

chemistry

October 2016

in Australia



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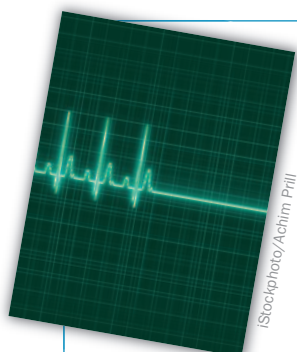
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cover story

Drugs and the death penalty: breaking the supply chain

A new Pfizer restriction means that lethal injection drugs are no longer available on the US open market.

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Mike Zammit reflects on the different perspectives of IP for researchers, IP coordinators and patent attorneys.

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From the President

This is my last President's column as I hand over to the President Elect, Peter Junk, at the RACI Annual General Meeting in November. So it's customary at this time to acknowledge the people who have helped me during my two-year term as President.

However, this year in particular, has been rather different. In April, while on my bicycle on the way to work at the University of Queensland, I literally 'went under a truck'. The abridged version is that I'm much better now. I can't put into words how vital the love and support of my family have been to my recovery; they already know. I also would like to thank all of the RACI members who sent cards, letters, flowers, emails or called with their best wishes. It was very much appreciated.

I would like to thank the Royal Brisbane and Women's Hospital, which hosted me for seven weeks and to acknowledge the skills and dedication of their doctors, nurses and 'wardies'. After seven operations and lots of physiotherapy, my recovery is still ongoing, but I'll get there eventually. Recent Past Presidents will agree that the RACI Presidency seems to have been dogged by extended hospital visits. Don't worry Peter, the curse stops with me!

In terms of RACI duties, I have many people to thank for their support. Roger Stapleford, our valued CEO, and Peter Junk as acting President kept things in order without me doing anything during April and May while hospitalised. I thank all Board members for getting on with the job in my absence. I particularly want to single out David Edmonds not only for his relentless dedication to his position as Honorary General Treasurer but his personal support, including hospital visits. David and I both joined the Board in November 2012 and he has been a valued confidant. His experience as a Past President has been invaluable not only to me but to the entire Board and CEO. Corporate memory is vital in any organisation and the current structure of two years on the RACI Board as President Elect then two years as President greatly facilitates that process. Anyone who has aspirations to be a future RACI President (Elect) should be assured that there is a strong support base and you don't have to know everything about the Institute to be nominated.

The current Board has a broad range of skills and experience. There will be a changing of the guard at next month's Annual General Meeting with three elected members to join the Board. We also look forward to welcoming Board-nominated people from outside the RACI membership (non-chemists) to bring an even more diverse set of talents to the RACI's governing body. This was enabled by a key change to the RACI Constitution approved by the membership at a Special General Meeting in July 2015.

So as I hand over to Peter, I can say that it's been a privilege to serve as RACI President for the last two years. I have enjoyed the company of my fellow Board members and learned from them. It has very much been a team effort. I hope that RACI continues to become an increasingly broad-based organisation. I have also appreciated the RACI Assembly meetings with the State or Territory Branch Presidents and Divisional Chairs. These are the people who play a vital role in coordinating activities of direct interest to members. It's not unusual for RACI members to think of themselves as members of a specific Division or Branch. Although it's an artificial distinction (we're all in it together actually) the first point of contact and reason for joining RACI is often due to events run by a local Branch (or Group) or specialist Division. The RACI Assembly bears a great responsibility at grass roots level; without its collective drive and commitment we cannot effectively support our membership.

The Institute is 99 not out. That's a good innings, so far, for a not-for-profit organisation run mostly by volunteers, i.e. you, the membership, with coordination provided by the National Office. Next year we will celebrate a great milestone with events around the country. The largest event will be in Melbourne; the RACI Centenary Congress (23–28 July 2017, www.racicongress.com). I look forward to seeing you there.



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ISSN 0314-4240 e-ISSN 1839-2539



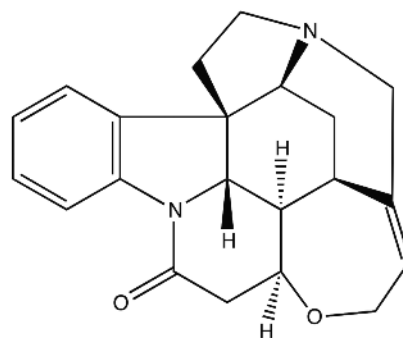
Chakravarti and Robinson

I was interested to read in the August 2016 issue (p. 41) the article by Ian Rae on the Indian organic chemist Chakravarti and his collaboration with Sir Robert Robinson, having myself published an article on Robinson (October 2012, p. 40). In my article, I cited the biography of Robinson by T.I. Williams, and this contains further information on Chakravarti's involvement with the discovery of the structure of strychnine.

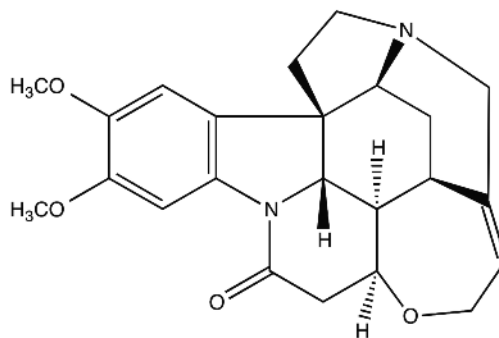
Chakravarti spent the period 1945–7 with Robinson at Oxford before going to Harvard to work with Louis Fieser. As late as 1961, Robinson wrote to Chakravarti, who was by then back in India, to suggest that the two might collaborate in the writing of a monograph partly on strychnine and partly on brucine, another alkaloid that Robinson and Chakravarti had investigated. This was to have reviewed not only their work on the topic but also independent work in order that there be an accurate record of the respective contributions. Robinson reiterated the suggestion in a further letter to Chakravarti in 1964. As recorded by Williams *op. cit.*, there was not sufficient interest in the international organic chemistry community for such a monograph to be published as by then the work that it would have covered was seen as being dated.

Chakravarti, who lived to be 91, married a graduate student of Robinson's. Her name was Debi Mukherji. Robinson would have liked her to be a co-author of the proposed monograph.

Clifford Jones FRACI CChem



strychnine



brucine

'Your say' guidelines

We will consider letters of up to 400 words in response to material published in *Chemistry in Australia* or about novel or topical issues relevant to chemistry. Letters accepted for publication will be edited (no proof supplied) for clarity, space or legal reasons and published in print and online. Full name and RACI membership type will be published. Please supply a daytime contact telephone number (not for publication).

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ANSTO welcomes new board members

Professor Margaret Sheil FRACI CChem and Professor Brigid Heywood were both appointed to the ANSTO Board in July.

Sheil has been the Provost at the University of Melbourne since April 2012, and has previously held significant positions across numerous committees, advisory boards and specialist technical institutes. She was CEO of the Australian Research Council for five years, and prior to that was Deputy Vice Chancellor (Research), Dean of Science and a Professor of Chemistry at the University of Wollongong.

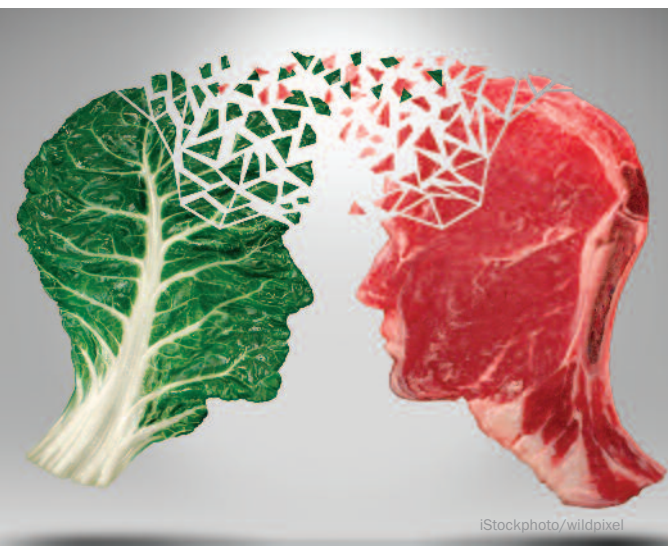
Heywood is the Deputy Vice Chancellor (Research) at the University of Tasmania, and is responsible for the University's research and innovation strategy, its research institutes, students and infrastructure, and commercialisation services. A trailblazer in many respects, she was the first woman in the UK to hold an established Chair in Inorganic Chemistry – which is particularly notable given her founding disciplinary background in biological studies.

ANSTO

The depth and breadth of their work histories across the science, health and research sectors both in Australia and abroad will bring invaluable insights to ANSTO.

Dr Adi Paterson, CEO of ANSTO

Food science meets culinary skill



Chefs are mixing the culinary arts with food science to create new menu items and commercial products. The products include vegan burgers that taste like big juicy hamburgers and caramelised meat flavours that can mimic flavours typically acquired through traditional cooking techniques. The latest developments in this merging of food science and the culinary arts – known as culinology – were presented at a symposium in July hosted by the US Institute of Food Technologists (IFT).

More commercial ingredients and food science techniques are being used in restaurant kitchens. For instance, cranberry beads, which can be a garnish on a dessert or a flavour component in a cocktail in a restaurant, wouldn't be possible without the food science – the gelling reaction of calcium chloride and alginate through a process called spherification, says John Draz, executive research chef of Ed Miniati LLC. In the product development world, this combination would be termed 'encapsulated', but on the restaurant menu it is cranberry caviar, he says.

Chris Warsow, corporate executive chef at Bell Flavors & Fragrances, is blending food science with the culinary arts by designing flavours that replicate the caramelised taste that's created when meats are roasted in a traditional method. Those caramelised flavours can be added to packages of fish and meat that are being prepared by *sous vide* cooking (where food is sealed in airtight plastic bags and placed in a water bath). He's also using different techniques to help food companies make meat analogues from plant-based proteins. Meat production puts a great deal of stress on the environment, he says, and this science can help relieve much of that stress.

US Institute of Food Technologists

There are a lot of good meat analogues that eat, chew and taste like meat protein.

Chris Warsow, corporate executive chef, Bell Flavors & Fragrances

How fish scales and magnetism could mop up oil spills

Discovering what makes oil bond to some surfaces and not others could be the key to environmental clean-ups.

Researchers at the University of Wollongong's Institute for Superconducting and Electronic Materials (ISEM) with their partners at Beihang University in China have demonstrated two novel methods of controlling the movement of droplets of oil within other liquids using magnetic forces.

The research is inspired in part by the oil-repellent nature of fish scales as a way of reducing the oil's adhesion, or stickiness, to any surface it touches. The two techniques – one using tiny particles dispersed through the oil and the other using an oil-repellent film – have major implications for environmental protection, as well as protective coatings for drug delivery.

In recent years, researchers have attempted to reduce the stickiness by manipulating the liquid's surface tension and using external forces such as electricity, pressure differences, heat and even sound waves to move the oil droplets. ISEM research fellow Dr Yi Du said the challenges of controlling the speed and direction of the droplet remain.

The joint-research teams developed nanoscale magnetic particles that are dispersed into oil or water. Once they bond with the oil, a magnetic liquid is created that can be pushed or driven using a relatively simple magnet. The concept could be likened to using a magnetic leaf blower, and has the potential to drastically reduce the cost and time spent cleaning up major oil spills.

In cases where the oil leak is under water, or where the oil is heavier than water, the particles sink through the water until they bond with the oil, overcoming a major problem for environmental clean-up.

The same concept could be applied to spills on land, where the particles are diffused in water instead of oil and could be ready to use in spill clean-up kits.

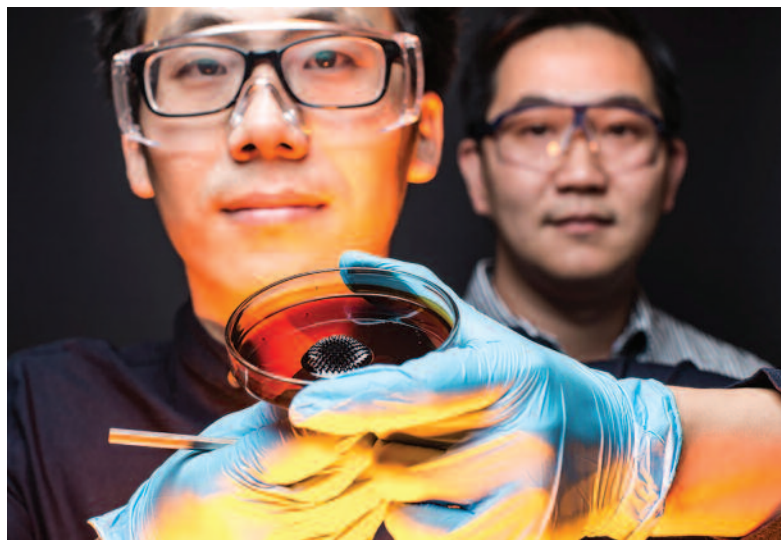
The nanoparticles are non-toxic and re-usable, as well as cheap and easy to produce. The ratio of the particles to oil is as little as 100 mg/L and can be adjusted to improve the response to the magnetic field.

'If you think of a lubricant that many people have in their garage, such as WD40, we know that it sticks very well to surfaces it's sprayed on because it has very good bonding chemistry,' Du said.

'Understanding that bonding chemistry is what is helping us ensure that particles stick to the oil droplets so they can be driven and or pushed using a magnet.'

The results were published recently in *ACS Nano* (doi: 10.1021/acsnano.6b02318).

Du said it was extremely difficult to manipulate and move oil droplets in a liquid medium, such as water, without loss because of its tendency to stick to certain surfaces. Tested over 10 cycles, their 'smart film' did not lose any oil, while the comparison smooth surface film lost 40% of the oil droplet



PhD student Haifeng Feng and Dr Yi Du demonstrate the magnetised oil.

volume through sticking to the surface.



'We know that fish scales can be self-cleaning because of their oil-repellent nature under water, so we made a surface that mimics the fish scales by placing nanoscale rods on a film,' he said.

In between the nanorods are an uncountable number of holes or wells in the surface, which are filled with water when they are immersed. This creates a repellent force because only the top surfaces of these nanorods are in contact with the oil droplet.

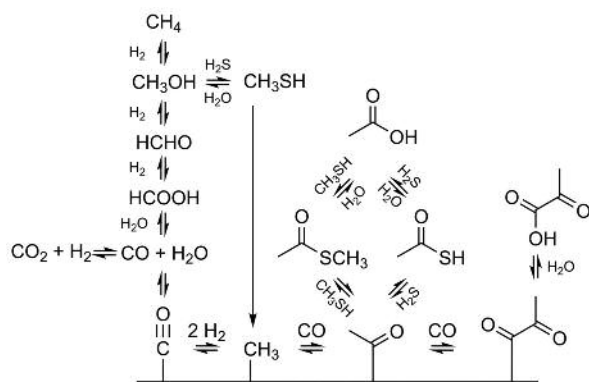
'If we magnetise the fluid using the particles, the oil-like fluid can be transported through very small liquid-filled networks, such as blood vessels or piping, where a traditional electric pump is not feasible.'

The next step is to fabricate and test the film with the magnetic fluid and oil on a large scale. The results were published recently in *Physical Chemistry Chemical Physics* (doi: 10.1039/C6CP01419D).

University of Wollongong

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Kinetic analysis questions chemistry proposed for origin of life



Some proposed mechanisms for the abiotic production of TAA and MTA in hydrothermal settings. The thick line represents a mineral surface (e.g. a metal sulfide or oxide).

Kinetic and thermodynamic considerations reported by researchers at the Tokyo Institute of Technology suggest that thioesters at the heart of many theories on the origin of life are unlikely primordial contributors. The research is reported in *Scientific Reports* (doi: 10.1038/srep29883).

How life emerged from a primordial soup of simple chemicals remains unknown. However, scientists have proposed several possible schemes for the origin of life, many of which rely on chemistry involving thioesters such as thioacetic acid (TAA) and methylthioacetate (MTA). Now results of kinetic and thermodynamic considerations reported by Kuhan Chandru and his colleagues at the Tokyo Institute of Technology (Earth-Life Science Institute) question the likelihood of these schemes.

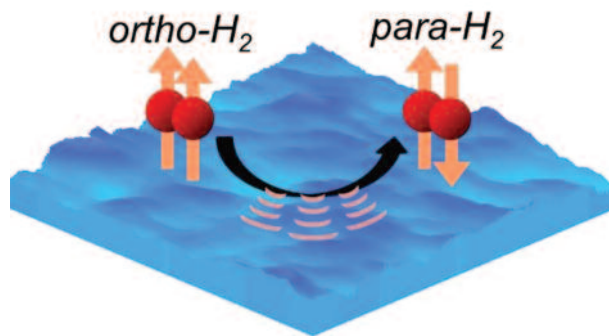
Many of the reactions that form biological matter require enzymes that would not have existed in prebiotic times. However, the high temperatures in hydrothermal vents can overcome reaction barriers without the need for enzymes, making them widely considered likely sites for the origin of life. With this in mind, Chandru along with colleagues led by Jim Cleaves – a researcher affiliated with Tokyo Institute of Technology in Japan and the Institute for Advanced Study in Princeton, US – studied the reaction kinetics in the conditions found in hydrothermal vents.

The researchers used nuclear magnetic resonance to study the reversible hydrolysis of TAA and MTA in a range of possible pH, temperature and concentration conditions common to hydrothermal settings. They conclude that: 'TAA and MTA differ significantly in terms of their stability and reactivity as a function of pH and temperature, though both are implausible prebiotic reagents for different reasons in different contexts.'

The researchers also add that the results suggest 'estimates of the ubiquity of suitable environments for the origin of life in and beyond our solar system may be somewhat overestimated, if these compounds are indeed crucial for jumpstarting early metabolism.'

