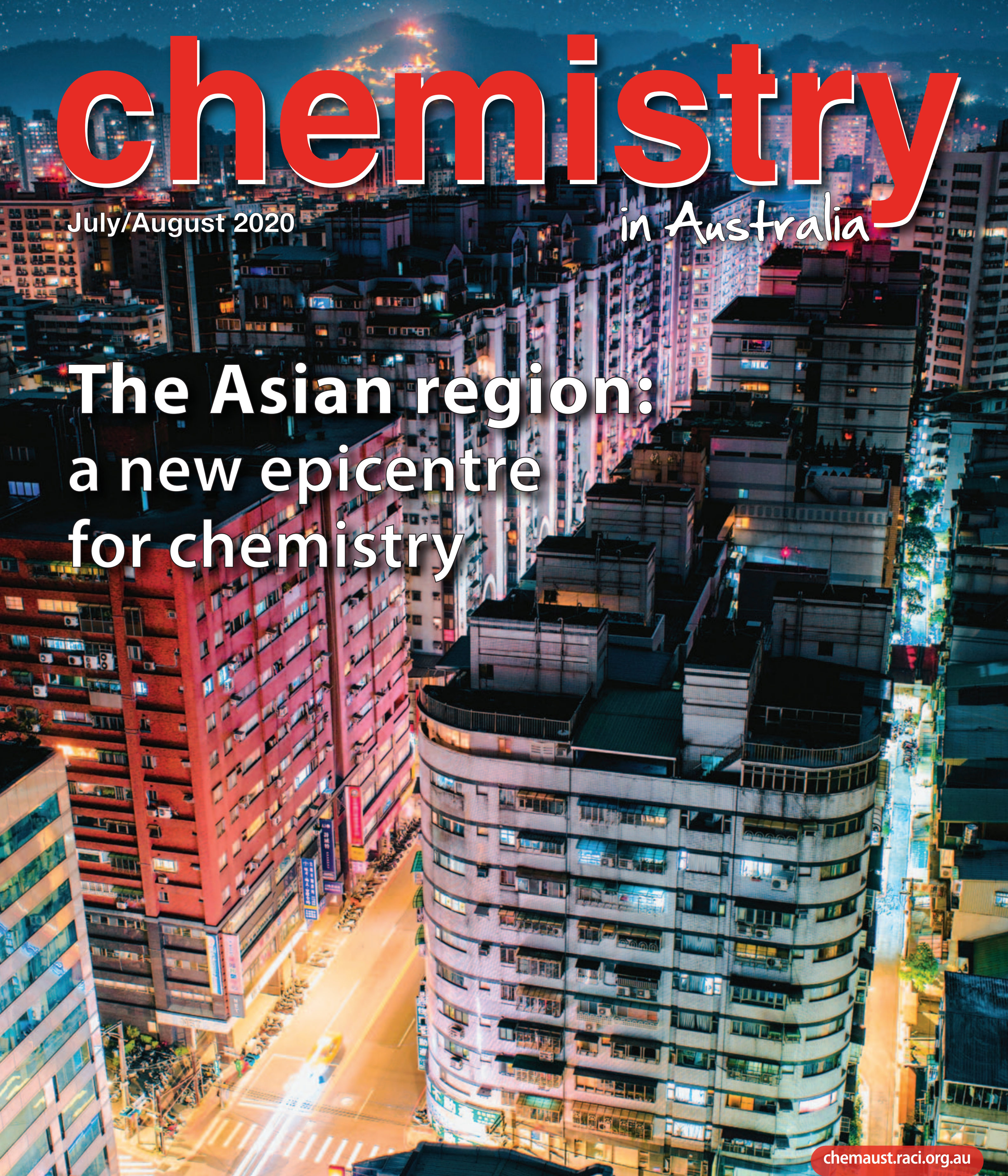
chemistry in Australia

July/August 2020



The Asian region: a new epicentre for chemistry

chemaust.raci.org.au

- Analogue still a trusty tool in science
- Practical chemistry activities during COVID crisis
- RSC Lectureship tour report

raci
Royal Australian Chemical Institute

chemistry in Australia

July/August 2020

iStockphoto/Andrew Haimerl

chemaust.raci.org.au

From the President

A recent survey conducted by the Australian Institute of Company Directors shows that 43% of their not-for-profit members are apprehensive about making going-concern assessments or solvency declarations for their organisations in light of the pandemic.

