price of aluminium ingots, which at the time of writing is reported as US$1478/t (31 March 2016).

However, Australian producers have been helped with the fall in the Australian dollar, which has served to reduce the cost of electricity (this is generally charged in Australian dollars) and employee and related costs. But aluminium smelting in Australia still remains a marginal operation at best.

In the next few months it is reported that in Victoria the Portland aluminium smelter power supply contract is up for renegotiation. This was the foundation contract for the Loy Yang A power station in the La Trobe Valley and as the foundation contract, was negotiated at a low power price. There is now considerable pressure to increase the power costs, which will further marginalise the operation and may force its closure. If this happens, it could have serious repercussions on the supply and price of electricity to other users, not only in Victoria but in other states that now rely on the Victorian generators for back-up power – South Australia and Tasmania.

In the October 2015 issue (pp. 36–7), I reported on the possible impact of the gas demand of the three large LNG facilities at Gladstone on the chemical process industries, and gas intensive industries in general. There have been several developments since then. An important change has been the collapse in the price of oil, which is now feeding into lower prices for LNG. This is rendering new LNG investments uneconomic at the high capital constructions cost for land-based facilities, especially in Australia.

Shell, and its partner Petro China, has cancelled its proposed LNG project at Gladstone and has written off a substantial part of its Arrow Energy coal seam gas joint venture. The latter was stated to be due to poor results for Bowen Basin coal seam gas recovery. At the time of writing, Shell is in the final stages of taking over the BG Group, which operates two LNG trains at Gladstone. We may speculate that any CSG gas developed from Arrow's Bowen Basin resources would be dedicated to support the BG operations and be unavailable for use elsewhere in Queensland.

The write-down of Bowen Basin assets by Shell, and other reports of abandonment of CSG projects in New South Wales, will increase concerns that there is insufficient gas on the eastern seaboard to supply the three LNG export plants or to continue to supply other gas-intensive industries and customers. This concern serves to maintain a reluctance of gas suppliers to enter into long-term contracts at what the present chemical industry users consider a reasonable price. This has

Alcoa's aluminium smelter at Portland, Victoria.
Stuart Woollett

The write-down of Bowen Basin assets by Shell, and other reports of abandonment of CSG projects in New South Wales, will increase concerns that there is insufficient gas on the eastern seaboard to supply the three LNG export plants or to continue to supply other gas-intensive industries and customers.

further increased calls for a gas reservation system, keeping gas for domestic use.

One proposal that has gained some momentum is for a gas pipeline from the Northern Territory to the eastern seaboard. This would bring gas from the north to the Moomba gas hub from where it would be distributed to Adelaide, Sydney or Brisbane. Unfortunately, there is little conventional gas in the Northern Territory and any that was to become available would probably be diverted to the Darwin LNG facility, which is now running short of gas from the Timor Sea. The aim of the pipeline proponents is to develop unconventional gas reserves, mainly in shale, by fraccing and similar production techniques. However, the Northern Territory government is considering banning these advanced production methods, which would eliminate the Territory as a source of gas for the eastern seaboard.

At this time, the demise of the process industries is being welcomed by commentators across the political spectrum as 'the economy transitions to the digital age'. This 'digital age' is only vaguely defined and, as I have opined previously about lithium/graphite batteries, there is little in this new technology for Australia other than a supplier of the basic (low value) raw materials.

Duncan Seddon FRACI CChem is a consultant to coal, oil, gas and chemicals industries specialising in adding value to natural resources.