Tokyo University of Technology

Reconsidering molecular evolution theory



Ortho-hydrogen converts to para-hydrogen by releasing energy to the ice surface. The conversion rate differed depending on the ice temperature. Naoki Watanabe, Hokkaido University

Scientists at Hokkaido University have revealed temperature-dependent energy-state conversion of molecular hydrogen on ice surfaces, suggesting the need for a reconsideration of molecular evolution theory.

Molecular hydrogen, the most abundant element in space, is created when two hydrogen atoms bond on minute floating ice particles. It has two energy states: ortho and para, depending on the direction of proton spins. Ortho-hydrogen converts to para-hydrogen on extremely low temperature ice particles, although its mechanism remained unclear.

When molecular hydrogen is released from tiny ice particles in space, the particular state of its energy plays a key role in molecular evolution – the process of generating a wide range of molecules over a long period of time in space.

In the study, the researchers developed a special system that could detect the ortho-to-para ratio of molecular hydrogen on artificial ice particles. The study discovered that the ratio of the ortho-to-para conversion rate (as time passed) was dramatically different in the relatively small temperature range of between -264°C and -257°C , thus, in a world first, unravelling the conversion mechanism. Ortho-hydrogen converts to para-hydrogen by releasing energy to the ice, in a temperature-dependent manner.

Until now, the energy conversion rate was believed to be identical regardless of the temperature of ice particles – a theory that has been scotched by the new research. The finding will likely prompt scientists to rebuild theories of molecular evolution, opening new horizons in studies of molecular formation and molecular evolution.

Hokkaido University

A glimpse inside the atom

The ability of an electron microscope to image a structure – and how successful this imaging will be – depends on how well you understand the structure. Complex physics calculations are often needed to make full use of the potential of electron microscopy. An international research team led by Professor Peter Schattschneider from the Vienna University of Technology set out to analyse the opportunities offered by energy-filtered transmission electron microscopy (EFTEM). The team demonstrated numerically that under certain conditions, it is possible to obtain clear images of the orbital of each individual electron within an atom. Electron microscopy can therefore be used to penetrate down to the subatomic level – experiments in this area are already planned. The study has now been published in *Physical Review Letters* (doi: 10.1103/PhysRevLett.117.036801).

Although it has been possible to calculate the shape of electron orbitals for a long time, efforts to image them with electron microscopes have been unsuccessful to date.

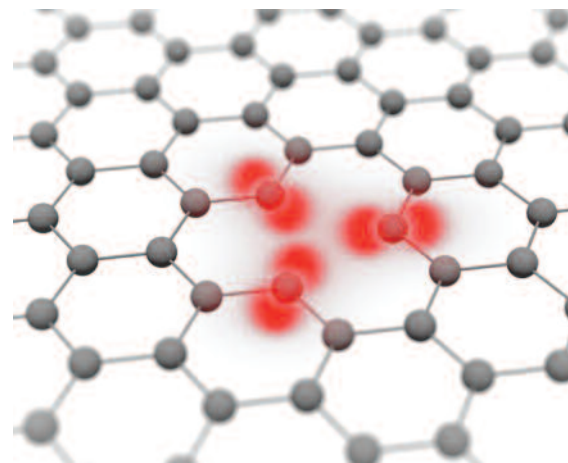
‘We have calculated how we might have a chance of visualising orbitals with an electron microscope,’ said Stefan Löffler from the University Service Centre for Transmission Electron Microscopy at Vienna University of Technology.

‘Graphene, which is made of just one single layer of carbon atoms, is an excellent candidate for this task. The electron ray is able to pass easily through the graphene with hardly any elastic scattering. An image of the graphene structure can be created with these electrons.’

EFTEM can be used to create quite specific visualisations of certain kinds of atoms while blocking out the others. For this reason, it is often used to analyse the chemical composition of microscopic samples. ‘The electrons shot through the sample can excite the sample’s atoms,’ explained Löffler. ‘This costs energy, so when the electrons emerge from the sample, they are slower than when they entered it. This velocity and energy change is characteristic for certain excitations of electron orbitals within the sample.’

After the electrons have passed through the sample, a magnetic field sorts the electrons by energy. ‘A filter is used to block out electrons that aren’t of interest: the recorded image contains only those electrons that carry the desired information.’

The team used simulations to investigate how this technique could help reach a turning point in the study of electron orbitals. While doing so, they discovered something that actually facilitated the imaging of individual



Atomic orbitals of carbon atoms in graphene. Vienna University of Technology

orbitals: ‘The symmetry of the graphene has to be broken,’ said Löffler. ‘If, for instance, there is a hole in the graphene structure, the atoms right beside this hole have a slightly different electronic structure, making it possible to image the orbitals of these atoms. The same thing can happen if a nitrogen atom rather than a carbon atom is found somewhere in the graphene. When doing this, it’s important to focus on the electrons found within a narrow and precise energy window, minimise certain aberrations of the electromagnetic lens and, last but not least, use a first-rate electron microscope.’ All of these issues can be overcome, however, as the research group’s calculations show.

Vienna University of Technology

Making underwater glue with a biomed engineer

Bruce Lee, an assistant professor of biomedical engineering at Michigan Tech, focuses on adhesives inspired by nature – more specifically, the natural glues made by mussels that anchor them to rocks, boats and docks. Lee’s past work on hydrogels and tissue adhesives led him to look more closely at what makes these adhesives work underwater – and how people could use them to not only improve robotics and submarine sensors but also help heal wounds.

As a participant in the US Navy’s Young Investigator Program, Lee plans to continue delving into what makes mussels sticky and how to reverse that adhesion.

‘This work is novel in the sense that there is no smart adhesive out there that can perform underwater,’ he said.

‘The chemistry that we can incorporate into the adhesive, causing it to reversibly bond and de-bond, is quite new.’

The challenge now is to determine how to apply an electric current, causing the DOPA-based adhesive to release, and then reapplying the current to make it glue-like again.

‘A smart adhesive can bind sensors underwater; it can attach to a ship hull; it potentially could help underwater robotics or unmanned vehicles and integrate with naval systems,’ Lee said, adding that there is also a biomedical component. ‘Think of a Band-aid – our adhesive would be a less painful way to remove a bandage – or being able to detach or reattach a prosthetic limb or a wearable sensor.’

Michigan Tech



Encouraging a good grounding in soils

An initiative launched by Soil Science Australia in 2015 is making solid progress teaching Australian schoolchildren the relevance and importance of soils in everyday life. The Soils in Schools program uses topics within the national curriculum and encourages a wider interest in our soil resources.

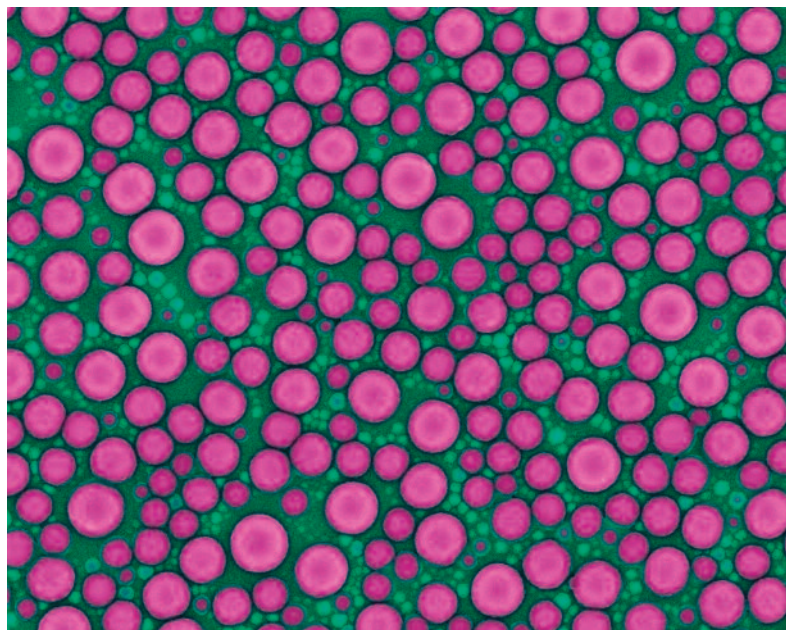
Soils in Schools aims to:

- promote soil science and its relevance to teachers and school students develop specific soil science educational materials based on the national F–10 curriculum
- deliver the soil science educational materials, for example presenting at externally run teacher professional development conferences or via web-based teacher outlets
- raise government and industry awareness on the importance of integrating soils-based teaching into the curriculum.

The program has successfully developed four teacher guides based on the national curriculum and provided teacher training for these guides at externally run teacher conferences. The teacher guides are available at www.soilsinschools.com.au.

Soil Science Australia

Perpetual ‘ice–water’ solid–liquid state revealed in gallium nanoparticles



Gallium nanoparticles

Imagine placing ice cubes into a glass of water and having the ice cubes remain unchanged and in the same state for hours, even under intense heat or freezing conditions.

This is similar to a surprising discovery made by an international team that included researchers from the University of Western Australia, Duke University (US), the Institute of Nanotechnology (Bari, Italy), Linz University (Austria) and the University of Melbourne and published in *Nature Materials* (doi: 10.1038/nmat4705).

However, instead of testing water, the researchers made the discovery using nanoparticles of the metal gallium.

Gallium is a soft, silvery bluish metal at room temperature that melts at 30°C. Below –18°C, gallium becomes hard and brittle.

Researcher Dr Alexandra Suvorova from the University of Western Australia’s Centre for Microscopy, Characterisation and Analysis said the researchers used advanced electron microscopy facilities at the university and imaged the atomic arrangement within the particles.

‘We discovered that, by controlling the growth of the nanoparticles on the substrate, both a liquid and solid state are possible in the metal nanoparticle at a same time,’ she said.

‘The finding was surprising, especially because of its stability over such a large temperature range.’

Suvorova said the discovery was a major breakthrough in understanding the nanoscale behaviour of gallium, and created new possibilities in science and technology and for the future development and use of gallium.

‘Gallium is an important element in electronics and is used in microwave circuits, high-speed switching circuits and infrared circuits,’ she said.

‘The discovery of this new part-solid, part-liquid nanoparticle phase could be useful in ultraviolet sensors, molecular sensing devices and enhanced photodetectors.’

University of Western Australia



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Science graduate numbers growing but the jobs are not

Many recent science and information technology graduates are failing to find full-time work at a time when science, technology, engineering and mathematics (STEM) education is a priority for government and industry, according to a new Grattan Institute report.

Mapping Australian higher education 2016 shows that in 2015, only half of bachelor degree science graduates seeking full-time work had found it four months after completing their degrees, 17 percentage points below the average for all graduates.

Among recent science graduates who found full-time jobs, only half say their qualification is required or important for their job – about 20 percentage points below the average.

Although job outcomes improve over time, science bachelor degree graduates are less likely than other STEM graduates to work in high-skill managerial or professional jobs.

Mapping Australian higher education 2016, Grattan Institute's regular overview of key trends in higher education, focuses on STEM graduate employment.

Grattan Institute Higher Education Program Director Andrew Norton says that despite poor employment outcomes, demand for science courses continues to grow.

'Prospective students thinking about studying science need to know that a bachelor science degree is high risk for finding a job. Often students need to do another degree to improve their employment prospects,' Norton said.

Although there are many more potential jobs in IT than science, a third of recent IT graduates cannot find full-time work. IT students are less satisfied than other students with their skills development and more likely to leave their courses without finishing. IT industry and professional bodies suggest that university IT courses need improving.

Engineering graduates have better employment prospects than science or IT graduates. Three-quarters of new engineering graduates have full-time work, and have the highest rate of professional or managerial employment of all STEM graduates.

In other trends examined in *Mapping Australian higher education 2016*, domestic enrolments exceeded one million for the first time in 2014, with the fastest growth in health.

International student numbers are growing again, after a fall between 2010 and 2012. Student satisfaction with teaching is also increasing.

Australia performs well in global research rankings, but in recent years levels of university research expenditure and outputs have stopped growing.

By Andrew Norton, Grattan Institute

Right mix of skills critical for Australia's STEM graduates

Professional Scientists Australia warns it is critical that highly qualified STEM graduates have the right mix of technical and non-technical skills as they enter the workforce.

This follows the release of a Grattan Institute report in August revealing many of Australia's science graduates face challenges securing permanent employment (see previous news story).

Professional Scientists Australia CEO Chris Walton expressed concerns that only 51% of science graduates secured full-time positions within four months of graduating but rejected the Grattan Institute's claim that future STEM students should reconsider.

'The Grattan Institute's Andrew Norton is missing the point when he says STEM graduates should look at studying something else', said Walton.

'The skills STEM graduates acquire in their degree equip them with critical thinking, reasoning, logical deduction, problem-solving and quantitative analysis – all skills crucial to both the corporate and research sectors.

'We need to ensure that graduates have opportunities, both within their studies and through their employer to become "job capable". This means that employers must start recognising the capacity of STEM graduates to benefit their business.'

The non-technical STEM skills Walton refers to include management, leadership, entrepreneurial, business, operational, marketing and commercialisation skills – the soft skills often not taught explicitly with a STEM undergraduate course.

'We call on the Turnbull government to work with state governments, industry bodies and businesses to make sure we have a long-term approach to workforce development and to ensure that the strong technical and non-technical skills of STEM professionals are recognised as central to the National Innovation and Science Agenda,' said Walton.

Professional Scientists Australia

Suspense in the movie theatre air

With some movies, suspense is quite literally in the air. Scientists at the Max Planck Institute for Chemistry and the Johannes Gutenberg University in Mainz, Germany, analysed the air in cinemas during various movie screenings and determined that every movie leaves a characteristic pattern in the air.

It is now possible to determine whether a movie scene is full of suspense, funny or somewhat boring, using chemistry. The Mainz researchers investigated how the composition of the air changed when an audience watched movies from different genres such as comedies like *The Secret Life of Walter Mitty* and *Buddy*, fantasy movies like *The Hobbit* and the science-fiction thriller *The Hunger Games*. The researchers determined how the audience reacted to individual movies on a scene-by-scene basis. Using their analyses, they were also able to reconstruct which scenes were playing at the time. The chemical patterns are best defined during suspense or funny scenes.

'The chemical signature of *The Hunger Games* was very clear; even when we repeated the measurements with different audiences,' said Jonathan Williams, group leader at the Max Planck Institute for Chemistry.

'The carbon dioxide and isoprene levels in the air always increased significantly as the heroine began fighting for her life.'

Isoprene is one of more than 800 chemical compounds typically exhaled by healthy people in tiny amounts in addition to carbon dioxide. However, it is not yet known what physiological processes are causing the formation of the molecules.

One explanation for the increasing carbon dioxide and isoprene levels, according to the Mainz researchers, is the fact that moviegoers tense up, become restless and breathe faster when watching scenes of suspense. Funny sequences consistently resulted in different molecular traces in the air than moments of excitement or suspense. 'We can clearly differentiate the mass spectra,' said Williams.

'We were wondering whether it is possible to chemically differentiate between scenes in which different emotions are induced,' said Williams, who has been studying the exhaled air of large groups of humans for some time, and has also used his devices during a match at the Mainz football stadium. Previously Williams wanted to find out whether human breath has a significant impact on the concentration of trace gases, such as the greenhouse gases carbon dioxide and isoprene. According to the analysis in the soccer stadium, it does not, and hopes for characterising the football crowds' chemical reaction to a goal were dashed as the match ended 0:0. Therefore, Williams and his colleagues decided to analyse human emissions during emotional experiences in a more controlled environment and came up with movie screenings.

'It appears that we can measure whether there is suspense in the air,' said Williams. He believes these exhaled air

measurements have great potential for research into human respiration and with further characterisation could allow us to investigate human metabolism. Measuring the exhaled air of large groups of humans or 'crowd breath' provides an alternative to studies of individuals, which are laborious and increasingly subject to ethical hurdles.

There could also be practical applications for studies of air exhaled by large groups of people. The advertising industry could, for example, quickly and objectively measure how large groups of people react to emotional stimuli without having to conduct lengthy surveys.

The team's study included a total of 16 movies, which were shown multiple times to audiences of different sizes. *The Hobbit* alone was shown 15 times. The researchers attributed different objective labels to all scenes of all movies, in order to assign them to the 30-second measurement intervals. The researchers had each film scene assessed, e.g. as humour, dialogue or a fight scene, independently by ten volunteers. A scene label was only assigned when the subjective assessments of several researchers corresponded.

The researchers installed their devices in the cinema's technical room to record carbon dioxide and more than 100 other chemical components exhaled by the audience in the cinema's exhaust air. They inserted into the ventilation system the inlet of a mass spectrometer, which took measurements every 30 seconds.

To analyse the data, Williams sought the assistance of Stefan Kramer, Professor at the Institute of Computer Science at the Johannes Gutenberg University in Mainz. This institute is one of the world leaders in the field of systematic data collection and analysis, also known as data mining. 'In statistical terms, we got a clear chemical signal for humorous and suspenseful scenes, and were able to identify these even without seeing the movie,' said Jörg Wicker, who developed the evaluation algorithms.

Wicker and Kramer are already looking forward to continuing the study: researchers are currently assessing chemical traces from audiences during the blockbuster *Star Wars*.