In addition, the top strategic priorities for Australian Institute of Company Directors members in the next six months include addressing cash flow and customer demand uncertainty, pivoting business operationally and adapting to new ways of working.

These issues have also been at front of mind for the RACI Board, which has been meeting fortnightly to ensure that it is agile in its response to COVID-19. The Board is also very mindful of the pressures members are facing. In response, the Board has frozen increases in membership fees and introduced a monthly payment program to ease the burden of an annual lump sum payment. To encourage the uptake of the monthly payment, the Board has also agreed to a once-off 10% discount to the 2020–21 membership fee, to be spread over the membership year. The RACI is in a good financial position, which has allowed us to offer this relief.

The Board has made several decisions to ensure the longer-term viability of the organisation. This includes some changes to *Chemistry in Australia*, which will be moving to a quarterly magazine. Also, the price of receiving a hard copy will increase to cover the cost of production and distribution. The *Chemistry in Australia* committee will be tasked with looking at ways to bring news to members through the new website, which will complement the magazine.

A number of other savings have been found for the coming year, including the cancellation of the awards night, and face-to-face board and assembly meetings.

The RACI has pivoted the way it delivers member events and I would like to thank all who have been involved. Within a matter of weeks, the Assembly and groups were delivering multiple webinars weekly that were attracting participants from all over Australia.

The Board is now looking at how to capitalise on the changes that have happened in terms of the delivery of on-line webinars and networking events to continue connecting our members wherever or whoever they are. This is in line with the strategic priorities that came out of the Board's planning day in February: education and professional development, standards, and governance and management.

I would like to make special mention of Dave Sammut, who has put together an amazing virtual careers development program and networking activities.

Members told me they hoped online event options remain because it is the first time they have been able to fully engage with the community.

Members should also be aware of the access to the digital version of *Chemistry World* until December 2020. This was achieved because of the RACI's relationship with Commonwealth Chemistry.

The past few months have required the RACI to express concerns on a number of issues. I would like to thank our educators at all levels for the leap of faith as well as agility to change modes of delivery for our students. But while online teaching may play more of a role in the future, it is the RACI's firm view that online practical demonstrations alone will not prepare students and that hands-on practicals are a critical component of any chemistry program.

We are also firm that racism and discrimination does not belong in our profession or society. This is reflected in our revised Code of Conduct and Inclusion and Diversity policy. We must all be vigilant of society's and our own biases and actively find ways to support each other.

The future looks very bright for the RACI. At RACI2017, I mentioned that I hope to start the leadership of the organisation's next 100 years. While I never expected needing to be part of a leadership team during a pandemic, I believe the RACI is set up to succeed as I had hoped.

Vicki Gardiner FRACI CChem (president@raci.org.au) is RACI President.

Editor's note: From the next issue (to be published in September or October), *Chemistry in Australia* will be a quarterly magazine.

chemistry in Australia
chemaust.raci.org.au

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

PRODUCTION EDITOR
Catherine Greenwood
catherine.greenwood@bigpond.com

ADVERTISING SALES
Mary Pappa
Ph/fax (03) 9328 2033/2670
mary.pappa@raci.org.au

PRODUCTION
Control Publishing
publishing@control.com.au
www.control.com.au

BOOK REVIEWS
Damien Blackwell
damo34@internode.on.net

RESEARCH HIGHLIGHTS
David Huang
david.huang@adelaide.edu.au

EDUCATION RESEARCH HIGHLIGHTS
Reyne Pullen
r.pullen@unsw.edu.au

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

PRESIDENT
Vicki Gardiner

MANAGEMENT COMMITTEE
Helmut Hügel, Colin Scholes, Madeleine Schultz, David Springer, Richard Thwaites

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

ISSN 0314-4240 e-ISSN 1839-2539

Greatest good for greatest number

The mathematician John von Neuman pointed out that the maxim 'The greatest good for the greatest number' was a mathematical impossibility; you can't maximise simultaneously for two variables. Wanting to arrive at our destination as quickly as possible and as safely as possible means setting various speed limits and restrictions along the route judged on the variable conditions of the road and the traffic.