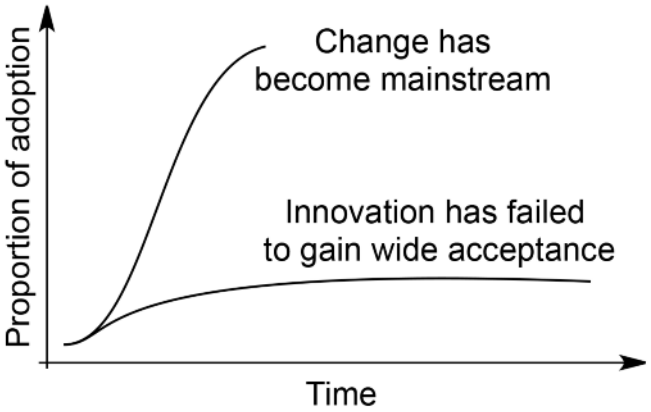
Mainstreaming change

Over the last few months, I have been watching *Madam Secretary* on DVD. The television series revolves around the professional and personal life of a fictional female US Secretary of State, and also features a female Chair of the Joint Chiefs of Staff (head of the military), a female Attorney General, and a female director of the FBI. In real life, the US has had three female Secretaries of State in recent administrations, including one who could be the next President, significant numbers of women at the top levels of government, and more than 30 4-star admirals and generals.

At the same time, I have also been reading Jay Newton-Small's *Broad influence: how women are changing the way America works* (Time Books, New York, 2016): when the proportion of women at the top of any organisation reaches critical mass, they begin to change how things are done. For example, when the US federal government was facing financial shutdown in October 2013, it was the 20 female senators who put aside partisan blame and brokered a compromise to end the crisis. It is not the purpose of this column to comment on North American politics – *Broad influence* also has allegorical meaning for us: it is the story of how the mainstream culture was changed by a minority group with distinctive practice.

Many educational innovations have failed to be widely implemented, while others have become mainstream practice. For example, interactive whiteboards are now standard features in most primary and secondary schools but not in tertiary institutions. The early adopters of any innovation are initially a minority group. Innovations tend to take off after 10–20% of the relevant population have adopted the change, which is similar to Newton-Small's observation that after achieving a critical mass of 20–30%, the minority group starts to effect change in the community and the majority adjusts to accommodate that minority group. Similarly, a guiding coalition with sufficient position power, expertise, credibility and leadership is one of eight essential factors for implementing change. Before achieving critical mass, the minority group is seen as the *other*, both separate from and not fully accepted by the majority; after the critical point, the presence and practices of the minority are viewed as part of the *norm*.

There are two lessons for us to take away from these ideas. First, when funding is provided for innovative teaching and learning projects, it is important to have critical mass early. Hence teaching and learning projects should concentrate on a few pilot schools or universities, which can achieve and implement the project goals, and then spread from those institutions to others. This is the model that has been used in ALIUS and ASELL for Schools projects, which are spearheaded by a small number of institutions (see June 2010 issue, pp. 18–19; and February 2016 issue, p. 40). It is also the model used by the ARC and other funding bodies to give bigger grants to a relatively small number of groups, rather than more-numerous small grants to many more recipients; numerous small grants would each be unable to achieve critical mass or have effective impact. Harking back to *Madam Secretary* and *Broad influence*, the second lesson is that many women have a different mode of operation from most men, and that any project or institution would benefit from critical masses of both genders in positions of influence.



… a guiding coalition with sufficient position power, expertise, credibility and leadership is one of eight essential factors for implementing change.

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TPP: the mystery continues

Paul Whenman, Partner and Registered Patent and Trade Marks Attorney, FB Rice

Shrouded in mystery, the Trans-Pacific Partnership (TPP) negotiations provided fuel for the media to engage in endless speculation about Australia's commitments. Unsurprisingly, once the TPP negotiations were concluded, the Agreement that had been achieved provided answers to much of this speculation.

Importantly, while the Intellectual Property Chapter 18 of the Agreement provided appropriate clarity, what is not at all clear is how Australia will comply with its obligations, in particular, the requirement for a patent term adjustment (PTA), patent term extension for pharmaceuticals (PTE) and protection of data in the regulatory approval of biologics.