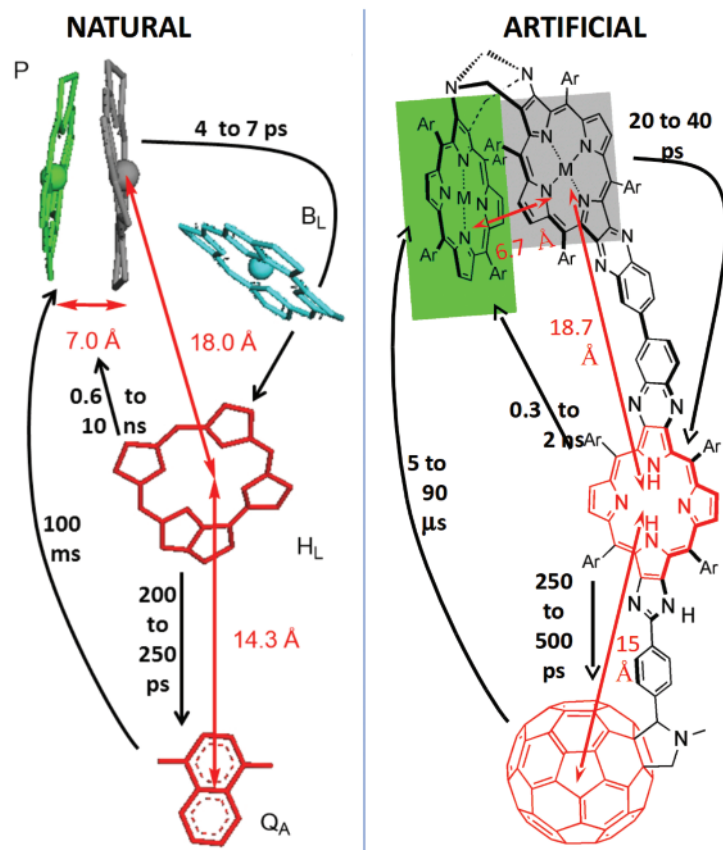
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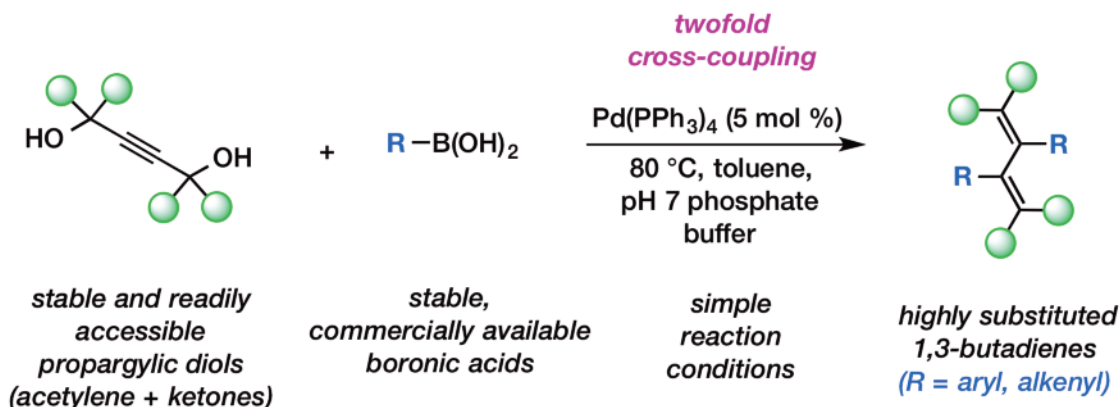
iStockphoto/BenSilva

Synthetically tuneable photosynthetic reaction centre mimics

Rigid ferrocene–porphyrin tetrad molecules with the same basic shape, size and photochemical rate properties as the key pigments involved in bacterial photosynthesis have been synthesised and characterised (Lee S.-H., Blake I.M., Larsen A.G., McDonald J.A., Ohkubo K., Fukuzumi S., Reimers J.R., Crossley M.J. *Chem. Sci.* 2016, doi: 10.1039/C6SC01076H). The design, synthesis and electrochemical and spectroscopic characterisation were performed in the laboratory of Professor Maxwell Crossley at the University of Sydney, with transient absorption spectra recorded in the Osaka University laboratories of Professors Kei Okubo and Shunichi Fukuzumi and analysed at University of Technology Sydney and Shanghai University in the group of Professor Jeffrey Reimers. The tetrad molecules were shown to be useful as artificial light-harvesters, with rate constants for energy loss processes being substantially larger than those of most artificial systems. Their synthetic flexibility combined with their structural rigidity makes in situ redox and spectroscopic properties easy to control. A zinc Tröger's base porphyrin dimer mimics the C_2 symmetric special pair primary donor P, a free-base porphyrin mimics the bacteriopheophytin primary electron acceptor H_L , and a ferrocene mimics the quinone secondary electron acceptor Q_A . Of all artificial light-harvesting molecules reported, this system by far most closely resembles the characteristics of the natural bacterial photosystem.



Single-step synthesis of substituted 1,3-dienes

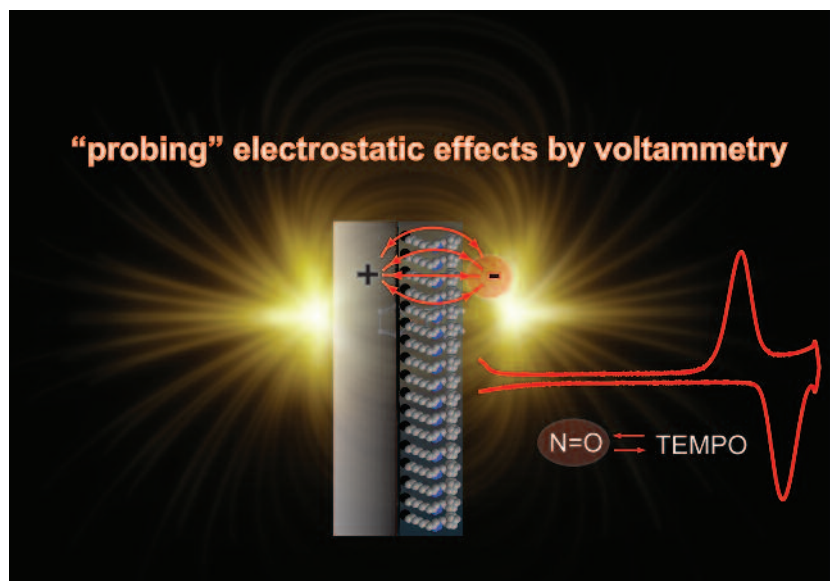


1,3-Butadienes have long been the target of synthetic efforts. The most substituted varieties have proved difficult to make, requiring lengthy sequences and harsh reaction conditions, or routes severely limited in generality. Research from the Sherburn group in the Research School of Chemistry at the Australian National University has shown that these tricky butadienes are best made via a simple one-step procedure, employing commercially available precursors, reagents and catalyst (Green N.J., Willis A.C., Sherburn M.S. *Angew. Chem. Int. Ed.* 2016, **55**, 9244–8). Thus, a twofold cross-coupling can

be performed with a large variety of aryl or alkenyl boronic acids and substituted propargyl diols to make 2,3-diaryl-1,3-butadienes and [4]dendralenes, respectively. Alternatively, a single cross-coupling can furnish allenyl alcohols. Remarkably, in 'wet' solvent, the diols are reactive enough to require no derivatisation – only the diol, boronic acid, solvent and a palladium catalyst are used in a 'halogen-free' procedure. The products of the new reactions are easily transformed through acid-catalysed cyclisations into other highly substituted, unsaturated multi-cyclic fused ring systems.

Controlling electroactivity of surface-tethered radicals

Cyclic voltammetry is a well-established form of electrochemical 'spectroscopy' that yields a great wealth of mechanistic and thermodynamic information from the analysis of a current flowing across an electrified interface. A team of researchers from the University of Wollongong, the Australian National University, the University of New South Wales, Institut de Bioenginyeria de Catalunya and ANSTO has used this technique to show how a seemingly simple 'dynamic' current-potential trace can yield quantitative insights into the 'electrostatic' environment around a surface-tethered nitroxide radical (Zhang L., Vogel Y.B., Noble B.B., Gonçalves V.R., Darwish N., Le Brun A., Gooding J.J., Wallace G.G., Coote M.L., Ciampi S. J. *Am. Chem. Soc.* 2016, **138**, 9611–9). The level of doping and nature of the electrolyte were found to cause drastic kinetic changes to the electroactivity of the radical monolayer as well as electrochemical non-idealities. Calculations indicate that these unusual effects are electrostatic in origin and arise from interactions between the nitroxide radical (2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO)) and either electrolyte species or ionised dopants in the semiconducting electrode. This work has important implications for how charged groups or externally applied electric fields can influence chemical bonding and reactivity, an area that is beginning to attract enormous interest (see, for example, Aragonès A.C. et al., *Nature* 2016, **531**, 88–91).



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.

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Monowave 50 reactor – simplified, safe and affordable synthesis at elevated temperatures

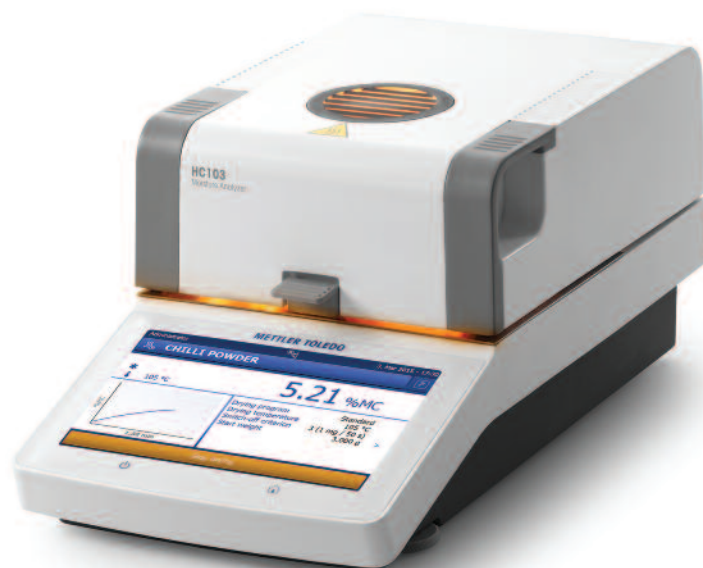
Anton Paar announces the latest addition to its industry-leading synthesis reactor portfolio: the Monowave 50. Priced at \$11 320, the Monowave 50 puts the capabilities and benefits of dedicated high-temperature synthesis reactors within reach of every chemistry lab.

Shorter reaction times, higher yields, lower reagent consumption, and simplified handling are all reasons that thousands of laboratories per year are moving away from conventional chemical synthesis methods to dedicated sealed-vessel reactors, including microwave systems. The relatively high price of these dedicated systems has, however, proved to be a barrier for many graduate and undergraduate laboratories from adopting microwave chemistry in teaching. The Monowave 50 all but eliminates that barrier.

The Monowave 50 incorporates the convenience and scalability of conventional heating in sealed vessels, thereby enabling high-temperature reaction conditions similar to microwave reactors. An ultra-compact footprint ensures that the Monowave 50 can be placed even in crowded labs, while Anton Paar's high safety standards ensure that even inexperienced users can simply 'plug and play'.



The full range of Anton Paar instruments is available at MEP Instruments, a company of Metrohm and Anton Paar. For further information, please contact MEP Instruments, ph. (02) 8899 5200, email info@mep.net.au or visit www.mep.net.au.



New guide for moisture measurement

The moisture content of foods, pharmaceuticals and other materials affects their processability and price and helps to guarantee freshness, potency and safety. But moisture analysis accuracy requires methods that suit the product and proof that equipment heats reliably and weighs very small changes in moisture content with precision. Mettler Toledo's free, downloadable *Guide to moisture analysis* can help.

Mettler Toledo's next instalment in its year-long Laboratory eCalendar addresses everything from preparing samples to ensuring reliable and consistent heating to help tackle the most persistent moisture analysis challenges. Using clear, easy-to-follow examples, users will learn tips and tricks that can help more accurately assess moisture content as well as provide assurance of equipment performance to satisfy regulations and auditors.

Future instalments of the 2016 eCalendar will highlight a range of issues that affect lab performance, such as balance stability and hygiene to help optimise the function of all lab equipment. Users have the choice of simply accessing the guide or requesting additional information from Mettler Toledo on products and services.

Download a copy of the Laboratory eCalendar entry *Guide to moisture analysis* from bit.ly/2aBf8SS and gain access to a wealth of Mettler Toledo eLibrary materials that will help improve lab processes today.



Drugs and the death penalty

Breaking the supply chain

iStockphoto/Андрей Юдин

BY **BRITTANY HOWARD**

A new Pfizer restriction means that lethal injection drugs are no longer available on the US open market.

In April of this year, pharmaceutical giant Pfizer announced that it will be imposing sweeping restrictions concerning its drugs that are used in carrying out the death penalty, which will effectively bring an end to the open market for execution drugs in the US. As it stands, all FDA-approved manufacturers of potential execution drugs, a diverse suite of 25 global companies, have blocked the sale of their products for use in executions (rsc.li/2aFfuJ7).

Adding to the difficulty in procuring drugs for use in executions, the UK introduced a ban on the export of drugs that are utilised in lethal injection. Europe followed shortly thereafter, and introduced a ban by amending its torture regulation. Because of this, as of 2011, the US has

been prevented from procuring lethal injection drugs from both Europe and the UK. US state correctional facilities looked farther afield, approaching Mumbai company Kayem Pharmaceuticals. When it became evident to Kayem that the drugs were being used for lethal injection, Kayem immediately stopped exporting drugs to the US.

For opponents of capital punishment, these events are significant steps towards abolishing the death penalty. However, the events raise serious concerns over the emergence of a black market for execution drugs, drug regulation and correct drug use in lethal injection. Indeed, many attribute the shocking 2014 botched execution of Clayton Lockett to the administration of a

For opponents of capital punishment, these events are significant steps towards abolishing the death penalty. However, the events raise serious concerns over the emergence of a black market for execution drugs ...

cocktail of drugs that had not been previously tested in such a procedure (bit.ly/2aFcjhG).

Pfizer's position

In its Global Policy Paper released in April, Pfizer stated that its 'mission is to apply science and our global resources to improve health and well-being at every stage of life ... Consistent with these values, Pfizer strongly objects to the use of its products as lethal injections for capital punishment.' Further, '... we are enforcing a distribution restriction for specific products that have been part of, or considered by some states for their use in lethal injection protocols. These products include pancuronium bromide, potassium chloride, propofol, midazolam, hydromorphone, rocuronium bromide and vecuronium bromide.' (bit.ly/2aFdMES)

Pfizer has vowed to now limit the sale of these seven products to a select group of trusted wholesalers, distributors and direct purchasers under the condition that they will not resell these products to correctional institutions for use in lethal injections

(nyti.ms/2b6wDtW). Pfizer also plans to continually monitor these product channels to ensure that the conditions are not breached.

Lethal injection protocol

Historically, administration of the lethal injection has involved the consecutive administration of three drugs: (1) sodium thiopental, (2) pancuronium bromide, and finally (3) potassium chloride. It is essential that the drugs be administered in this order to prevent excruciating pain to the recipient.

Sodium thiopental, also referred to as pentothal, belongs to the barbiturate chemical class of molecules that were first discovered in the early 1900s. Sodium pentothal was developed by Abbott laboratories, and was taken into clinical trials in 1934 at the Mayo Clinic as an anaesthetic. Abbott continued to manufacture the drug until 2004, when it was taken over by its spin-out company Hospira, which was subsequently acquired by Pfizer.

Sodium thiopental is a rapid-acting anaesthetic and short-acting depressant of the nervous system that is initially administered in the lethal injection procedure to induce unconsciousness. The mechanism of action of sodium pentothal remains poorly understood, though is believed to be a summation of enhancing responses to gamma-aminobutyric acid (GABA), diminishing glutamate responses, and increasing membrane conductance to directly depress excitability. The resultant effect is a decrease in neuronal excitability, and, thus, induced anaesthesia.

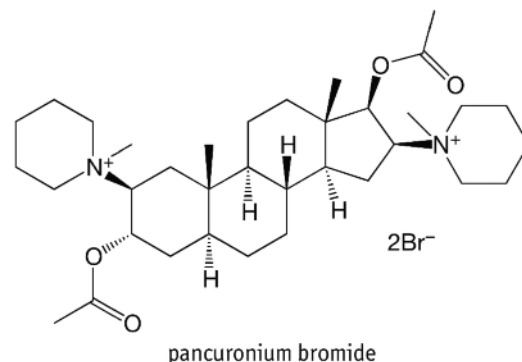
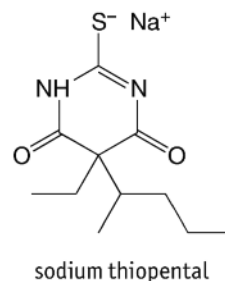
The molecule itself is highly lipophilic, and readily crosses the blood-brain barrier to its site of action. Its short duration of activity can also be attributed to this lipophilic nature, as it is redistributed in the fatty tissues away from the central nervous

system. Once it is released into the blood, sodium thiopental is metabolised by the liver, primarily into pentobarbital.

In medicine, sodium thiopental is employed as a sole anaesthetic agent for brief surgical procedures. It is also used for the induction of anaesthesia prior to administration of another anaesthetic more suitable for the ongoing maintenance of anaesthesia during prolonged surgical procedures. Sodium thiopental has also found limited use in controlling seizures.

For anaesthesia, the barbiturates have more recently been replaced with safer alternatives, including compounds from the opioid class, such as fentanyl, the benzodiazepine class, such as midazolam, and general sedatives such as propofol.

A dose of sodium pentothal, and indeed any barbiturate, could be sufficient to result in death itself, usually within 30–60 minutes of administration. However, this is not considered satisfactory in lethal injection practice, as death is preferred within approximately 10 minutes of administration (bit.ly/2aFeUZ8). As such, the three-drug regime is preferred.



UN human rights chief welcomes Pfizer's decision to bar use of its drugs in executions



High Commissioner for Human Rights Zeid Ra'ad Al Hussein addresses the 31st regular session of the Human Rights Council in Geneva.

UN Photo/Jean-Marc Ferré

On 19 May the United Nations human rights chief warmly welcomed the initiatives announced by pharmaceutical company Pfizer to ensure that the drugs it produces will not be used by States to carry out executions by lethal injection.