It should be no surprise that dealing with this dilemma to a new normality from the pandemic of COVID-19 is so contested. Whether deciding where and when to put traffic lights or accept a new drug on the PBS, one variable has to be fixed and that means putting a price on a human life. Obviously not widely publicised!

Ivan Kennedy (May/June, p. 16) reminds us that the AVPMA not only has dilemmas, but faces multi-lemmas when assessing registrations of agricultural and veterinary chemicals: safety for consumers, farmers, efficacy, environment (e.g. the soil), economic benefit, and trade implications. A better public understanding of process would be useful.

Ben Selinger AM, FRACI CChem

COVID-19 sources related to food

Some of the reports regarding the source of the COVID-19 virus suggest 'wet markets' where animals are freshly slaughtered for human foods, including domestic animals (cats, dogs etc.) and wild animals (pangolins, civets etc.). Although cats and dogs have been frequently reported as being used for human food, pangolins are not well known in Australia, as pets, in zoos or for food. Civets are probably better known, being used in the flavour and perfumery industries for the skatole in a glandular excretion.

Other food and fragrance natural extracts include musk (from musk ox, muscovy duck and muskrat), ambergris (sperm whales), cochineal (a South American female insect), beeswax (bees), shellac (an Asian insect) and vanilla (orchid pods).

In the very early 1970s, the author was involved in developing a new style of non-alcoholic strawberry flavour for confectionery, based on about 30 flavouring substances. These substances included the then recently available but not yet gazetted raw material called ethyl maltol, which was regarded as a powerful synergist, plus an old but favoured ingredient in berry flavours, castoreum extract.

Fast forward to the mid-1990s and the author was still developing products, only this time it was cough mixtures.

A Therapeutic Goods Administration (TGA) ruling was that a 'no alcohol' claim strictly meant zero ethyl alcohol presence, thus limiting the choices to non-alcoholic flavours, acceptable to children and that could mask the bitter pharmaceutical actives. The author used the still available 1970's strawberry flavour development and it proved to be very successful. It has since been in continuous use in one of the largest selling cough mixtures in the Australia–Asia region.

During the late 1990s and the 'mad cow' BSE (bovine spongiform encephalopathy) scare, TGA requested all pharmaceutical manufacturers notify it of therapeutic products that had any trace of *any* animal products. To the author's complete surprise and shock, the above strawberry flavour contained an animal component that turned out to be castoreum extract.

Originally and naively it was thought that castoreum extract was derived from the castor oil plant. Not so – it is an extract taken from glands in the anal region combined with the urine of mature beavers. Hence the name, castoreum extract, from the Latin *castor* (beaver), probably would not be challenged as being deceptive by the Australian Competition and Consumer Commission.

Incidentally, the following quote from Wikipedia provides a possible, but modern-day, explanation for my confusion:

Castor oil is a vegetable oil obtained by pressing the seeds of the castor oil plant (Ricinus communis). *The common name 'castor oil', from which the plant gets its name, probably comes from its use as a replacement for castoreum, a perfume base made from the dried perineal glands of the beaver.*

I now wonder about the acceptability of some flavours and perfumes for vegetarians and vegans, especially as there is no requirement to list their components.

Tony Zipper FRACI CChem

Representing the water molecule

In the March/April issue (p. 14), an article about symbolic representations prevalent in large-class teaching shows a number of 'icons' representing the water molecule plus some properties. Models are important to give students a picture to help learning concepts, and water's angular shape is explained in terms of a tetrahedral one (similar to methane) due to two O–H bonds and two equivalent lone pair sp^3 hybrid orbitals. These came about because molecular orbitals were beyond calculation and the hybrid orbitals helped visualise the structure.