The criticality of these aspects is that they all directly impact on the cost of health care. This is especially significant for two reasons. First, the Pharmaceutical Benefit Scheme (PBS) is a key component providing pharmaceuticals at a government-subsidised price. While ever third parties are prevented from supplying pharmaceuticals, the cost of the PBS will be negatively affected. Second, since Australia's pharmaceutical industry is small, any reciprocal benefit to be gained by this industry through export is likely to fall well short of the net cost of imported pharmaceuticals.

At the heart of PTA is the requirement that a patent office ensure that a patent is issued by the later of five years from filing or three years from the filing of a request for examination. If this does not occur, Article 18.46 provides that a patentee may request that a patent office effectively extend the patent term by a period representing the unreasonable delay in processing the application.

The Patents Act 1990 does not provide for a PTA. Assuming the Patents Act is amended, the impact will be two-fold. First, a system would be required for a third party to readily determine an actual patent expiry date. Conveniently this could be based on that current for pharmaceuticals. Second, when the underlying patent is for a pharmaceutical, a PTA could provide a patent term extension in addition to the current PTE and that contemplated by Chapter 18.

A PTE is currently available for all pharmaceuticals. Essentially, the maximum extension of five years is achieved if regulatory approval takes at least 10 years. By contrast, Article 18.48 of the TPP calculates a PTE with reference to 'unreasonable curtailment of the effective patent term as a result of the marketing approval process.' Compliance with this Article can only be accepted if 10 years or more is regarded as excessive for the marketing approval process.

All pharmaceuticals that are regulated by the Therapeutic Goods Act 1989 are afforded five years of data protection from achievement of regulatory approval. By contrast, Article 18.52 requires for biologics a period of either eight years or five years and 'through other measures, and recognising that market circumstances also contribute to effective market protection.' There is nothing in the Therapeutic Goods Act that provides these latter measures and circumstances.

Australia's position that no legislative changes are required for compliance with these aspects of Chapter 18 appears to be incorrect. Rather, it seems that changes will be required that may well impact on the cost of pharmaceuticals.

For more information, email pwhenman@fbrice.com.au.

Adjustment of grape and wine acidity

In my May column, I outlined what many winemakers in Australia see as the need for acid adjustment to decrease the pH and increase the titratable acidity (TA) of crushed grapes and wine. In this and my next column, I will address various options for acid adjustment, some of which involve some rather intriguing chemistry.

Leaving aside the old approach of sulfuric acid addition, which is no longer approved, the most widely used method in Australia is the addition of tartaric acid. This is relatively easy to perform and the amount to be added to lower the pH by the chosen amount can be determined by bench trials or by using web-based calculators. The tartaric acid is then dissolved and mixed with the juice (white grapes) or must (red grapes) or wine in tank and allowed to stabilise.

There are several limitations to this apparently simple procedure. First, it is expensive because quality L(+)-tartaric acid (the natural form in grapes) is costly. For grape juice and wines that are very low in acid, the amount of tartaric acid required to attain the desired decrease in pH can be large. This can add an additional layer of complexity as some countries have limits on the amount that can be added. One frustration, especially with juice or wine that may be high in potassium, is that the added tartaric acid may exceed the solubility product of potassium hydrogen tartrate (KHT) with subsequent precipitation of some of the added tartaric acid. This can require further additions and more cost.

To try and minimise the cost, some winemakers have explored adding DL-tartaric acid, rather than the L(+)-form. The cost of the DL-form is approximately one-tenth that of the pure L(+)-form, but the DL-form can lead to unpredictable precipitation post-bottling, especially of calcium DL-tartrate. Calcium tartrate tends to settle out as flakes, rather than crystalline material, and more than one winemaker has had bottled wine returned because of the presence of 'detergent flakes'.