‘Businesses, across many industries, can help prevent human rights violations from occurring,’ UN High Commissioner for Human Rights, Zeid Ra-ad Al Hussein, said in a statement released by his Office (OHCHR). ‘It is heartening to see companies playing an active role in furthering the trend towards ending use of the death penalty.’

Pfizer announced that it would restrict the sale of seven products that have been part of lethal injection protocols in some States. Resale will be restricted and Government entities will be required to certify that the products they purchase will not be used for any penal purposes. Pfizer has said it will monitor the distribution consistently.

Mr Zeid called on all businesses to act in accordance with their human rights responsibilities as set out in the UN Guiding Principles on Business and Human Rights, to ‘avoid causing or contributing to adverse human rights impacts through their own activities, and address such impacts when they occur’ as well as to ‘seek to prevent or mitigate adverse human rights impacts that are directly linked to their operations, products or services’.

The High Commissioner noted that other companies beyond the pharmaceutical industry may be involved in activities relating to the administration of the death penalty, and called on such businesses to carry out human rights due diligence across their operations to ensure that they are not in any way contributing to the use of capital punishment.

Mr Zeid also urged States not to resort to questionable sources for the drugs required to administer lethal injections. He stressed that the UN opposes the use of the death penalty in all circumstances.

United Nations News Centre

During execution, the administration of an anaesthetic is followed by the administration of a non-depolarising neuromuscular blocking agent, which acts to prevent chemical signals travelling from the brain and spinal cord to the muscle, by competing for cholinergic receptors at the motor endplate. This results in the prevention of muscle contraction. The neuromuscular blocking agent typically employed in lethal injections is pancuronium bromide, though rocuronium bromide and vecuronium bromide have also been utilised. These agents serve a dual purpose in that they ensure the recipient's breathing is stopped, and also assist the aesthetic purpose of making the recipient appear still during the execution. These drugs do not, when administered in this way, induce unconsciousness.

In medicine, neuromuscular blocking agents can be administered to children and adults for most surgical procedures, and allow a breathing tube to be inserted and the prevention of involuntary contractions during surgical procedures.

The final drug to be administered during the execution is potassium chloride. Potassium is stringently regulated by the body, and is involved in numerous physiological processes, including the transmission of nerve impulses, the contraction of cardiac, skeletal and smooth muscle, and the maintenance of normal renal function. Normally, only a small fraction of potassium is freely circulating in the blood, with a majority being stored in cell reservoirs. However, upon administration of a lethal dose, increased potassium chloride concentrations in the blood effectively paralyse the heart. The drug administered alone is understood to be incredibly painful, and thus necessitates the prior administration of an anaesthetic and muscle relaxant.

Potassium chloride is indicated in medicine for hypokalemia (potassium deficiency) in patients for whom dietary management with potassium-rich foods is insufficient. The usually prescribed dose in adults is 20 milliequivalents per day, well below the lethal dose of 100 milliequivalents.

Cutting corners

To circumvent issues with obtaining the lethal injection drugs, many US states are now turning to alternative drugs for the lethal injection procedure. Midazolam has been employed in several executions, despite it not being well understood what dose, if any, is required to perform a ‘humane’ execution. The drug is usually given for medicinal purposes at doses of one, two and five milligrams to

To circumvent issues with obtaining the lethal injection drugs, many US states are now turning to alternative drugs for the lethal injection procedure.

induce anaesthesia, although Florida has indicated that 500 mg will be used in executions in that state (bit.ly/2aFeUZ8). However, and most importantly, midazolam is completely void of analgesic effects, which has been a primary objection to its use in lethal injections. It is believed that there is a risk of recipients not being adequately anaesthetised, resulting in a terribly painful execution.

Maya Foa, the Director of London-based Reprieve, a human rights advocacy group and a staunch opponent of the death penalty, has stated that: '[W]ith Pfizer's announcement, all FDA-approved manufacturers of any potential execution drug have now blocked their sale for this purpose ... Executing states must now go underground if they want to get hold of medicines for use in lethal injections.' (nyti.ms/2b6wDtW) In order to source the required lethal injection drugs, many states are covertly

seeking compounding pharmacies to obtain the necessary drugs. Such compounding pharmacies operate in the absence of FDA oversight and thus are loosely regulated. Of course, this lack of regulation raises serious questions as to what composition is actually being injected into recipients.

Adding to this question of the actual composition of the drug is the imposition of secrecy around a state's drug source, in an alleged attempt to protect the suppliers of these drugs from death penalty opponents. In fact, many US states have put laws in place that prevent or prohibit public disclosure of information about the sources of drugs and how they are obtained. However, Robert Dunham, executive director of the Death Penalty Information Center, states that: 'The secrecy is not designed to protect the manufacturers, it is designed to keep the manufacturers in the dark about misuse of their products.' (nyti.ms/2b6wDtW)

There is also an increasing trend for states to employ a single-drug protocol in lethal injections. This was first undertaken in Ohio in 2009, and used a single, lethal injection of sodium thiopental. Shortly thereafter, the state of Washington employed a similar practice. As at 2014, eight states had used a single-drug protocol in lethal injection, which was a lethal dose of an anaesthetic. Consequently, other states had planned to use the single-drug protocol.

Ultimately, the ongoing experimentation with new drugs that are relatively unknown in such procedures is resulting in a series of botched executions that are drawing widespread criticism from not only

death penalty opponents but also the wider community. As a consequence, some states are considering alternative, albeit outdated, methods of carrying out executions, including the electric chair, firing squad and gas chamber (nyti.ms/2b6wDtW).

The current state of lethal injections

According to the Death Penalty Information Center website (www.deathpenaltyinfo.org), as of mid-June, Arizona declared that it did not have a supply of lethal injection drugs, nor did it have access to them. The website also states that Louisiana will not carry out any executions until at least 2018, in part due to its inability to obtain lethal injection drugs. Similarly, Ohio will postpone all executions until at least 2017. In 2015, Arkansas had purchased a stockpile of drugs, reportedly midazolam, in an effort to continue executions.

As at 1 January 2016, there were 2943 death row inmates awaiting execution in the US. Exactly what experimental drug concoction they will be administered remains to be seen.

The ongoing challenge for Pfizer will be ensuring that the sale of its products is for the intended use. That is, that each of these regulated drugs is used for medicinal purposes. Ultimately, these drugs were not intended to kill. They were designed to improve the lives of patients, and ultimately, save lives.

Brittany Howard MRACI completed a PhD in medicinal chemistry at the Monash Institute of Pharmaceutical Sciences before undertaking a postdoctoral position with the National Institutes of Health (US). She is currently a trainee patent attorney with FB Rice Patent and Trade Mark Attorneys.



WEIGHTY issues

BY **DAVE SAMMUT**

**Is a switch to
artificial sweeteners
a smart alternative
to sugar?**

In March 2016, Britain introduced a 'Sugar Tax' to be applied to high-sugar drinks (excluding fruit juices and milk-based drinks). The levy will be based on volumes produced in two total sugar categories: >50–80 g/L and >80 g/L. The most popular cola drinks in Australia, for example, contain at least 106 g/L sugar. During the recent federal election, the Greens again raised a sugar tax as policy.

If sugar taxes hit their target, it may be assumed at least some portion of the consumer base will switch to artificial sweeteners, particularly in the soft drink market.

Obesity is a growing problem in

Australia. According to the Australian Institute of Health and Welfare, 63% of adults and 25% of children are overweight or obese. These rates are increasing faster than anywhere else in the world (ab.co/2amR6WO), with Australia already ranked as one of the world's most obese countries.

A 2013 study published in *The Lancet* concluded: 'Not only is obesity increasing [globally], but no national success stories have been reported in the past 33 years. Urgent global action and leadership is needed to help countries to more effectively intervene.' (bit.ly/2aK6Khw)

However, obesity is a complex issue. The sugar taxes that have been

introduced or mooted only address one causal factor. And if artificial sweeteners are one logical alternative to sugar, then do artificial sweeteners offer any advantage? Sure, the calorific value of the drinks may be lower, but are we just swapping one problem for another? Questions have been raised about the safety of artificial sweeteners – potential carcinogenic and mutagenic effects, metabolic changes, and the potential to actually trigger weight gain.

Let's start with the basics. Artificial sweeteners are used as sugar replacements for two reasons. First, they offer the body lower energy on consumption, either by requiring substantially less material to achieve the same sweet taste intensity (see *How Taste Works*, box, page 25), or by not being metabolised by the body. And second, the most common artificial sweeteners are substantially cheaper than sugar. Aspartame, for example, is typically one-third of the cost of sugar per litre of soft drink.

In principle, it would seem logical that artificial sweeteners should be a viable replacement for sugar. Not only

should lower energy intake reduce obesity, particularly if this is balanced with lifestyle improvements such as increasing exercise, but reduced sugar intake should also improve dental health.

However, for decades artificial sweeteners have been subject to an evolving series of serious health concerns and complaints. There do appear to be some genuine causes for concern – certainly worthy of serious study.

International regulatory agencies have engaged in in-depth considerations of the available information, but the field is complex. The science is tarnished with claim and counter-claim, duelling studies with mutual criticism, selective study design and/or data selection. All of this is underlaid with the distorting influences of vested interests/science for sale, politics and the hysterical non-science of the anti-fluoride/antivaccination variety. Throw in a solid dose of media sensationalism, and the truth is incredibly difficult to discern.

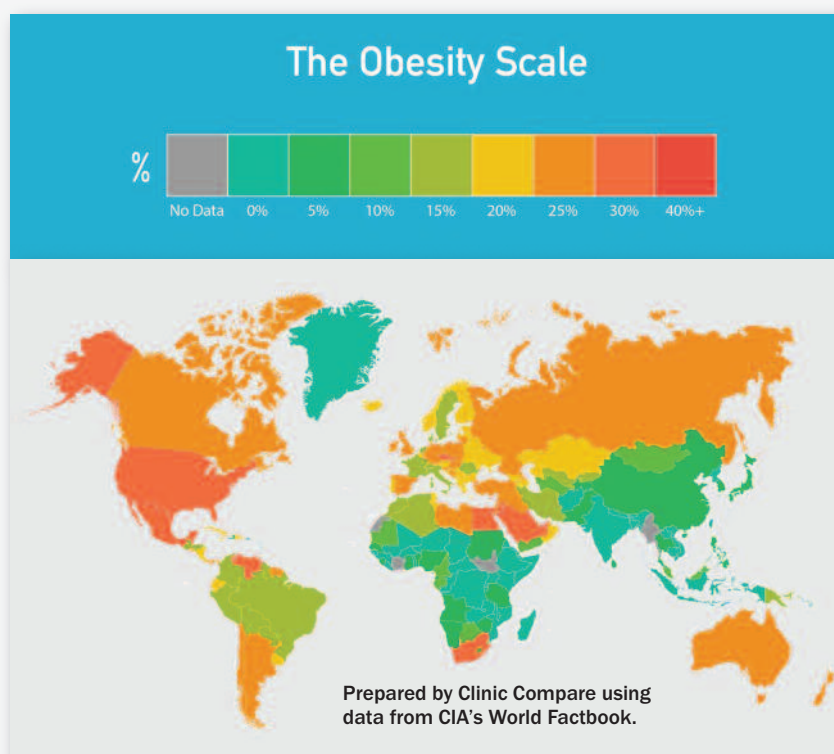
Aspartame is a good example. It has been anecdotally blamed for a



huge range of health problems, from headaches and seizures, to chronic fatigue syndrome and multiple sclerosis, Alzheimer's disease and cancer. Of these, the cancer threat grabs many of the headlines. This may be linked to the legacy of cancer studies associated with saccharin (no longer widely used), which may have 'bled over' in the public perception to the wider range of sweeteners. Yet regardless of how the concerns arose, and despite aspartame's long-standing use, its safety remains a current issue and an ongoing area of active investigation for health authorities worldwide.

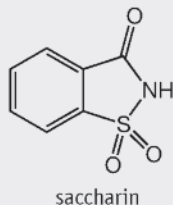
Aspartame is unusual among artificial sweeteners in that it fully breaks down during digestion, into phenylalanine, aspartate and methanol. While these are normal compounds as part of our diets, it has been argued in a 2011 study at Gujarat's Government Medical College in India that at high levels, they can cause problems to the central nervous system, and/or that their negative effects are increased in the absence of the other amino acids that would normally be ingested at the same time (bit.ly/2auPMmD). Similarly, the methanol produced as a breakdown product of aspartame has been argued to significantly exceed recommended daily allowances.

In response to the concerns, regulatory authorities globally have conducted multiple studies and reviews, including of large populations. The consensus appears to be that aspartame is safe at reasonable consumption levels (bit.ly/2auPMmD) (the European Food Safety Authority acceptable daily intake is 40 mg/day per kilogram of body mass; an average can of diet soft drink in Australia contains less than 200 mg of

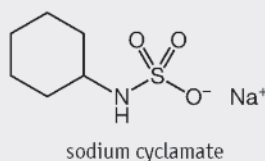


The sweetest things

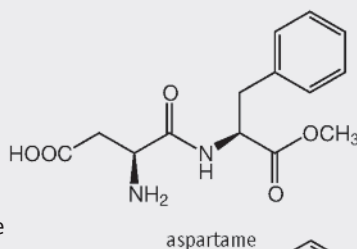
Saccharin: Accidentally discovered in 1879 by Constantin Fahlberg, who failed to wash his hands before eating after working in the lab, the name is derived from the Latin word for 'sugary'. Roughly 300 times sweeter than sugar, saccharin isn't used extensively any more but can still be found with aspartame in some soft drinks and in Sweet 'N Low®. In the 1970s, it was found to potentially cause bladder cancer in rats, and it carried a warning label until the 1990s. However, it was later concluded that the cancer mechanism was different in rats, and saccharin was removed from the US NIH's list of carcinogens in 2000.



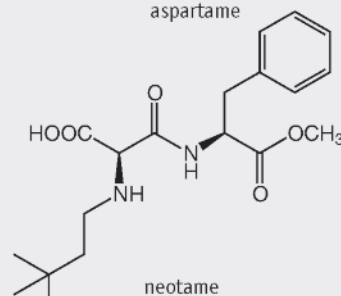
Cyclamate: Accidentally discovered in 1937 by student Michael Sveda while smoking in the lab, sodium cyclamate is 30–50 times sweeter than sugar. It was banned by the US FDA in 1970 because of reports that it causes cancer in animals, but is still used widely worldwide (such as Canadian Sweet 'N Low®), usually in combination with other sweeteners. It is cheap, and stable under heating.



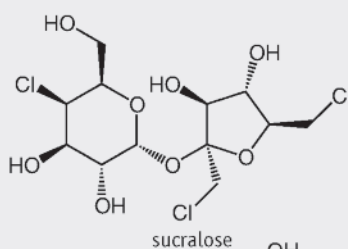
Aspartame: Accidentally discovered in 1965 (seriously folks, take some *care* in the lab, this isn't safe) by Jim Schlatter, who licked a finger before picking up a piece of paper from a bench, aspartame is roughly 200 times sweeter than sugar. It is the most commonly used artificial sweetener, in most diet soft drinks and in Equal®, NutraSweet® and NutraTaste®. Aspartame breaks down in heat, so it isn't used in baked or heated foods.



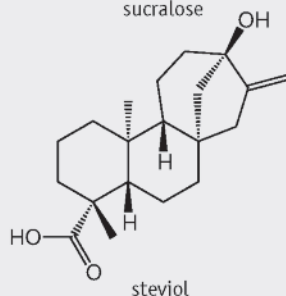
Neotame: Similar to aspartame, neotame is derived from a combination of aspartic acid and phenylalanine. It is 8000 times sweeter than sugar, but being the newest artificial sweetener approved for general use in the US, it is not yet widely used.



Sucralose: Produced from sugar via the replacement of three hydroxyl groups with chlorides, sucralose becomes 600 times sweeter than sugar in processing. It is used in Splenda®, and is the most heat-stable of the artificial sweeteners. This has seen its introduction into a broad range of foods and beverages as a substitute for other artificial sweeteners.



Stevia: A natural plant extract, Stevia has been used as a sweetener in Paraguay and Brazil for centuries. It is roughly 300 times sweeter than sugar, and is not metabolised by the body. However, studies have suggested that it may be linked to lower sperm production and smaller offspring. Stevia is currently not approved for food use by the FDA. Steviol (pictured) is the basic building block of Stevia's sweet glycosides.



aspartame)

Even if artificial sweeteners are not directly toxic, there is still the important concern as to whether they are actually effective in combating obesity. In this, there does seem to be a growing consensus that the artificial sweeteners may actually have the opposite effect to that intended, via one or more mechanisms.

Following a 2005 study of more than 1500 adults in the US, Sharon Fowler of the University of Texas Health Science Center stated that: 'There was a 41% increase in risk of being overweight for every can or bottle of diet soft drink a person consumes each day' (wb.md/2auQ7pe). Fowler was careful to note that this is not necessarily a causal link, but is exemplary of wider observations. One possibility is that psychology comes into play. A person may say something along the lines of 'I've been good with this diet soft drink, so I can afford to have a little extra treat.' Alternatively, the extra ingestion might not be a conscious choice.

In a 2004 study at Purdue University in the US, two groups of rats were offered sugar-sweetened food after having been first primed with either artificial sweeteners or standard sugared food. The rats who ate sugar all the way through controlled or reduced their intake, while the rats fed with artificial sweeteners did not (go.nature.com/2b4g133).

Leaves of *Stevia rebaudiana* have been used as a natural sweetener for more than 1000 years. Flyingbike (Robert Lynch)/CC0 1.0



... there does seem to be a growing consensus that the artificial sweeteners may actually have the opposite effect to that intended, via one or more mechanisms.