Some 50 years ago, photoelectron spectroscopy was invented. This showed that molecular orbitals in molecules such as methane, ammonia and water did not have these sp^3 hybrid orbitals. In methane, for example, one 's' type orbital and three equivalent 'p' type orbital bonds were found. Similarly, in water the 2p bonding electrons showed three separate energies for these orbitals rather than two identical lone pairs (Price W.C., *Molecular spectroscopy* (ed P. Hepple), Elsevier, 1968, p. 221). I discussed photoelectron spectra for water in a chemical education article (*Chem. Aust.* 1979, vol. 46(8), p. 353). About 10 years later, concern was again expressed about how to properly teach these orbitals in chemical education (e.g. Liang M. *J. Chem. Ed.* 1987, vol. 64(2), p. 124). Here, another 30 years on, current chemical education research seems to imply it is still too hard to move away from the unsubstantiated two lone pairs model for water. Perhaps the experimentally measured molecular orbital energies don't suggest an icon that is easy enough to draw and visualise.

Ray Hodges FRACI CChem

Supporting online learning

Campus closures related to COVID-19 presented an exceptional event in tertiary teaching in 2020 (see p. 26). In response to the ACER article (May/June, p. 34), we aim to clarify that academic staff did not wait till the census date to start online teaching; we were waiting for instructions from the government with regard to pandemic restrictions, and some institutions halted teaching for one or two weeks after the start of semester to enable the transition. Tertiary academics have been delivering different levels of blended learning for many years, although the specifics depend on the institution. A glance at the abstracts for the Australian Conference on Science and Mathematics Education and other relevant education conferences (such as the Australasian Society for Computers in Learning in Tertiary Education) as well as scholarly journals clearly show that this has been an area of extensive effort for many years. Thus, most academics do not need 'training' in online learning; instead they need support and financial assistance to provide flexible, constructive learning environments that can assist their students' transition into online learning.

In the pivot in March, students were also suddenly exposed and needed support in how to learn online. The provision of feedback online is a good example. Academics are aware of its importance; however, in many cases it requires much more staff time, and some technical problems were not anticipated. Courses that had an established learning management system and existing blended resources experienced a smoother transition; however, most current learning management systems provide a limited quality online learning environment and are relatively inflexible. All institutions were guided by an inclusive approach, mindful of students who were physically isolated, quarantined on their return to home countries or had irregular internet service to access their resources.

The tips that are provided in that article are obvious – we understand our students' learning processes so we can adapt our teaching no matter what the platform. We know that we have to be in contact with online students; however, this becomes a massive task in undergraduate classes with hundreds (to more than a thousand) students, many of whom find it easier to send an email than check an FAQ. We suggest that the focus should not be on a deficit model of tertiary academic teaching and upskilling but that it be placed on better understanding how our students approach learning online so that we can improve the interactions between students, academics and content.

It is disappointing that *Chemistry in Australia* chose to republish this article at a time when we are all doing our utmost to create the best possible learning online environment for our students. We aim to keep students enrolled not for financial gain, but because we care about our students and their learning.

Magda Wajrak MRACI CChem, **Gwen Lawrie** FRACI CChem and **Madeleine Schultz** FRACI CChem

on the market

Accelerate lab innovation with intelligence-driven mass spectrometry

Thermo Fisher Scientific announced on 26 May 2020 a new generation of high-performance, accurate analytical instruments and innovative software to enable scientists and lab professionals to acquire data more quickly and with greater accuracy than ever before.