Blending options of grapes and/or wines of different acidity levels is an option that has been explored by some winemakers to minimise the amount of tartaric acid addition required. Earlier harvested grapes are generally higher in acidity and a judicious combination of early and later harvested grapes will help improve the acidity. Dual harvesting introduces considerable cost to the winemaking exercise. As grapes grown in cooler regions have higher acidity than those from warm to hot regions, multi-region blending is also an option if a winery has access to different types of vineyards. A colleague from Mendoza in Argentina told me that he has tried this approach using grapes from the warm region and those grown at over 2000 metres on the slopes of the Andes. It works in terms of improving acidity, but the high cost of the grapes from the elevated vineyard impacts on the final price point of the wine.

A third blending possibility is to use a small portion of a different grape cultivar in a blend, within the approved blending rules. Some white and red cultivars are known to hold their acidity in warm to hot regions and the challenge is how best to use these cultivars to benefit a blend and minimise the requirement for acid addition. Some examples are:

- Pinot Gris holds its acidity until late in the ripening process. It was grown successfully at Charles Sturt University for many years and was used as a sparkling wine base. Some of these sparkling wines showed amazing acidity, even after 20 years on lees.
- Furmint is a white cultivar common in Hungary as a principal component of the famous Tokaj wines. Its wines have been described as 'fine' and 'fiery', with many having very high acidity (TA values in excess of 10 g/L) and high alcohol (14%).
- Graciano is a red cultivar from La Rioja, Spain, and is now planted to a small extent in various regions in Australia. Its wines are characterised by a deep red colour, good tannin structure and high acidity with strong ageing potential. In La Rioja, Graciano is used as a blending component with Tempranillo. The downside is that Graciano vines are low yielding, so production costs are high.

Several countries including Australia now allow the addition of malic acid, lactic acid or citric acid as an alternative to tartaric acid.

- Malic acid can be added as either the L-form, as found in grapes, or the DL-form. The effect is similar to tartaric acid in terms of acid adjustment, especially the lowering of the pH value. As malic acid is a weaker acid, a higher addition rate is required in comparison to tartaric acid, so the final TA will be higher.
- Lactic acid is claimed to produce a rounder and smoother mouthfeel than malic acid. Being weaker than malic or tartaric acid, addition rates are higher to achieve the same pH decrease. On the positive side, its potassium salt is soluble so that losses after addition are minimal and this in turns means that the pH decrease is more predictable.
- Citric acid is effective in white wine as it generates a fresher mouthfeel. As it is a substrate for bacteria, additions tend to be limited to 0.15–0.2 g/L. There is a higher risk of bacterial spoilage if citric acid is added to red wine, due to the lower SO_2 concentration.

In my next column I will outline additional chemical and physical methods for acidity adjustment.

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

Fulbright comings and goings

I have been researching the way that Australian chemists increased their involvement with the US, replacing Britain in that segment of professional development called 'overseas experience'. Naturally I looked at the working of the Fulbright scheme, which provided travel and support for a variety of visits across the Pacific. In the golden years of the scheme, 1950–89, Australian chemists received 28 postgraduate awards and 23 postdoctoral awards; 70 of the senior awards went to university chemists going on sabbatical leave.

This scheme sprang from the Fulbright Commission, which owed its existence to J. William Fulbright (1905–95), US Senator for Arkansas 1945–74 and chairman of the Foreign Relations Committee 1959–74. Fulbright's initiative owed a lot to his own experience of studying in a foreign country. After majoring in political science at the University of Arkansas (BA 1925), he won a Rhodes Scholarship, which took him to Oxford University where he spent three years studying modern history and completing an MA degree.

Funding for the Fulbright scheme was to come from the sale of surplus war materials described in the Surplus Property Act 1944. The Australian version of the Fulbright initiative was the United States Educational Foundation in Australia (USEFA), which was signed into being by the two countries in November 1949. $US5.6 million in accumulated Australian war debt was dedicated to an educational exchange program and the first awards were made in 1950. When the money ran out, a successor scheme, the Australian–American Educational Foundation, was put in place in 1964.