A 2013 review of multiple similar studies at Purdue University argued that our taste receptors play an important function in regulating our energy intake (bit.ly/2amWcCC). Under this hypothesis, our taste receptors detect the total sweetness of our food intake, giving an indication of when we have 'had enough'. By using artificial sweeteners, it is argued that the 'calibration' of the learned behavioural link is thrown off, so that we no longer receive accurate signals on when to stop ingesting other sugary foods. 'This somewhat counterintuitive result may reflect negative consequences of interfering with learned relationships between sweet tastes and typical post-ingestive outcomes, which may result in impaired ability to compensate for energy provided when caloric sweeteners are consumed.'

The review was emphatically attacked by various people and organisations with apparent links to the vested interests in the beverage industries, such as the Calorie Control Council. This potential conflict of interest may not eliminate the criticisms, but it leaves room for doubt.

There is also some evidence to suggest that artificial sweeteners may be addictive. In a 2007 study at the University of Bordeaux in France, rats were given a choice of water sweetened with saccharin or intravenous cocaine; 94% of the

animals selected the saccharin, with specific indicators of addiction observed through variations in the methodology (bit.ly/2azhEI0).

Emerging studies also point to the importance of the balance of our digestive flora to the extraction of energy from food. For example, a 2014 study at the Weizmann Institute of Science in Israel found that even short-term ingestion of artificial sweeteners may favour the growth of bacteria that maximise the energy extracted from our food (bit.ly/2aOQm0y). High levels of these bacteria have been associated with obesity in rats, and also potentially in humans, but again it is not yet certain whether this is a causal link.

What is indisputable among the various viewpoints is that with obesity as a growing public health issue, it is critical not only that action is taken to induce behavioural change (including decreasing sugar consumption), but that the direction of that change doesn't lead us down the wrong path. There is an urgent need for independent, consensus science to determine whether artificial sweeteners are effective in reducing obesity, or are actually worsening the problem.

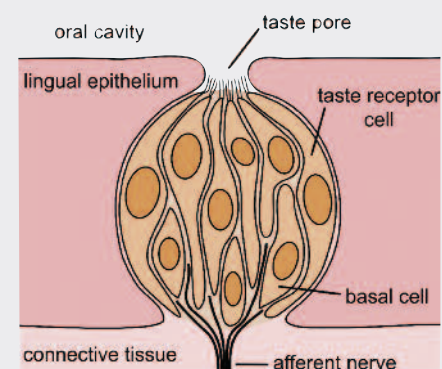
Dave Sammut FRACI CChem is principal of DCS Technical, a boutique scientific consultancy, providing services to the Australian and international minerals, waste recycling and general scientific industries.

How taste works

How does our body actually perceive flavour? What we see on our tongue are three forms of taste papillae. These structures host the much smaller taste buds, and perform various specific functions to enhance our perception of taste, temperature and touch. The taste buds themselves (2000–4000 in total, spread throughout the oral and nasal cavities) each contain 10–50 sensory cells, which are in turn connected to nerve fibres. When the chemicals in our food come in contact with proteins on the surface of the 'taste pore' at the outer reservoir of the taste bud, the cell is activated and produces messenger chemicals to inner nerve cells. These, in turn, pass the information for a particular perception of flavour to the brain.

About half of the sensory cells are 'coded' to react to just one taste, and transmit the intensity of the stimulus. The other half have varying sensitivity profiles for all of the five basic tastes: sweet, sour, salty, bitter and umami (savoury). One cell might be particularly sensitive to salty, then sour and bitter, while another might have a completely different profile. The combined signals give the full experience of flavour.

Most artificial sweeteners are said to be 'sweeter' than sugar. The intensity of the sweet response is much greater than for the equivalent amount of sugar. For example, saccharin is 300–500 times sweeter than sugar. However, such measurements are empirical, relying on statistical analysis of perceptions from trained panellists, typically compared to 0.1 M sucrose solutions.



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From researcher



to attorney

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Mike Zammit
reflects on the
different
perspectives of IP
for researchers, IP
coordinators and
patent attorneys.

In my career, I have spent time working as a researcher, an IP coordinator, and more recently as a patent attorney. Together, these roles span the process of IP generation and protection – the researcher spends time on generation, the attorney on protection, and the IP coordinator participates in each activity. Experiencing these different perspectives has changed my understanding of IP.

Different roles – an overview

Researchers may undertake fundamental research directed at explaining the world around us, the purpose often being the explanation itself. There are direct benefits of this research, for example to other scientists, and indirect benefits can also flow, such as the pure research into the structure of the atom that led to nuclear power and silicon chips. Applied research is more focused on finding answers to specific questions,

which are typically directed at solving problems in the marketplace, such as making a process more efficient or cost-effective, addressing a polluting or less sustainable process, or product development generally.

IP coordinators work with senior in-house IP counsel, business development managers and outside IP service providers to protect new and existing IP assets locally and abroad to meet business IP needs, including providing IP advice and education to researchers (see box page 27).

Attorneys advise on IP generally, and assist IP owners to register, maintain and enforce their property (see box).

The researcher's view

In my experience, some researchers perceive IP as a 'necessary evil', and are often in the dark about IP/legal matters, or possible business uses of IP. There are not always easy answers to questions such as: 'Could/should the

In terms of the prior art, patent prior art searches, in particular, can be difficult to conduct and the output can be difficult to understand, so that there can be a tendency to ignore patent prior art because it is in an unfamiliar form.

IP coordinators and attorneys in action

IP coordinator

- assessing invention disclosures for technical merit and value according to strategic business direction
- facilitating patent review meetings to priorities inventions for patent filings
- coordinating/conducting invention brainstorming sessions
- working with and managing outside counsel in connection with the filing and prosecution of patent, design and trade mark applications
- identifying and participating in any out- and in-licensing opportunities
- providing IP support with respect to financing, merger and acquisitions
- providing IP training
- defending IP assets.

Attorney

- advising on IP, and helping IP owners apply for, register and maintain their property both locally and abroad, e.g. drafting patent specifications, advising on whether a development is patentable subject matter, and whether it is new and sufficiently inventive enough to justify a patent, lodgement of applications with government bodies and guiding the application through the process
- assisting in technology transfer, e.g. by licensing
- conducting IP audits, e.g. organisations, products, systems
- conducting litigation both locally and abroad
- assisting clients manage their IP portfolios, including advising on IP held by others and the risks in infringing, or for working around that IP.

development be patented?', 'What other forms of IP should be pursued?', 'What other pre-existing company-owned IP is there?' and 'How do I leverage that IP into new products under development?'. Often, valuable time and money is also spent 'reinventing the wheel'.

Many 'green' researchers are uncertain of what to invent, how to invent, how to invent around or in front of others, how to stand on the shoulders of other inventors, and how to prevent others from inventing in front of, or on top of, their own inventions. Answers to these questions often come from a deeper understanding of IP and/or a better commercial understanding.

In terms of the prior art, patent prior art searches, in particular, can be difficult to conduct and the output can be difficult to understand, so that there can be a tendency for researchers to ignore patent prior art because it is in an unfamiliar form. However, it is well

understood that ignoring the patent literature could be disastrous if one does not want to reinvent the wheel. The significance of different patent documents can also cause some uncertainty (e.g. continuation, divisional, provisional, complete). Additionally, to those who are inexperienced or untrained, patent prior art documents can sometimes be indecipherable, with frustrating amounts of repetition that obscure the invention, and without all the scientific information provided for the invention to be repeatable.

Researchers are also under pressure to invent or develop a new product and get to market quickly. There are competing pressures on time and budget and practical matters such as being forced to use existing equipment or resources, which may not be ideal. Cross-'fertilisation' of the IP generated by different research teams is also sometimes not explored and exploited. Other options such as

licensing-in technology or potentially invalidating a 'blocking' patent are not always considered. In an academic setting, there is often the added pressure to publish in order to justify grants, and patents are viewed as second-tier publications because they are not peer reviewed and do not count towards publication metrics.

The IP coordinator's view

The IP coordinator's role starts with a deep understanding of the business strategy so that informed IP decisions can be made. For example, the business strategy should assist with answering questions such as: 'What has been developed that could be protected?' and 'Of the IP that could be protected, what should be protected?' Of course, it must be a business decision on what gets protected, because an organisation simply cannot protect everything invented, especially due to limited resources. And of course a patent does not guarantee

IP generation

The practical application of a discovery or an idea to provide a solution to a problem or need.



IP protection

The means of creating wealth via commercial exploitation of the invention, and of bringing benefits to society.

Researcher

IP coordinator

Attorney

Two sides of the coin: the IP coordinator works with both researchers and IP counsel.

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commercial success; rather, it is a launching pad for commercial activity. Generally speaking, IP protection should strike a balance between what the market wants (i.e. 'the pull'), what the business capabilities can provide (i.e. 'the push') and what the competition is offering (i.e. 'the clash').

The IP coordinator will also need to grapple with questions about when, where and what to file. The 'what' is deciding on which inventions to pursue and which not to pursue; the 'where' (to file for protection) is usually dictated by factors such as the jurisdictions in which the major markets are located and where manufacturing will take place. Licensing possibilities may also affect the decision. The 'when' is a more complex question to answer. An applicant should file for protection when a new product may have a commercial advantage (to the applicant or its competitors), but before any non-confidential disclosure or commercial exploitation. There is also a balance between not filing too early (as there may be insufficient enablement; deadlines are triggered, causing costs that the applicant is

unable to meet at a time when the product is not fully developed; or potential follow-up applications on improvements may be required), and not filing too late (the competitor could file first, or the invention is superseded).

It is very likely that the IP coordinator will be faced with highly relevant IP owned by third parties. There are essentially five options to consider.

- **Avoid it:** Work around the IP at project design stage.
- **Ignore it:** Ascertain the likelihood of being sued.
- **Licence it:** Attempt to negotiate a licence early with the patentee to use the technology.
- **Attack it:** Ascertain the likelihood of invalidating the patent and having it removed from the Patent Office register.
- **Buy it:** Negotiate the purchase of the relevant IP or competitor's company.

There are many other responsibilities, such as providing training and support to assist each team with their IP requirements, including watching competitors and

understanding which companies may see your IP as infringing theirs. It is also important to continuously manage the content of the IP portfolio to ensure that it has continuing relevance to commercial strategy, comprising reviewing important IP assets to ensure that they remain valid and useful. Outside counsel must be managed, including decisions on when to get them in, what information to provide, and what to ask, while simultaneously seeking to minimise IP costs where possible, especially since there is usually a fixed budget.

The attorney's view

Attorneys are trained to think slightly differently from researchers. For example, where a researcher will try to explain something that is unknown and will postulate theories, an attorney generally thinks in a problem-solution manner, trying to identify a clear 'inventive step'. Where an academic will generally want to publish everything, an attorney will endeavour to include the best method and an enabling disclosure of the full width of the claims, but needs to be careful of saying too much as this could stand as prior art against later applications.

In the process of interviewing inventors, attorneys can also often identify overlooked or 'dismissed' inventions that may be commercially significant. More often than not, researchers can suffer from '... what I've developed is good, but it's just obvious ...' syndrome, probably because they deal with the technology day-in-day-out and become somewhat blasé about it. It is also common for a researcher to only consider one form of IP protection, whereas the concept may be protectable via a number of forms of protection – it is the attorney's responsibility to identify these possibilities.

Although an attorney must have some technical expertise in the same or a related field of art as the invention, the attorney understands that the inventor has a deeper understanding

... where a researcher will try to explain something that is unknown and will postulate theories, an attorney generally thinks in a problem–solution manner, trying to identify a clear ‘inventive step’.

of the prior art, and therefore comments from an inventor on prior art documents raised in an examination report are usually invaluable. Sometimes, however, the invention will stray from the field of expertise of the inventor, in which case the attorney will need to cover any gaps in technical knowledge. Further, while the attorney will have a view on what claim amendments may be required during prosecution, the input of the IP coordinator is extremely important to ensure that the resulting IP is aligned with the business needs.

Generally speaking, the researcher is focused on solving a relatively narrow problem in one field of art. It is

the attorney's role to think broadly and attempt to expand the scope of the IP as much as realistically possible when drafting the application in order to attempt to maximise the commercial value of the resulting IP. (Typically the broader the claim, the more valuable the IP, although in crowded fields of art narrow IP protection can still be quite valuable.) An attorney is also concerned with ensuring that the entire supply chain is protected. For example, in addition to directing claims to the article itself, the attorney should ensure that claims are drafted to protect the components of the article, and the use of the article (considering the answer to questions such as: ‘What is the context of its use?’, ‘How is it used?’ and ‘How might it be modified?’). It is also important to consider the time horizon: what could the invention be used for in 10, 15 or 20 years’ time? Alternative uses in related fields of art should also be considered, and different permutations of the invention. For example, what happens if the order of the features is rearranged, or if a feature is removed, or an equivalent is used instead? It is especially important to consider how the claims are drafted to increase the likelihood of catching an infringer. These considerations are not always at the forefront of the researcher’s mind.

The attorney has specialised training in technical legal matters, such as drafting patent specifications,

freedom to operate advice, and challenging the validity of a patent. Attorneys must also have an excellent knowledge of the patent laws of our major trading partners, and in particular the countries that are of commercial interest to the applicant. This can be a challenge, especially since laws change frequently.

There are many overlapping responsibilities between the IP coordinator and the attorney. However, where there is no IP coordinator, the attorney will be expected to step into the IP coordinator’s shoes, although clearly in this case it will be the researcher’s responsibility to be on top of the commercial aspects of the invention and understand the relevant marketplace.

A holistic approach

Each of these IP roles is essential for the generation and commercialisation of technology. IP coordinators and attorneys operate at the interface between science, law and commerce, and therefore have especially challenging and rewarding roles to play. However, teamwork is paramount to a holistic approach to IP generation, protection and management.

Dr Mike Zammit MRACI CChem completed a PhD in polymer chemistry at the University of New South Wales before working in industry for five years. Mike then trained to become a patent attorney and is currently a senior associate. He has been with the firm of patent and trade mark attorneys Shelston IP (www.shelstonip.com) for 12 years.



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Mander Best PhD Thesis in Organic Chemistry Award



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

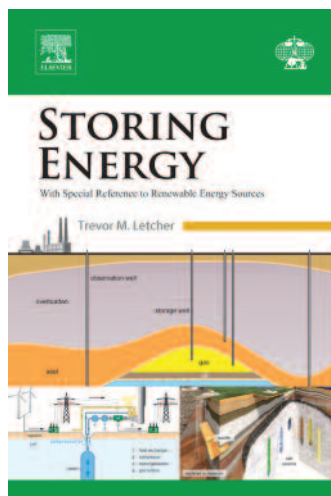
The recipient of the Mander Best PhD Thesis Award for 2016 is Dr Samuel Drew MRACI.

Dr Drew conducted his PhD studies under the supervision of Professor Michael Sherburn FRACI CChem at the Australian National University. His thesis describes the optimisation of the synthesis of polyene compounds and then the exploitation of these compounds as precursors in a number of elegant total syntheses of complex natural products. The true power of these polyene structure syntheses was highlighted in the *Chemical Science* (2015, vol. 6, p. 3886–90) and *Angewandte Chemie* papers (2013, vol. 52, p. 4221–4) where a unified synthesis of five natural products from the *Endiandra* genus of plants, including three major subfamilies of polycyclic compounds, was reported from a common TMS-tetrayne precursor. Dr Drew's research into the synthesis of diterpene marine natural products, the pseudopterosins, is also published in *Nature Chemistry* (2015, vol. 7, p. 82).

The originality, complexity and quality of the synthetic work presented in Dr Drew's thesis impressed both his examiners and the selection committee for the award.

We congratulate Dr Drew on an outstanding effort and wish him well in his future career.

Dr John Tsanaktsidis FRACI CChem, Chair – Organic Chemistry Division



Storing energy: with special reference to renewable energy sources

Letcher T.M., Elsevier, 2016, hardback, ISBN 9780128034408, 590 pp., \$165.95

Storing energy: with special reference to renewable energy sources is a superb companion volume to Trevor Letcher's earlier book, *Future energy: improved, sustainable and*

clean options for our planet (2nd edn) (see review, June, p. 33).

There seems little doubt that all countries need to move towards minimising emissions of greenhouse gases to the atmosphere if we are to avoid worsening the apparent warning signs evident in weather and rainfall patterns around the globe. This basically means moving to a low-carbon economy – generating and distributing energy in less environmentally deleterious ways. Letcher's first book most eloquently shows how this might be achieved.

The second major problem, having solved one of generation, is to more closely match energy supply and demand. This is one reason why nuclear power, coal, oil and natural gas are so convenient: they combine large and reliable capacity with straightforward technologies to allow supply to be adjusted to match the demands on the electricity grid. Solar energy, wind power and tidal power, to name a few, are great when the sun shines, the wind blows and the tidal oscillations are appropriate. Indeed, there are reports of a recent instance in Europe when the combined photovoltaic output of the buildings in an area exceeded the demand on the grid and the excess electricity had to be fed to earth.

However, these instances are inherently serendipitous. Obviously, if we are to move towards an ever-greater reliance on environmentally less deleterious energy sources, then we need

to have effective and efficient energy 'banks', so that we can 'bank' energy when we have an excess and draw on that bank when we have a shortfall. Energy storage is, therefore, vital.

Some ways of banking energy are familiar to us, and some are less so. For example, if you have an electric car, you bank energy from the electricity grid in an array of batteries and then draw on that banked energy to spin the electric motors that propel your vehicle. If you have a conventionally powered, petrol- or diesel-driven car, then you buy banked energy (fuel) from the service station and use that stored energy to speed you on your way, while not forgetting to bank a little bit in your car battery, so your car will start next time you would wander afield. When F1 racing cars need to be slowed down, some of the energy usually consumed as heat and friction can instead be used to spin a flywheel, thus banking the energy for future withdrawal as enhanced vehicle acceleration.