The new instruments extend the Thermo Scientific Orbitrap Exploris portfolio of high-resolution accurate mass systems, which comprises the Thermo Scientific™ Orbitrap Exploris™ 480 mass spectrometer launched in 2019, and will allow users to easily transfer knowledge and methods from research and discovery to routine testing:

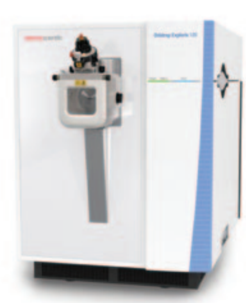
- **Thermo Scientific™ Orbitrap Exploris™ 240 mass spectrometer** – designed to give proteomics, metabolomics, biopharmaceutical characterisation and small-molecule scientists the analytical performance required for research and high-throughput analyses
- **Thermo Scientific™ Orbitrap Exploris™ 120 mass spectrometer** – designed for scientists working across small-molecule applications who require systems that support extensive, in-depth analysis of multiple complex samples, while simultaneously increasing output and decreasing costs.

The company also announced the Thermo Scientific™ Proteome Discoverer™ 2.5 software, which provides higher confidence peptide identification, more accurate quantification and higher throughput data analysis to proteomics scientists than previous versions.

These instruments and software will enable scientists, researchers, chemists and other laboratory professionals to push the boundaries of science to make the world healthier, cleaner and safer.

These innovations will be showcased at the virtual LCMS Conference on 23 June 2020. Register at https://thermofisher.com/vLCMS (available for on-demand after 23 June).

Thermo Scientific™ Orbitrap Exploris™ 240 mass spectrometer



Thermo Scientific™ Orbitrap Exploris™ 120 mass spectrometer

Oldest human genetic evidence clarifies dispute over our ancestors

An important advancement in human evolution studies has been achieved after scientists retrieved the oldest human genetic data set from an 800 000-year-old tooth belonging to the hominin species *Homo antecessor*.

The findings by scientists from the University of Copenhagen (Denmark), National Research Center on Human Evolution (Burgos, Spain), and other institutions, were published in *Nature* (https://doi.org/10.1038/s41586-020-2153-8).

'Ancient protein analysis provides evidence for a close relationship between *Homo antecessor*, us (*Homo sapiens*), Neanderthals and Denisovans. Our results support the idea that *Homo antecessor* was a sister group to the group containing *Homo sapiens*, Neanderthals and Denisovans', said author Frido Welker (University of Copenhagen).

Reconstruction of a *Homo antecessor* skull at Museu d'Arqueologia de Catalunya (Barcelona, Spain). Wiki/Xvazquez

The researchers used mass spectrometry to sequence ancient proteins from dental enamel, and confidently determined the position of *Homo antecessor* in the human family tree.

The new molecular method, palaeoproteomics, developed by researchers at the University of Copenhagen, enables scientists to retrieve molecular evidence to accurately reconstruct human evolution from further back in time than ever before.

The human and the chimpanzee lineages split from each other between nine and seven million years ago. Scientists have relentlessly aimed to better understand the evolutionary relations between our species and the others, all now extinct, in the human lineage.

'Much of what we know so far is based either on the results of ancient DNA analysis, or on observations of the shape and the physical structure of fossils. Because of the chemical degradation of DNA over time, the oldest human DNA retrieved so far is dated at no more than approximately 400 000 years', said lead author Enrico Cappellini (University of Copenhagen).

The fossils analysed by the researchers were found by palaeoanthropologist José María Bermúdez de Castro and his team in 1994 in stratigraphic level TD6 from the Gran Dolina cave site, one of the archaeological and paleontological sites of the Sierra de Atapuerca, Spain.

Initial observations led to the conclusion that *Homo antecessor* was the last common ancestor to modern humans and Neanderthals, a conclusion based on the physical shape and appearance of the fossils. In the following years, the exact relationship between *Homo antecessor* and other human groups, like ourselves and Neanderthals, has been discussed intensely among anthropologists.

Although the hypothesis that *Homo antecessor* could be the common ancestor of Neanderthals and modern humans is very difficult to fit into the evolutionary scenario of the genus *Homo*, new findings in TD6 and subsequent studies revealed several characters shared among the human species found in Atapuerca and the Neanderthals. In addition, new studies confirmed that the facial features of *Homo antecessor* are very similar to those of *Homo sapiens* and very different from those of the Neanderthals and their more recent ancestors.