As well as travel to the US, the Fulbright scheme facilitated visits to Australia by American chemists, 16 of whom were senior scholars and eight were postgraduate students. As with traffic in the other direction, some of those coming west as students already had PhD degrees and took advantage of the travel grant to continue their research careers here before (usually) returning home. One who didn't return was Jay Kent, my colleague at Monash for many years. Recently I have been in touch with another of those scholars, organic chemist Barton Milligan, who is living in retirement in the US.

Milligan completed his BS degree at Haverford College, a Quaker school in Philadelphia, with honours in chemistry. As an undergraduate, he contributed to work published in 1955 by O. Theodor (Ted) Benfey. He completed his PhD at the University of North Carolina and then secured a postdoctoral position with Arthur Birch, who was Professor of Organic Chemistry at the University of Sydney 1952–5. Milligan had applied for a Fulbright award but, having heard nothing by the time he was due in Sydney, borrowed the money for fares for himself and his new wife. Birch set him to work on a new synthesis of vitamin A but Milligan soon discovered that an identical scheme had been patented and so he was switched to a new project on the constituents of the non-saponifiable fraction of sesame seed oil. He must have also had a hand in some work on lignans, for which he shared publication with Birch, R.N. Speake and (Mrs) E. Smith in 1958. (I'll have some more to say in a subsequent Letter about the way in which women authors were recognised in those days.)

Milligan had not been in Sydney for long when G.K. Hughes, a senior organic chemist in the department, died suddenly in February 1955 at age 46 and the American postdoc was appointed as Temporary Lecturer in Organic Chemistry. He earned his increased salary with lectures in physical organic chemistry. In mid-year, Birch resigned to take up an appointment at the University of Manchester, and at about the same time Milligan learned that he had a Fulbright Award. He stayed at Sydney for a while, and made a side trip to Melbourne in August 1956 as representative of the University of North Carolina at the University of Melbourne centennial celebrations. Teaching physical organic chemistry was not his first love, so to get back into research he elected to take up the Fulbright at the University of Adelaide. After corresponding with the new professor there, Geoffrey Badger, the deal was done when Milligan called at the university as he passed through the city on his way to holiday in Alice Springs. Badger was happy to have him 'provided he didn't cost any money', so Milligan settled down in 1958 to tidy up some of the loose ends from his thesis work. There do not seem to be any publications arising from this Australian work.

Returning to the US, Milligan found a place at the University of Mississippi and stayed there teaching, researching and supervising postgraduate work for eight years before moving to a position at the Florida Atlantic University. His published research concerned the photochemical interchange of halogens in aromatic compounds. This new institution was slow to develop and so after a couple of years Milligan moved into chemical industry with Air Products & Chemicals in Allentown, Pennsylvania, where he worked for 18 years before retiring. One of his interests was aromatic nitration reactions, for which I found a *J. Org. Chem.* publication and a patent. However, his major output was a series of patents on polyurethanes.

Milligan is virtually unknown in Australia (although Betty Moore (BSc 1956) remembers him as 'tall with glasses'), but the names of some of the senior scholars will be better known, especially that of W.J. Moore (1918–2001). Under the auspices of the Fulbright scheme, Moore spent 1950–1 at the University of Bristol, and then some time in 1966 at the University of Queensland. He was later (1973–84) professor of physical chemistry at the University of Sydney. He is perhaps best known to chemists for his textbook *Physical Chemistry*, first published in 1950 and growing to almost 1000 pages by the time of the fifth edition (1972).