At a domestic level, it is certainly feasible to install a largish photovoltaic array on your (Australian) house accompanied by a reasonably compact storage battery, where you can bank your daytime excess electrical generation so you can withdraw it for your overnight needs. (The return on capital – maybe \$30 000 – is, I believe, around 6% per annum. Try getting that from your 'bricks and mortar' bank!) On a larger scale, excess electricity can be used to pump water into higher reservoirs, banking potential energy, which can then be withdrawn as hydro-electricity.


However, all of this is the tip of the iceberg, and the scale of a grid-sized storage system would be astonishingly immense. If you read *Storing energy*, you will get a reasonably complete picture of what is available, where its development presently sits, what opportunities and problems it presents and where its best future prospects might lie (although there are a number of emerging technologies specifically mentioned in the introduction, referenced but not discussed in the book).

Letcher has again assembled a formidable line-up of experts and has done a superb job of assembling a very worthwhile book. Each chapter is extensively referenced. As well as the technical issues, social, economic, political and environmental aspects are treated. This is a really well-rounded effort. Methods covered include gravitational, mechanical and thermomechanical ways of storing energy, as well as techniques such as compressed air storage and flywheel storage. Electrochemical and thermal storage are extensively discussed, together with chemical methods, principally hydrogen production and storage.

A substantial section of the book is devoted to social and geopolitical issues. The subject matter is profoundly interesting, as well as vitally important, and should be of interest to a wide spectrum of professionals, especially those interested in development and implementation of novel greener energy supply systems.

It is fascinating material. Chase it up – you will be wiser for perusing it.

R. John Casey FRACI CChem



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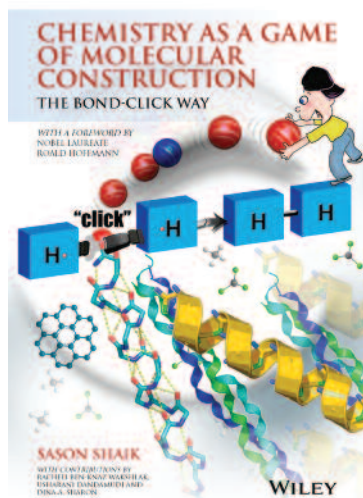
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Chemistry as a game of molecular construction: the bond-click way

Shaik S., Wiley, 2016, paperback, ISBN 9781119001409, 416 pp., \$142.95

Chemistry as a game of molecular construction: the bond-click way will be a memorable chemistry textbook for many who read it. Author Sason Shaik, a professor and director of the Lise Meitner-Minerva Centre for Computational Quantum Chemistry at the Hebrew

University of Jerusalem, has taken many unusual approaches in his efforts to craft a book that aims to inspire novices to learn chemistry without invoking 'chemophobia' – the fear of chemistry.

This textbook is not your traditional chemistry textbook for a number of reasons. First, each of the book's 11 chapters is preceded by a conversation between the author and a colleague. Importantly, the conversations are not mere novelties or peculiarities of this book, because they will add value to the reader's experience. The conversations serve as friendly guides to each chapter's content and how the chapter relates to earlier (or perhaps forthcoming) chapters. Importantly, the conversations also help to highlight concepts that require greater reinforcing based on the author's 20 years of chemistry teaching experience.

Another difference between this and other chemistry textbooks is how it tackles the teaching of chemistry by discussing the structure of molecules and the interactions that shape their architecture from the onset. While such a move may initially seem a little daunting for novices, Shaik has addressed this potential problem by the unique manner in which the topic is introduced. A Lego® analogy is used to describe the process of electrons 'clicking' and pairing to create bonds and form molecules. When building objects from Lego blocks, the blocks cannot arbitrarily click together and, as the author explains, neither can chemical molecules. The book discusses the building of molecules from the simplest, H_2 , all the way to DNA molecules.

As with any good book aimed at the novice, the reader will discover a wonderful text full of colour and helpful figures. Where possible, the author has provided real-world examples relating to the theory contained in the chapter. For example, in the first chapter the role chemistry plays in moods, addiction and love – including the role of Viagra – is discussed. Later, the

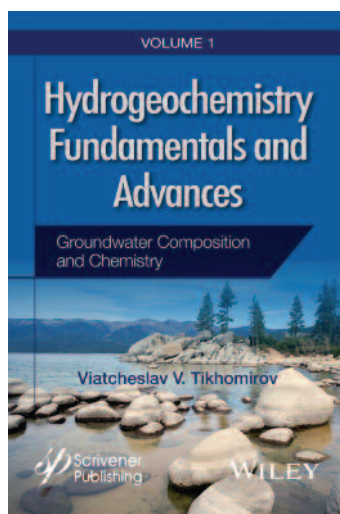
book discusses the importance of chemistry in climate change. In an effort to simplify the teaching of chemistry, Shaik has opted where possible to reduce the number of rules or terms that must be learned. For example, the duet and octet rules are replaced with a single law, the 'law of Nirvana'. While the merits of this approach can be debated, the end result is a book written in an easy to comprehend manner.

Each chapter contains a wealth of additional information. For starters, most chapters contain a list of suggested demonstrations that are perfect for catching student interest with the visual effects, or the wow factor, clearly the driving component of the demonstrations. For the more advanced readers, or just those with a thirst for knowledge, each chapter also contains a section called 'Retouches' that elaborates further on theory related to the chapter. Importantly for the novice, within each chapter are a number of practice problems, including the answers. The inclusion of all answers, and not merely those for the odd- or even-numbered questions, allows for instant feedback for those attempting to gauge their level of comprehension. It also avoids the frustration of not being able to find answers for all questions.

Because this book focuses on chemistry from a molecular perspective, unsurprisingly organic and biochemistry feature heavily. While reading the text, you will be walked through the molecular worlds of carbon and hydrogen, and be introduced to the different types of bonding and the formation of small to large molecules. Transition metals and spectroscopy are also among the topics discussed. However, other topics, including the quantitative aspects of chemistry, are absent. For instance, pH has only a minor role in the text, and concepts such as the mole will only be found in the supplementary reading material. While this book does an exceptional job at teaching chemistry to the novice, it does not have the breadth of some other introductory texts. This should, however, not be seen as a shortcoming if the author's unique approach builds the appetite of students to undertake further studies in chemistry.

The standout feature of this book is the fresh approach Shaik has used to teach chemistry to the novice. The book has the potential to invigorate teachers and motivate and engage the novice chemistry student. While the change in content and teaching style may not be to everyone's liking, there can be no doubt this book has a sense of warmth and helpfulness often lacking in many texts that incorporate chemistry.

Michael Leist MRACI CChem



Hydrogeochemistry fundamentals and advances. Vol. 1. Groundwater composition and chemistry

Tikhomirov V.V., Wiley, 2016, ISBN 9781119160397, 336 pp., \$223.16 (Kindle edition), \$230+ (hardback)

Have you ever wondered about the rich and varied chemistry going on out of sight many metres below you, but which nevertheless has a big

impact on modern society? No? Well then you might find much to like in this introduction to groundwater chemistry.

Australia, like many other countries with limited water resources, makes extensive (and increasing) use of groundwater for a variety of uses, including agriculture, mining and supplementing potable supplies. Potential contamination or flow disruption of groundwater is therefore a concern for many. A good understanding of the potential impacts on groundwater from factors such as urbanisation and mining is essential for future sustainable environmental management, and thus the topic of much research worldwide.

This book adds to the growing number available for the budding hydrogeochemist to choose from. Author Viatcheslav Tikhomirov plans a trilogy to cover the fundamentals and latest advances in the theory and practice of hydrogeochemistry and groundwater science. Volume 1 (the subject of this review) discusses the composition, chemistry and testing of groundwater. Volume 2 will cover practical applications such as mass transfer and transport within groundwater, while volume 3 will examine the environmental analysis of such systems.

Having recently started to do some work analysing groundwater, I was looking forward to reading volume 1 to find out more about the basics of the subject. I was pleased to find much to like here, but the book is not without its drawbacks.

Let's start with the positives. Chapter 1 gives a very good and detailed history of hydrogeochemistry to introduce the subject. After this, the book is divided into three main sections covering (i) the composition and properties of groundwater, (ii) hydrogeochemical testing and (iii) the processing of analytical test results (e.g. statistics). Readers are therefore exposed to all aspects of groundwater testing, and chemistry and chemical analyses are well covered throughout.

The book and its content are based on the author's many years of experience teaching at the St Petersburg State

University (the oldest, and one of the largest, in the Russian Federation). This background is a plus point for the book since not only does it offer a different perspective on the topic, but there are many references to Russian scientific literature in hydrogeochemistry and groundwater science that Western readers might not otherwise come across. The author does not limit himself to Russian references, however. Each section of the book is comprehensive and detailed and sets out the state of the science well. Good use is also made of diagrams and images to illustrate many points. You certainly feel as though you have learned something after reading each chapter.

Now to the negatives, of which there are, unfortunately, a few. Many of the images are of low resolution, rendering them 'fuzzy' and making much of the text contained within them hard to read. The figures also tend to show old and/or out of date equipment. The English could also have done with some further editing. For example, in my review copy of the book, the odd-numbered pages of the introduction are labelled as 'The History of Graphene' and there are many instances of incorrect syntax (and even spelling) throughout the book. These are relative minor annoyances but they do detract from the overall reading experience.

The book is also very expensive compared to others on the market, with even the Kindle version priced at over \$200. Purchasing all three volumes will set the reader back over \$600, likely beyond the reach of many. I also don't think the contents of this book are too much different from, nor significantly better than, some of the cheaper options available through Amazon or other retailers.

Overall, while there is much to like here and you are certain to learn something from reading it, undergraduate students of hydrogeochemistry would probably be served just as well by one of the cheaper books on the market. Postgraduate students and researchers who already have good background knowledge of groundwater science may not learn anything appreciably new (aside from the Russian scientific references), as the book is primarily designed to be an introductory (if comprehensive) text.

In short, Tikhomirov's book is a solid performer with an interesting perspective but possibly a little overpriced.

Oliver Jones FRACI CChem

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Why science is not at the heart of our innovation problem

Commercial innovation in the 21st century is very focused on IT engineering and much less so on science. By way of example, more than 90% of Silicon Valley's investments over the last decade have gone into IT start-ups. At the moment, science is considered very '20th century' in the tech investment world. The reason is that the comparative financial rewards for investments in IT are much higher, and with lower risks. It will take some time before this equation changes – we have a mountain of IT opportunities to work through and it will be decades before science once again becomes a primary focus of tech investment.

The comparative problem with a science outcome as a focus of technology investment is the long time to market and the corresponding heavy capital investment required in the development phase. Investment in technology is measured by internal rate of return, which is ruined by large investments that have long periods before profits are returned. And this problem is even further exacerbated by the fact that IT solutions are returning higher 'multiples' – the perceived value of a working IT solution usually has a much higher relative value than a working solution based on a science outcome.

Australia's well-publicised poor performance in innovation has very little to do with science and everything to do with our corporate sector being users of IT technologies, and not vendors and exporters of IT technologies. They can afford to be so because the implicit oligarchical environment in which they operate (e.g. four large banks, two large supermarket chains) to a large degree protects them from foreign competitors. Essentially, they have no strong driving force to become global technology vendors because there are easier profits to be made serving their protected Australian markets with off-the-shelf technology solutions.

If history is a measure, any solution to an innovation 'problem' that has an Australian government at its core is almost certainly going to fail. We have had program after program over the last three decades focused on innovation, knowledge nation, and various other catch-cries. And yet our high-tech exports continue to fall as a percentage of our GDP. The reason is that government expenditure, focused on technology innovation, usually starts with a misdiagnosis of the 'problem' followed by what could only be called a perversion of the process of remedy, i.e. it gets muddled by pork-barrelling and self-serving parties looking for government funding.

Contrary to oft-repeated pronouncements, Australia is not a risk-averse nation. Indeed in mining exploration and other areas, we are more than happy to invest in risky ventures because we have been doing so for a century and a half and there is an investor class that fully understands the risks.

What we don't have is large investment in tech-sector innovation because the return on investment into the tech

sector in Australia, which has historically eked out a small existence usually with government support, has traditionally been very negative. This will not change unless our large corporations start becoming global vendors of technology solutions; without this driving force to create a local market for innovation assets, most of our high-value technology ideas (and their progenitors) will continue to disappear overseas and we will be left with the rump that ensures a negative return on investment. In this scenario, our investors are not 'risk adverse' but 'loss adverse', i.e. very sensible indeed.

So do we actually have a problem? The only one that I perceive is that less than 1.5% of our exports can be considered as high tech, and this number is shrinking. We rely heavily on exports of resources and agricultural products, as well as imports of students and tourists. All of these revenue sources are susceptible to profitability and revenue cycles and if they all trend down at the same time, we may be in a little strife.

Is there a role for government to fix the 'problem'? Maybe, but only if the issue is handed over to a modern-day Senator John Button; these political characters who can cut through the self-serving noise seem to be few and far between these days. The primary focus of any government-sponsored solution should be incentives, tax and otherwise that act to get our large corporations into the business of exporting technology solutions to global markets. Short of this focus, I can't see the opportunity for meaningful change.

In terms of other actions, this country badly needs a Chief Technologist. We have a Chief Scientist but this role, absent a large corporate R&D sector, pretty much serves the needs of research institutes and universities. The widely publicised focus on STEM needs to be broken up into IT and SEM; STEM is an unholy grouping that does not recognise that a large fraction of IT innovation occurs in start-ups, SMEs and the corporate sector, and has very little to do with universities (other than training of the graduates who go into this sector). And finally, 'Innovation and Science Australia' needs to be supplemented with a body called something like 'Innovation, Companies and Exports, Australia'.

Finally, I would suggest that the success of any investment of public funds into the innovation 'problem' needs to be measured in the context of high-tech exports. Without a quantitative metric of success, it is all too easy for governments to invest in one failed program after another, with little carried-over learning.



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Understanding patent claims

Michael Moore, Registered Patent Attorney, FB Rice



A patent provides to its owner a temporary monopoly in exchange for public disclosure of an invention. A patent document includes a specification that describes the invention (akin to an instruction manual) and claim(s). Importantly, the claims define the invention and mark the boundary of the exclusive rights provided by a patent.

A claim set will include at least one independent claim to define the invention's essential features. It is drafted to protect the broadest form of the invention. Dependent claims are narrower and serve to provide subsidiary coverage. Different types of claims are used. For example, a pharmaceutical patent may include product claims, process claims and medical use claims.

The steps in interpreting patent claims can be illustrated by considering a pharmaceutical invention based on compounds that inhibit inflammation by relieving oxidative stress. A hypothetical claim reads:

1. A composition comprising a compound that relieves stress in a mammal so as to treat cephalgia.

The first step is to read the claim as a whole to give it context. In the broadest sense, claim 1 refers to a composition containing an active ingredient compound.

We then look at the claim in finer detail, giving words their ordinary English meaning. Special 'terms of art' such as 'cephalgia' can present obstacles in claim comprehension. However, we consider the viewpoint of the worker in the relevant field or skilled addressee, in this case a medicinal chemist. Consulting a medical dictionary shows that 'cephalgia' denotes head or neck ache, and any potential misunderstanding is resolved.

Every word needs to be examined when interpreting a patent claims. What does the term 'stress' mean? The approach is to consider what the skilled addressee would understand the word to mean. Standing in the shoes of the medicinal chemist, it would be reasonable to suggest that 'stress' means 'biological stress'. Applying this reasoning, claim 1 encompasses a composition containing a compound that modulates any biological activity that leads to headache. That is, the composition may include anti-inflammatories, endorphins or beta-blockers.

However, if 'stress' in claim 1 is meant to denote 'biological stress', then we have to ask why 'biological' is absent. When interpreting a claim, words cannot be added. The specification refers to compounds that inhibit inflammation by relieving oxidative stress. When claim 1 is read with this in mind, an interpretation closer to the patentee's intention is the result. However, this interpretation is narrower than that discussed above. On this interpretation, claim 1 encompasses a composition that only includes anti-inflammatories.

For guidance, when interpreting a claim, read the claim as a whole for context; dissect it into smaller parts for further analysis. Ask what the skilled addressee would understand by the terms in the claim and keep in mind the purpose of the patentee.

Of course, it is not that simple. The use of seemingly innocuous claim terms can lead to a situation where it is difficult to determine claim scope and consequently whether there is infringement or not.

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Lessons learned from underground coal gasification technology

Many major chemical processes require the production of synthesis gas (a mixture of carbon monoxide and hydrogen) from coal or natural gas. The synthesis gas is then converted into hydrogen, ammonia synthesis gas, methanol or high-quality fuels and chemicals by the Fischer–Tropsch process. Synthesis gas can also be used to generate electricity in a gas turbine; for example, in the integrated coal gasification combined cycle route to potentially carbon-free power production. In these processes, synthesis gas production is the principal unit operation of highest capital cost. So, what if a route could be developed that substantially eliminated the capital cost of synthesis gas production? This is the main driver behind underground coal gasification (UCG) technology.

The earliest suggestion that the gasification of coal could be conducted underground appears to have been by C.W. Siemens in an address to the Chemical Society of London in 1868. Independently in Russia, Mendeleev was encouraged by observations on underground mine fires in the Urals and started to develop detailed designs for UCG, which were published throughout the 1880s and 1890s. In 1910, a patent was granted to Anson Betts for a method of utilising unmined coal that describes the basis for many future developments. Betts' ideas were verified in trials in several parts of the world.

In the early part of the 20th century, most industrial cities were polluted by the mass burning of coal. This led to the suggestion by William Ramsey in 1912 that the pollution could be eliminated if the coal was gasified underground and piped to the surface. Ramsey's suggestion was widely reported and spurred interest in UCG trials in the US and UK. Ramsey became credited with inventing the concept.