University of Copenhagen

... palaeoproteomics ... enables scientists to retrieve molecular evidence to accurately reconstruct human evolution from further back in time than ever before.

Heating N95 masks may be best for disinfection

Wiki/Navy Medicine

Since the outbreak of the COVID-19 pandemic, N95 face masks have been in short supply. Healthcare workers, in particular, desperately need these masks to protect themselves from the respiratory droplets of infected patients. But because of the shortage, many have to wear the same mask repeatedly. Now, researchers reporting in *ACS Nano* (https://doi.org/10.1021/acsnano.0c03597) have tested several methods for disinfecting N95 materials, finding that heating them preserves their filtration efficiency for 50 cycles of disinfection.

N95 masks contain a layer of 'meltblown' polypropylene fibres that form a porous, breathable network. To help capture smaller particles that could slip through the holes, the fibres are electrostatically charged. The US Centers for Disease Control and Prevention has recommended several methods for disinfecting N95 masks, such as heating, ultraviolet (UV) radiation and bleach treatment, but so far they have not been tested extensively, especially for multiple rounds of disinfection. Yi Cui and colleagues wanted to compare five of the methods that could reasonably be used within a hospital setting to see how mask materials hold up to repeated disinfections.

In this study, instead of analysing N95 masks – which should be reserved for healthcare workers – the researchers examined pieces of the meltblown fabric used to make these masks. They treated the material with a particular disinfectant and compared its ability to filter aerosol particles (resembling respiratory droplets, but lacking coronavirus) before and after disinfection. The team found that spraying the fabric with an ethanol or chlorine bleach solution drastically reduced the filtration efficiency after only one treatment, from about 96% to 56% (ethanol) or 73% (bleach). A single steam treatment maintained filtration, but five steam treatments led to a sharp decline in efficiency. UV radiation allowed up to 20 cycles of disinfection; however, administering the exact dose of UV that kills the virus without damaging mask materials could be problematic, the researchers note. The best disinfection method appeared to be heating. For example, heating at 85°C for 20 minutes allowed the fabric to be treated 50 times without loss of filtration efficiency. But frequently donning and removing N95 masks could affect fit, which also affects performance, the researchers point out.

American Chemical Society

Super concentrated ionic liquids for better batteries

Deakin University

Scientists from the University of Western Australia, Deakin University and Monash University have discovered that super concentrated ionic liquids are key to achieving better batteries for future use. The findings are published in *Nature Materials* (https://doi.org/10.1038/s41563-020-0673-0).

The new work by Professor Rob Atkin and Dr Hua Li (University of Western Australia), Dmitrii Rakov, Professor Maria Forsyth FRACI CChem and Dr Fangfang Chen (Deakin University), and Dr Alexandr Simonov (Monash University), paves the way for the next generation of high energy density batteries for use in households and industries worldwide.

'This makes the breakthrough a key to achieving a clean energy future', Atkin said.

'The paper reports an ideal combination of sodium metal anode and safe, high-performing ionic liquid electrolytes can lead to much higher performing batteries.

'Currently used electrolytes cause "dendrite formation" when they're frequently charged and discharged, which is a growth of lithium metal inside the battery.

'This can cause a short circuit that releases a large amount of heat and can lead to batteries exploding.

'These new electrolytes explains how super concentrated ionic liquids that contain liquid electrolytes with very high salt concentration can help with battery stability and mitigate this safety issue.'

This new research also highlights the importance of the pre-treatment processes in future battery development.

While their work has demonstrated the mechanism for sodium metal batteries, the team said the findings are applicable to other advanced batteries including lithium and zinc metal batteries.

University of Western Australia

Tasting groundwater reveals rich flavours for exploration

CSIRO research scientist Dr Nathan Reid taking field measurements on site.

Mining companies could more accurately pinpoint reserves of valuable minerals using a new water-tasting approach developed by CSIRO, in research supported by the Minerals Research Institute of Western Australia.