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.

events

7th Heron Island Conference on Reactive Intermediates and Unusual Molecules
9–15 July 2016, Heron Island, Qld
www.Heron7.org

27th International Conference on Organometallic Chemistry
(incorporating the RACI Inorganic Chemistry Division Conference)
17–22 July 2016, Melbourne Convention and Exhibition Centre, Melbourne, Vic.
http://icomc2016.com

International Conference and Exhibition on Marine Drugs and Natural Products
25 July 2016, Rydges, Melbourne, Vic.
http://naturalproducts.pharmaceuticalconferences.com

2nd Energy Future Conference and Exhibition
4–6 July, University of NSW, Sydney, NSW
http://energystoragealliance.com.au/event/energy-future-conference-exhibition

NZIC-16
21–24 August 2016, Millennium Hotel, Queenstown, New Zealand
www.nzic16.org

6th International Meeting on Antimicrobial Peptides
1–3 September 2016
Leipzig, Germany
http://peptideconferences.org/imap-2016

European Symposium of Biochemical Engineering Sciences (ESBES)
11–14 September 2016, Dublin, Ireland
www.esbes2016.org

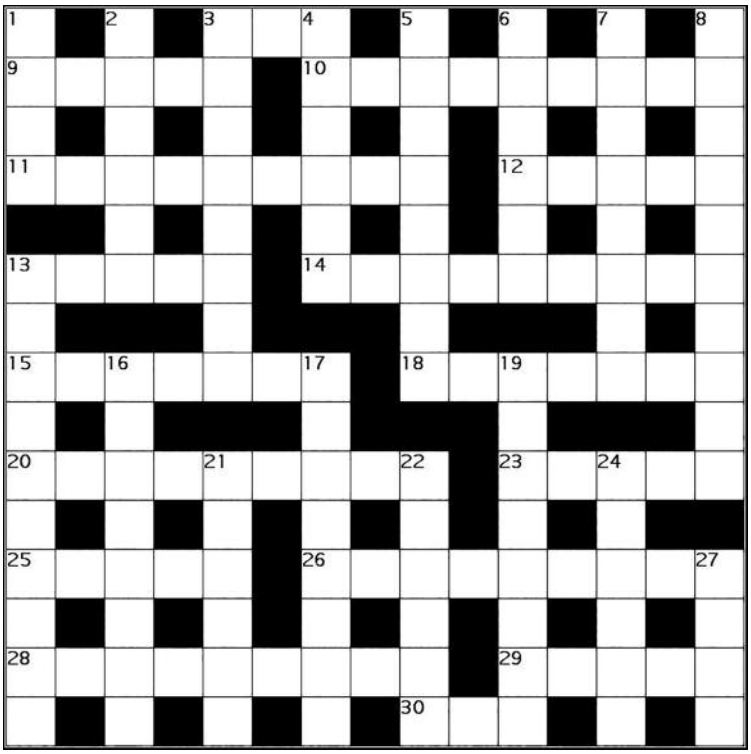
Chemeca 2016
25–28 September 2016, Adelaide Convention Centre, Adelaide, SA
www.chemeca2016.org

6th International Conference and Exhibition on Pharmaceutical Regulatory Affairs and IPR
29 September – 1 October 2016, Orlando, Florida, US
http://regulatoryaffairs.pharmaceuticalconferences.com

AusBiotech 2016
24–26 October 2016, Melbourne Convention Centre, Vic.
www.ausbiotechnc.org

RACI events are shown in blue.

cryptic chemistry



Across

3 For example, got first cackleberry. (3)
9 Extent of sulfur break down. (5)
10 Choose way sensing plate. (9)
11 Mixes load to make compounds of formula RCH=NOH. (9)
12 Regions are as . . . (5)
13 . . . chosen and titled. (5)
14 They live nearby Spooner's inlet (Scandinavian). (9)
15 Chlorine fools school groups. (7)
18 One lute playing compound. (7)
20 Blunder in East charges radiation. (9)
23 Visitor sequestered by rogue state. (5)
25 Cans old televisions. (5)
26 Net matter becoming procedure. (9)
28 Distributed false ID and pressed flesh. (9)
29 Adjacent acids having the structure $RC(OH)_3$. (5)
30 Sulfur a French star. (3)