Lenin (then in exile) wrote an article in praise of Ramsey's 'invention', noting that the fate of mineworkers would be different under communism. And what Lenin said had to be

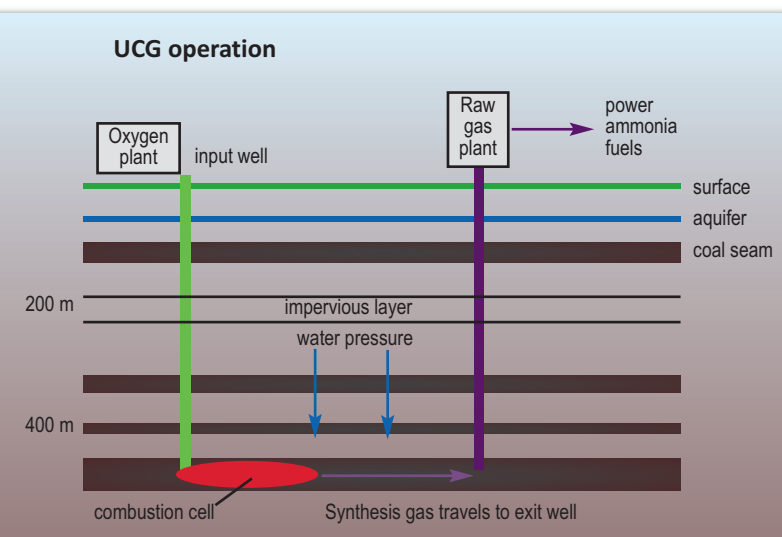
proved correct, so the USSR made major attempts to bring UCG to fruition. Unfortunately, UCG theory proved difficult to reduce to practice; there was very little success and only one operation remains at Angren in Uzbekistan.

The general layout of the process is shown in the diagram. The prime targets are deep coal seams typically deeper than 500 metres. This coal could be contaminated with salt or the seams could dip steeply, which makes them poor targets for conventional mining. These seams are also often targets for coal seam gas (CSG) recovery and hence a potential source of conflict of interest with CSG developers.

Two wells are drilled into the seam a distance apart. These wells are connected by natural fractures (cleats) in the coal. Air or oxygen is sent down one of the wells and combustion is initiated at the base of the well. The burning process follows these cleats with the coal burning out, forming a cigar-shaped cavern towards the second well, from which the combustion gases are removed. The process progresses until all of the coal is consumed. Unlike conventional underground mining operations, the UCG process can theoretically remove all of the coal present, making the process even more attractive.

During the 1980s, following the oil shocks of the 1970s, the US Department of Energy funded a major series of trials of UCG in the US. This program of work confirmed many of the USSR results and defined the boundaries of the technology. Some of the more important issues that were identified were as follows.

- The coal measure has to be very deep. Burning coal generates a cavity and collapse of the roof can cause subsidence, which travels to the surface. This can also lead to toxic gases escaping through the strata to the surface.
- Partial combustion produces toxic materials that remain in the cavity (phenols, aromatics etc.). Many of these materials are water soluble and will contaminate the local aquifers. Not only should the UCG combustion cell be isolated from usable (near surface) aquifers, preferably by the presence of impervious layers, but the nature and flow rate of the aquifers around the cell (immediately above and below it) should be known. Determining the flow of underground aquifers is not a trivial task and it may take several years to properly assess the hydrodynamics of the system.
- The strata above and below coal measures can contain sufficient combustible materials that combustion outside the cell (towards the surface) occurs. This could destabilise the cavity roof and lead to loss of product (which is toxic) to the surface. It is important to know the detail of the upper and lower strata and the likely effect of high temperatures and oxygen on them.
- The combustion process is only controlled by the flow of oxidant to the cell and the pressure in the cell. The pressure in the cell is limited to that of the hydrostatic pressure around the cell, which maintains the combustion products



within the cell. Overpressure could cause products to move outside the confines of the system and contaminate surrounding areas.

- Published data indicates that it is very difficult to get a good mass balance for the operation. Often, 20–30% of the theoretically produced synthesis gas is missing; this suggests significant losses outside the system.

During the past decade, UCG development became of interest in Australia, particularly Queensland. This was driven by high oil prices and the identification of large untapped coal reserves. Several projects were aimed at producing fuels (Linc Energy, Coogar Energy), power (Carbon Energy) and ammonia (Liberty Resources). Some of these projects were enthusiastically endorsed and promoted by both the Commonwealth and the Queensland Governments. Of these projects, the Carbon Energy technology utilised a novel directional drilling approach to burn the coal across a coal face, which was developed by CSIRO.

The Carbon Energy project is in the process of proving that the combustion cell can be safely closed down and the coal field and surrounding aquifers successfully rehabilitated to normal. There has been significant concern with the outcome of the Linc Energy and Coogar Energy projects with claims of water and air contamination. All of the active projects have now ceased by government edict.

Australian experience with UCG delivers several lessons.

- UCG, like many other so-called ‘novel’ and ‘innovative’ processes, has a long history, and lessons learned from previous work are often ignored in the rush to achieve the desired outcome.
- Project promotion by ‘blue sky thinkers’ often ignores (deliberately?) serious issues or cost constraints on the technology.
- Unwarranted enthusiasm and euphoria can influence government decision-making just as easily as private equity. When the project goes sour, this euphoria quickly turns to panic, resulting in bans shutting down possible viable technology.

In Australia today, UCG is a dead technology option. Development has now been transferred to other countries such as South Africa where it is reported that UCG is being used to supplement fuel to a power station.



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

UCG, like many other so-called ‘novel’ and ‘innovative’ processes, has a long history, and lessons learned from previous work are often ignored in the rush to achieve the desired outcome.

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What now for Australian post-Brexit world?

Nobody can yet predict exactly what the ramifications will be now the United Kingdom has voted to leave the European Union, but UK science commentators are already foreshadowing Brexit Mark 2 – a Brain Exit of researchers.

Brexit has created incredible uncertainty. The potential disruption that it may cause to the many international collaborative research programs involving the UK is something the international scientific community could certainly have done without.

Whatever form the Brexit negotiations take, and however long the timeline, the disruption is real. It will be more so if Brexit causes still wider political and economic instability.

Aftershocks in Australia

There will likely be some aftershocks felt here too for some considerable time given the extent that Australian researchers engage in collaborative programs with both the UK and the rest of Europe.

Firstly some facts. UK researchers are among the most internationally collaborative in the world. Around 60% of the roughly 120 000 research articles published each year by UK-based authors are co-authored with international collaborators. More than half of these are in the EU.

According to the 2013 report on International Comparative Performance of the UK Research Base, more than 70% of UK researchers working between 1996 and 2012 published papers while affiliated with non-UK institutions.

Unsurprisingly, the more internationally collaborative researchers are significantly more productive than those researchers who stayed at home and were more inwardly focused.

About 28% of academic staff in UK universities are non-UK citizens. Again, more than half of these are from the EU.

If, as has been suggested, the UK ramps up restrictions on mobility and work entitlements, it is possible that many of these researchers will choose or be forced to leave.

Until now, Britain has been a very significant net beneficiary of EU research funds. It received an estimated €8.8 billion funding between 2007 and 2013 on the strength of an estimated €5.4 billion contribution. This made it the second most successful nation behind Germany.

Looking forward, it is estimated that UK research could be £1 billion worse off each year as a consequence of the decision to leave the EU.

Beyond the horizon

The most significant impact could potentially be felt by research programs funded through the Horizon 2020 program.

This 30-year collaborative research and innovation framework is by far the largest research funding mechanism in Europe, and one of the largest in the world. In the current

research in a

funding cycle that runs from 2014 to 2020, an estimated €80 billion funding would flow to researchers in EU member states and associated nations.

While some non-EU members have negotiated eligibility to apply for Horizon 2020 funding, eligibility is conditional upon the free movement of people. In the UK's case, continued access to the Horizon 2020 program may need negotiation.

Australia may participate in Horizon 2020 projects as a non-associated industrialised third country. But projects are not automatically eligible for funding. Accordingly, much of Australia's access to European research and research funding is leveraged through collaborations in the UK.

Potential benefits for Australia

We should also note that there are large numbers of research students from EU member nations studying in the UK, a significant proportion of the research workforce. There are concerns that these students might now be categorised as 'international' students and face significant fee increases to study in the UK.

If this does take place and the UK does become a more expensive destination for European research students, it is likely that higher education institutions in Australia, the US and Canada will all benefit as alternative English-language study options for European students.

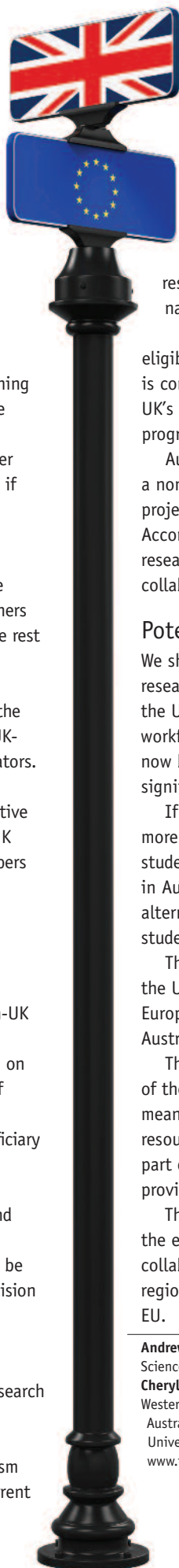
There are strong natural links between Australia and the UK. It is possible that the UK decision to leave Europe may actually provide new opportunities for Australian researchers.

The UK will now be potentially more open to the rest of the world. Having the UK as part of the EU has often meant that there was preferential access to positions, resources, collaborations and so on for those who were part of the EU. The lifting of that restriction may well provide new opportunities for Australia.

The Australian Academy of Science is recommending the expansion of Australia's bilateral and multilateral collaborations with a variety of partner countries in regions including Asia, East Asia, the Americas and the EU.

Andrew Holmes FRACI CChem is President of the Australian Academy of Science and Laureate Professor Emeritus, University of Melbourne.

Cheryl Praeger is Professor of Mathematics and Statistics, University of Western Australia. **Les Field** is Secretary for Science Policy at the Australian Academy of Science, and Senior Deputy Vice-Chancellor, University of New South Wales. First published at *The Conversation*, www.theconversation.com.



Heavy metals in wine

The presence of heavy metals in wine, as with any food or beverage, stimulates active debate about the safe consumption of the product. A UK study released in 2008 created a considerable flurry of articles on the web that were not particularly favourable to the wine industry. For example, the *Scientific American* review of the UK study was entitled 'Jeers! Hazardous levels of metals found in wines' with a subtitle of 'Are we swallowing toxic elements with every sip of vino?' (bit.ly/2bd2aaJ), while the WebMD site review goes under the heading 'Red, white wines carry dangerous doses of toxic metals' (wb.md/2b6w9UG).

There are several questions about the accuracy of the conclusions in the UK study. It would appear that the claims were based on a calculated target hazard quotient that does not consider the actual absorption of metals from the wine. This bioavailability is often overlooked, particularly the link between metal ion complexation and bioavailability. Lead is a good example. Although lead acetate was used by the Romans as a method of sweetening wines, leading to elevated lead concentrations, current winemaking practice limits the amount of lead that finds its way into a finished wine. One exception that we have worked on was a wine made from grapes grown near a lead smelter. Even though yeast cells during fermentation absorb a considerable part of the heavy metals present in grape juice, the lead concentration of this particular wine was about six times the maximum acceptable limit.

Dr Alison Green in her PhD thesis at the University of Melbourne (2000) used stripping potentiometry to examine the lability of lead in wine. Alison's results showed that at the natural pH of wine, there is rarely any labile lead present and only at pH 1 did the labile concentration approach the total lead concentration. The 'lead smelter wine' did have a considerable amount of labile lead, so consumption was not part of the experimental profile! Collaboration between Alison and colleagues at the INRA (Institut National de la Recherche Agronomique) in Montpellier showed that the acidic polysaccharide rhamnogalacturonan-II (RG-II) would bind lead ions rapidly until a saturation point was reached, after which any added lead became labile. Using models and actual wines,

Although lead acetate was used by the Romans as a method of sweetening wines, leading to elevated lead concentrations, current winemaking practice limits the amount of lead that finds its way into a finished wine.

Alison was able to derive complexation capacity plots and relate the binding of lead to the amount of RG-II present. No binding with grape-derived tannins was found. These results have obvious implications for lead bioavailability.

Manganese is one metal that is creating considerable interest at the moment. The *Scientific American* article mentioned above reports claims that 'consuming too much manganese ... can cause manganism (slow, clumsy movements) and may also contribute to Parkinson's disease'. The unanswered questions are 'How much is too much?' and 'Is one likely to suffer liver failure from consuming large amounts of wine before manganism sets in?'. Recently, China imposed a manganese limit of 2 mg/L for imported wines, although the basis for this number is not clear, and Wine Australia now recommends that all wines be checked for manganese before export (bit.ly/2aESxBV).

Dr Eric Wilkes MRACI CChem of the commercial services division of the Australian Wine Research Institute (AWRI) has reported the results of a survey of 1561 white and red wines from vintages 2008 to 2014 (bit.ly/2aSZ8rQ). The median manganese level of all wines was 1.4 mg/L, with that for red wine (1.7 mg/L) being somewhat higher than the value for white wine (1.1 mg/L). Around 25% of all wines analysed exceeded the 2 mg/L limit for China.

Until recently, there has been little work on the chemistry of manganese in wine, with most attention being paid to copper and iron because these two metals are clearly involved in oxidative and reductive processes as well as haze formation. The late Dr Gordon Troup of Monash University long proposed, on the basis of his electron paramagnetic resonance spectra research, that manganese was potentially important in wine chemistry because of its capacity to switch oxidation states, as occurs with copper and iron. Research at the AWRI is now showing the activity of manganese in reductive processes, particularly the formation of reduced sulfur compounds (bit.ly/2aT5k4I), while results soon to be published from the National Wine and Grape Industry Centre in Wagga Wagga demonstrate the participation of manganese in oxidative reactions. Manganese would seem to be less effective than copper in mediating oxidative spoilage reactions.

These studies on the reactivity of manganese in wine have not yet shed any light on its binding or complexation chemistry. Winemakers are finding that the amount of manganese can be lowered significantly by ion exchange, which is generally used for the reduction of potassium, suggesting that manganese is in a rather labile state. There is still a way to go, however, before the bioavailability of manganese can be assessed.



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.

Intensive mode learning and threshold concepts

Intensive mode teaching and learning refers to educational activities that occur on fewer days, and for longer each day, than a 'traditional' unit or module in the discipline. In traditional education, a full-time student studies between four and eight subjects or units per term or per semester at school, TAFE or university. Hence, each subject or unit is effectively part-time study, taking up between 10% and 25% of the study hours available in each week. By way of contrast, an intensive mode subject might take between 30% and 100% of the available study hours. Examples include field trips and study tours, during which students devote 100% of the available hours to a single subject.

In chemistry, the University of New England and Central Queensland University offer courses by distance education, but students are expected to attend compulsory residential schools. During these residential schools, the students participate in chemistry laboratories and tutorials, all day, every day for up to one week.

The success of intensive mode learning often depends on the ability of the instructor to identify threshold concepts and to provide scaffolding to avoid learning difficulties and misconceptions.

At school-age level, examples of intensive mode teaching and learning include vacation 'camps' and year 9 programs that provide opportunities for intensive off-campus, community-based learning experiences, which is a form of intensive mode learning within a formal school curriculum but outside the school campus.

Sally Male and her colleagues at the University of Western Australia, University of Tasmania and RMIT have surveyed academic staff involved in teaching 105 intensive mode units (subjects) at 26 Australian universities as part of an Australian Government Office for Learning and Teaching (OLT)-funded project on intensive mode teaching and learning. They found that reasons for intensive mode teaching and learning include fitting study between other activities, engaging in interactive learning activities over extended continuous periods, and focusing on one unit with limited distractions. They found that some advantages of intensive mode learning are social bonding within the learning cohort, focus and immersion in a discipline in a retreat-like environment, longer interactive activities of flexible duration, and continuity of learning – students can learn a concept, apply the concept and overcome challenges all on the same day. In many instances, intensive mode learning, such as weekend retreats, can better fit student life and course schedules, and free

up time for other activities. Often there is a perception of better learning.

However, intensive mode teaching and learning can also have significant disadvantages. Male et al. found that disadvantages of intensive mode units include problems of timetabling and finding venues alongside regular units, students not understanding the workload, exhaustion for both teaching staff and students, students not managing studies and preparing for the next class, students finding it difficult to catch up if they had a mishap such as illness, difficulty in providing timely feedback, a perception that students do not engage in learning, difficulty in finding time for group work, and student anxiety.

The success of intensive mode learning often depends on the ability of the instructor to identify threshold concepts and to provide scaffolding to avoid learning difficulties and misconceptions. A threshold concept has several key characteristics. Threshold concepts are:

- *transformative*, in that, once understood, they cause a significant shift in the perception of a subject
- probably *irreversible*, in that once learned are unlikely to be forgotten
- *integrative*, exposing the previously hidden interrelatedness of something
- *troublesome* because they are key ideas that must be mastered before further learning can occur. For example, the idea that many substances consist of molecules, with a fixed combination of atoms, and are described by a formula is a threshold concept, which is fundamental to balancing equations, stoichiometry, the mole concept and many other concepts and skills.

Traditional teaching and learning has time and opportunity to seek additional explanation and clarification of threshold concepts between classes. In contrast, there is little or no time between classes in intensive mode. Hence, lessons need to be carefully structured to maximise the mastery of threshold concepts at each step. In intensive mode learning, if there are significant difficulties in mastering a threshold concept, the resultant delay in learning means that the student might never catch up on subsequent concepts and hence not be able to complete the unit. While identifying and explicitly planning to clarify threshold concepts is absolutely critical in intensive mode learning, it is also good teaching practice in all modes of learning.

For more information about the OLT-funded project on intensive mode teaching and learning, please contact Dr Sally Male (sally.male@uwa.edu.au) or visit www.ecm.uwa.edu.au/staff/learning/research/intensive-mode-teaching.



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Discovering Engelbert Kaempfer

When I came across the name of Engelbert Kaempfer (1651–1716), I felt sure that I had discovered the source of the name given to the flavonol 3,5,7-trihydroxy-2-(4-hydroxyphenyl)-4*H*-1-benzopyran-4-one – kaempferol. It's true, I had, but the story is more complicated than I had imagined.

But first, the name kaempferol rang a bell for me because my MSc supervisor, R.G. Cooke, with his student Howard Haynes, published a paper about it in 1960, the year that I joined the research group. They isolated several glycosides of kaempferol from the leaves of a small tree. This was a tree that Cooke had noticed as he drove to the family's holiday house on the Mornington Peninsula in Victoria. Normally a dull green, *Exocarpos cupressiformis* develops a bright yellow colour about this time of year and it was this blush of spring that caught the eye of a natural product chemist. Botanically, the tree is unusual because it is a parasite on the roots of nearby larger trees, which explains the crowding visible in the photo.

Kaempfer was born in Germany but studied law and medicine at Cracow, Königsberg and Uppsala. From the last of these institutions, he was hired by the Swedish court and included in a 1683 delegation to Persia where they were delayed for several months in Isfahan waiting for an audience with Shah Sulayman. Kaempfer filled in his time exploring the nearby ruins of Persepolis and also did some botanising that included a special interest in the production of dates.

Most members of the delegation returned home, but Kaempfer found employment with a Dutch trading company, the United East India Company (Vereenigde Oost-Indische Compagnie, VOC) that had a depot in Isfahan. The VOC had a strong presence in the 'Far East', a term that covered much of South-East and East Asia and especially the Netherlands East Indies (now Indonesia), a Dutch version of the East India Company that played a major role in trading and governance in the sub-continent. Kaempfer was first transferred to Batavia (now Jakarta), paid as a physician but spent as much time on botany, and then in 1690 to Japan. Concerned over the activities of Christian missionaries and Portuguese traders, Japan had expelled most foreigners in 1637 but the VOC, one of a small number of foreign outposts sanctioned by the Japanese government, was able to maintain a 'factory' (trading depot) on reclaimed land off the coast near Nagoya.

Kaempfer took an interest in Japanese medical practice, learning much about acupuncture and also a technique I had not heard of before, moxibustion. It involved 'a half-inch long wad of the finest fibres of *Artemisia vulgaris* (being) set alight on the spot where the pain was felt and allowed to burn down to the skin'. Ouch!

Kaempfer was the first European to describe the plant *Ginkgo biloba*, and when he returned to Europe in 1692 he brought some *Ginkgo* seeds that were planted in the botanical garden at

Utrecht and grew to trees that survive to this day. He also carried with him a plant known by its Chinese name as Wanhom and he cultivated it in his garden in his hometown of Lemgo. He had encountered the plant when he visited Siam (now Thailand) and learned that its rhizome (tuberous root) had found medicinal uses in Asia, notably for settling the stomach. Linnaeus (1707–78) had heard about this plant but it was only in 1753 that he included it in his binomial system of nomenclature as *Kaempferia gelanga*, thus honouring the botanist who had provided a good description of it.

There the matter rested until Kaempfer's compatriot Rudolph Brandes (1795–1842) set out to find the active principle and in 1839 isolated a yellowish substance he called kãmpferol. In 1882, Ernst Jahns (1844–97) determined that this was a mixture and he retained the name kãmpferol for the least soluble component to which he ascribed the (correct) molecular formula $C_{16}H_{12}O_6$. Later researchers isolated this substance from other genera in the family *Zingiberaceae* and demethylated it to what was eventually named kaempferol ($C_{15}H_{10}O_6$).

The long story tracing the name from Engelbert Kaempfer to the flavonol kaempferol was related a few years ago by a German historian in a book with the subtitle 'a case study of what eponyms in chemical nomenclature can tell us', and I have drawn extensively on his work to write this Letter. A major source of information about Kaempfer is the collection of papers and 'curiosities' (including acupuncture sets) acquired for the British Museum a few years after his death by another collector-physician, none other than Sir Hans Sloane (1660–1753). Scholars can consult the papers in the British Library. And, yes, that's Sloane of Sloane Square in London and the stereotypical upper-class British girl, the Sloane Ranger.



Exocarpos cupressiformis

Melburnian/CC BY 2.5



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.

International Conference on Applied Crystallography

17–19 October, Houston, US

<http://crystallography.conferenceseries.com>

Effective Communication for Engineers

18–19 October, Perth, WA

www.icheme.org/eceaus

Nanoparticle Therapeutics 2016

23–26 October 2016, Palm Cove, Qld

<http://nanoparticletherapeutics2016.org>

AusBiotech 2016

24–26 October 2016, Melbourne Convention Centre, Vic.

www.ausbiotechnc.org

Women in Chemistry AGM

16 November 2016

www.raci.org.au/events/event/women-in-chemistry-agm

36th Australian Polymer Symposium

20–23 November 2016, Lorne, Vic.

www.36aps.org.au

Chemical Engineering for Non-Chemical Engineers

30 November – 2 December 2016, Brisbane, Qld

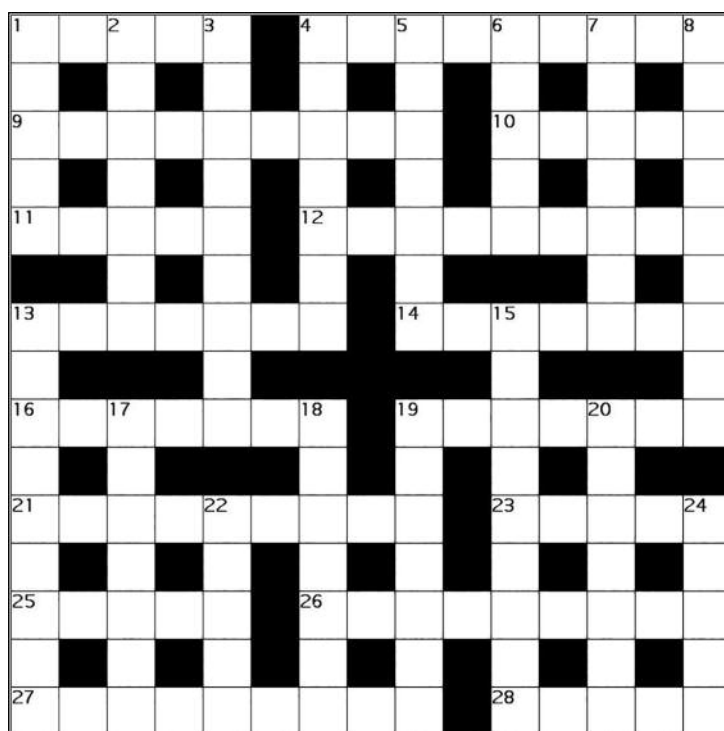
www.icheme.org/shop/events/courses/2016/aus%20and%20nz%202016/chemical%20engineering%20for%20non-chemical%20engineers.aspx

R&D Topics 2016, NSW

5–7 December 2016, Parramatta, Sydney

www.raci.org.au/events/event/r-d-topics-2016

RACI events are shown in blue.



Across

- 1 Inapt arrangement covers a surface. (5)
- 4 Treated Spooner as very busy. (9)
- 9 Pity over mix or over juxtaposition. (9)
- 10 Grasps supports. (5)
- 11 Underplay organic chemistry involvement when returning to our Institute's beginning. (5)
- 12 As_3H_5 is rare as tin compound. (9)
- 13 A regret? It could become more than a few. (7)
- 14 Man is so tickled: he won the Nobel Prize in Chemistry for his work isolating fluorine from its compounds. (7)
- 16 Promote orbital on SO radical. (7)
- 19 Inimical written opinion of named author about Point of Sale. (7)
- 21 2-Methylpropane, no silicon: beaut arrangement! (9)
- 23 θ temperature heat blast. (5)
- 25 Be a flame one way. (5)
- 26 Describes a crystalline overlayer made from a Xe/Li/Ti/Pa mixture. (9)
- 27 Mimics make adjustments to male suits. (9)
- 28 They look first to make a radical. (5)

Down

- 1 Daily report on our work. (5)
- 2 Size O? My foot! Different sequence; same reaction. (7)
- 3 Conjugate bases of RSH that I lose, sadly. (9)
- 4 Dog of a clue. (7)
- 5 Oxidised Lu/Y mix used to make R-O^+ . (7)
- 6 It took 68 to hold the compound. (5)
- 7 Cyclic sulfonamides and salt must react in less time. (7)
- 8 Saw rends iced concoction. (9)
- 13 Using sets over wherever the wind blows. (9)
- 15 Ask for mate. Petri dish broken. (9)
- 17 H_3O^+ or a substitution derivative fixes NO_2/U mix. (7)
- 18 Rat gene forms the basis of substance useful to us. (7)
- 19 Bravo! Scandinavians heard making compounds. (7)
- 20 Scandinavian dishes tungsten out. (7)
- 22 Before then it was raised in the explanation of how to split numbers into individual digits. (5)
- 24 C_3H_5^- used in chemically linked fragments antigen-binding. (5)

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

PolymerVic 2016

The RACI Victorian Polymer Group hosted PolymerVic 2016, 4–5 July, at Monash University's Parkville campus, with over 100 registrants across the two days. PolymerVic is a two-day technology workshop held annually to highlight the world-class polymer research taking place in Victoria, and to facilitate increased industry–academic engagement.

Now in its third year, PolymerVic 2016 incorporated mini-symposia on 'Polymers in Biotechnology and Medicine', and 'Young Victorian Polymer Researchers'. The meeting was held in partnership with the CRC for Polymers, Davies Collison Cave (DCC), the Victorian Centre for Sustainable Chemical Manufacturing (VCSCM), the ARC Centre of Excellence in Convergent Bio-Nano Science & Technology (CBNS) and the Monash Institute of Pharmaceutical Sciences (MIPS). This year, PolymerVic welcomed a new partner on board: the American Chemical Society, one of the world's leading publishers of new chemical research.

The Young Researchers theme provided Victorian-based early career researchers (ECR) (less than five years post PhD) and PhD students with an opportunity to showcase their research. As part of this initiative, the RACI Victorian Polymer Group introduced two new awards to recognise outstanding presentations at PolymerVic 2016, each with a cash component of \$1000 for professional development. Competition was fierce between the five early career researchers and nine PhD students, with Dr Jeroen Goos (CBNS) taking the ECR Award for his presentation on 'Nanoparticles for PET/MR imaging: visualising tumours in the brain', and Laura Selby ('Understanding bio-nano interactions using molecular sensors')

and Wei S. Ng ('Surface-selective temperature-responsive polymers for minerals processing applications') sharing the inaugural PhD student prize.

The judges were particularly impressed by the high-quality presentations from the PhD students, noting that the future of Victorian polymer research looked exceedingly bright. To round out the 'Young Researchers' theme, Dr John Quinn (ARC Centre of Excellence in Convergent Bio-Nano Science & Technology) chaired a spirited panel discussion entitled 'I have a PhD in Polymer Science: what next?' with panel members Dr Francesca Ercole (Monash), Professor Bronwyn Fox (Swinburne), Dr John Lambert (PolyActive Pty Ltd) and Dr Ramon Tozer (DCC).

With 22 invited speakers in the 'Polymers in Biotechnology and Medicine' theme, the participants were treated to a showcase of the cutting-edge polymer research currently taking place in Victoria. While the focus was firmly on Victorian-based researchers, we couldn't pass up the opportunity to ask visiting academic Professor Vincent Rotello to give a special plenary lecture entitled 'It's all about particles ...'. Professor Rotello's research program focuses on using synthetic organic chemistry to engineer the interface between the synthetic and biological worlds, and spans the areas of devices, polymers and bionanotechnology.

With the continued support of our partners and sponsors (Shimadzu, InVitro, ATA Scientific, Corning, Agilent and Merck), planning is already well under way for PolymerVic 2017.

Dr Michael Whittaker MRACI CChem is at the ARC Centre of Excellence in Convergent Bio-Nano Science & Technology, Faculty of Pharmacy and Pharmaceutical Sciences, Monash University (Parkville Campus).



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Host Organisation



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24 – 27 October 2016, Melbourne Convention Centre, Australia



Mr Paul Perreault – CEO and Managing Director, CSL, USA



Biotechnology and innovation: risk and precaution: social license or not?
Prof Sir Peter Gluckman – Chief Science Advisor to the Prime Minister, Office of the Prime Minister, New Zealand



2016 Millis Oration
Prof Ian Gust AO – Professorial Fellow, University of Melbourne



A New Model for Drug Development in Academic Institutions
Prof Dennis Liotta – Executive Director Emory Institute for Drug Development, Emory College, Atlanta USA



Interrogating and Guiding the Microbiome for Macro-organism Health and Productivity
Dr James Tiedje – Director, Centre for Microbial Ecology, Michigan State University, USA



Self-Assembled Supramolecular Nanosystems for Targeting Therapy of Intractable Diseases
Prof Kazunori Kataoka – Professor, Department of Materials Engineering and Bioengineering Graduate Schools of Engineering, University of Tokyo, Japan



Synthetic Designer Vaccines Protect from Bacterial Infections
Prof Dr Peter Seeberger – Director, Max-Planck Institute of Colloids and Interfaces, Germany



Biotech and the future of man
Prof Huanming Yang – President, Beijing Genomics Institute, China

7 Plenary sessions

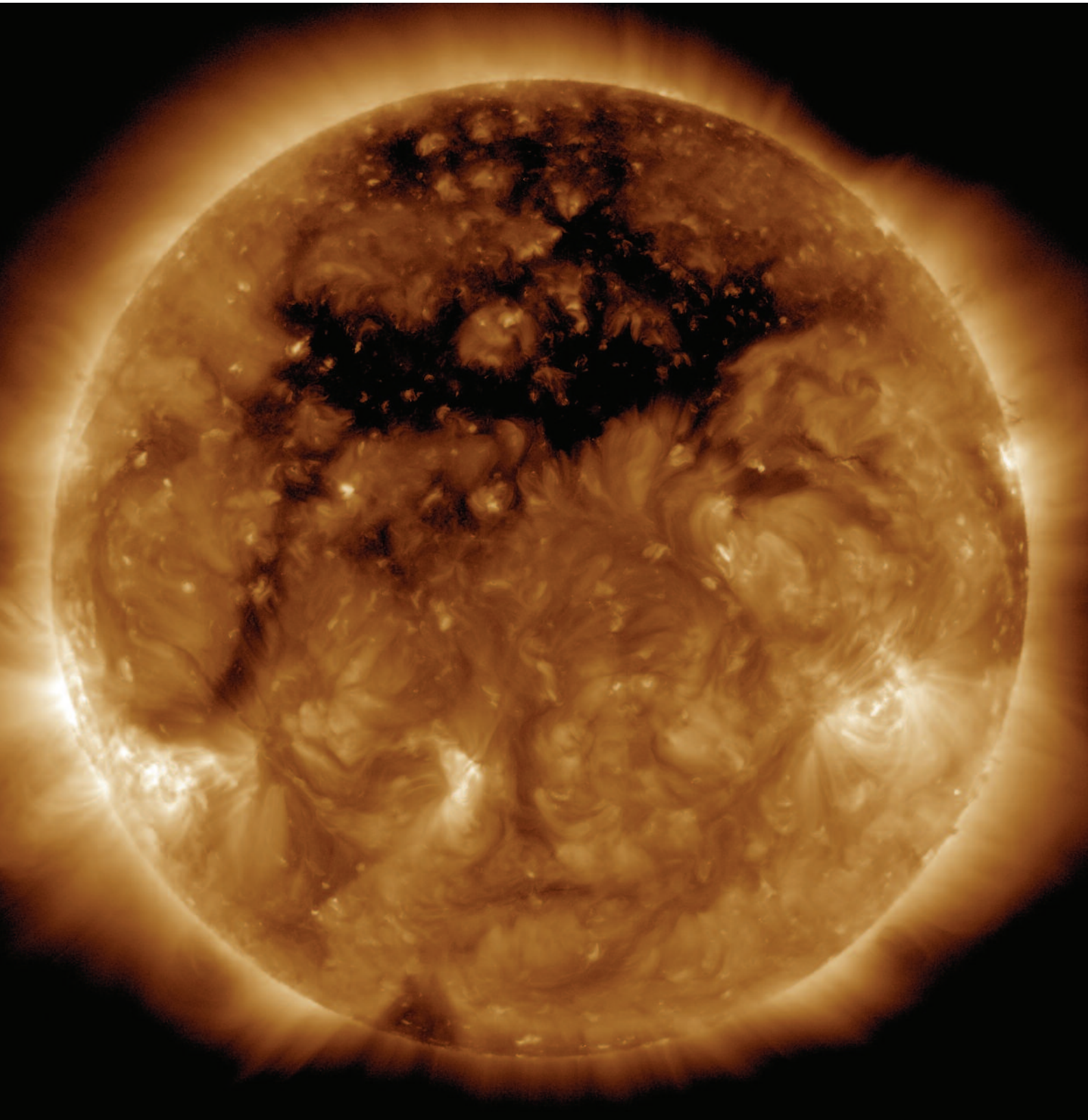
Abundance of networking opportunities

Over 160 speakers

Over 100 exhibiting companies

27 Sessions

Over 1000 participants



The dark area across the top of the sun in this image is a coronal hole, a region on the sun where the magnetic field is open to interplanetary space, sending coronal material speeding out in what is called a high-speed solar wind stream. The high-speed solar wind originating from this coronal hole, imaged in October last year, by NASA's Solar Dynamics Observatory, created a geomagnetic storm near Earth that resulted in several nights of auroras. This image was taken in wavelengths of 193 Å, which is invisible to our eyes and is typically colourised in bronze. NASA/Solar Dynamics Observatory