Down

1 Continent as artificial intelligence returns. (4)
2 Models models, but not often. (6)
3 Oxygenated six deep new cyclic ethers. (8)
4 European name 111 translated. (6)
5 An increase in wavelength and he drifts away. (8)
6 Join at 7361. (6)
7 Predestined, it's said, that beryllium disappeared. (8)
8 Determined: enters tips in a different way. (10)
13 New clue noted iodine monomer of, perhaps, DNA. (10)
16 A group of investigators post important reactions. (4-4)
17 Little examination sounded most discourteous. (8)
19 Joining of nucleic acid fragments to ailing structure. (8)
21 Messy time over method. (6)
22 Deep S_2 reaction is fast. (6)
24 Makes a great effort and arrests sexter. (6)
27 Spoils lifting equipment. (4)

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

World Science Festival comes to Brisbane

In March I attended the World Science Festival, Brisbane, on behalf of the RACI. Held annually in New York since 2008, the World Science Festival is now one of the most celebrated science festivals in the world. Becoming the first city outside of New York to do so, Brisbane hosted an amazing inaugural event! The WSF held its promise and brought some of the world's greatest thought leaders to Queensland, and showcased local scientists and performers from around the Asia–Pacific region.

Tasked to explore opportunities of how the RACI can potentially become involved in the WSF, and to collect ideas for public engagement activities we can instigate for next year's RACI Centenary and beyond, I was thrilled to witness how the public and media welcomed and engaged in WSF Brisbane.

WSF Brisbane offered a huge variety of activities, with more than 100 events scheduled over five days. The program featured a mix of day and evening activities, including live performances, big debates, intimate discussions, workshops, films, and hands-on demonstrations. True to the vision of WSF Brisbane, a great many people were 'talking, doing and enjoying science'. I was thrilled to witness the enjoyment of young and old alike at Street Science. Street Science lived up to its description as a 'Free, two-day extravaganza – explore the fun of science in a non-stop, action packed program'. It offered stalls run by universities and science organisations, showcasing their expertise across all aspects of science through talks, debates and engaging science demonstrations. Chemistry was reasonably well represented, such as the Uni Open Day classic favourite making slime, which was popular, as were Queensland University of Technology's featured demonstrations of a 3D printer, and Griffith University's offering, Periodic Table Battleships.

Reflecting the background of one of its co-founders, renowned physicist and best-selling author Brian Greene, the WSF particularly highlighted physics-based events. Brian founded the event with his wife, Emmy award-winning producer Tracy Day, and Queensland welcomed him in the most Australian way possible – they named a spider after him! While I would like to see some more chemistry-led and centred events during the WSF, all the physics based events I attended – from Breakfast with the Brians (a conversation between ABC Radio's Robin Williams, Brian Greene and Brian Schmidt, Nobel Prize Laureate and the Australian National University's Vice-Chancellor – a personal highlight) through to the school-children-focused Chasing Down the Comet, to *Light Falls: Space, Time and an Obsession of Einstein*, a play about Einstein's life – were booked out and enthusiastically enjoyed by the very broad audiences.

Another special highlight was the opening reception (a VIP event to which I was privileged to be invited – special thanks to Brisbane Marketing) at The Lab – a marquee based at Southbank on the banks of the Brisbane River. The food alone was a gorgeous array of classic chemistry with cocktails served in beakers, dry ice fountains and a period table cake! It was a welcome opportunity to network with academia, learned societies, politicians and industry.

I travelled as a guest of Brisbane Marketing on behalf of the RACI. A special thank you to Brisbane Marketing for affording the opportunity to experience the WSF and the plethora of fantastic conference facilities Brisbane has to offer.

Breakfast with the Brians. Courtesy of Brisbane Marketing.

Street science. Courtesy of Brisbane Marketing.

Julia Stuthe MRACI CChem is Books Publishing Director at CSIRO Publishing. She is Vice-President and President Elect of the RACI's Victorian Branch.

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