CSIRO researcher Dr Nathan Reid led a team of scientists analysing samples of groundwater from the Capricorn region in Western Australia, where layers of sediment and weathering are believed to hide potential ore deposits from view.

The researchers discovered broad 'haloes' of altered water chemistry around known deposits of gold, uranium and other minerals where interaction with the ore systems had left distinctive traces in the water.

'Groundwater penetrates through covering sediments and interacts directly with the bedrock, dissolving trace amounts of the minerals present into solution', Reid said.

'By sampling those waters, our instruments can essentially "taste" the geology they have come into contact with.

'Where the underlying rocks contain a valuable ore deposit, the chemical flavour of that mineralisation extends much further than the concentrated mineralisation itself – just like a teaspoon of salt can make a whole glass of water taste salty.'

These haloes of altered water chemistry could help geologists identify areas where other ore deposits might still lie hidden below the surface, helping to focus mineral exploration in the right areas.

Chemical anomalies identified in groundwater from sediment-covered areas of the study region have already stimulated further exploration investment from companies seeking to identify undiscovered mineral deposits.

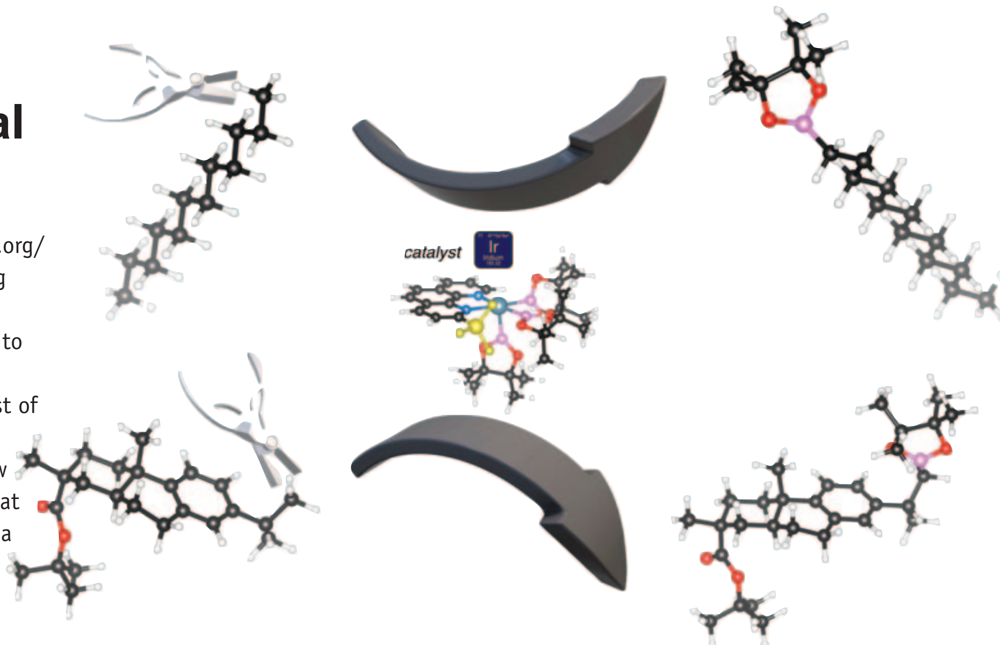
The technical report summarising the findings of this research can be found at Distal Footprint of Giant Ore Systems: Capricorn WA Case Study (https://geodocs.dmirs.wa.gov.au/Web/document/493276).

CSIRO

Scientists crack nature's most common chemical bond

In a recent issue of *Science* (https://doi.org/10.1126/science.aba6146), John Hartwig and colleagues from the University of California, Berkeley, USA, described how to use a newly designed catalyst to add functional chemical groups to the hardest of the carbon–hydrogen bonds to crack.

Dr Raphael Oeschger discovered a new version of a catalyst based on iridium that opens up one of the three C–H bonds at a terminal methyl group and inserts a boron compound, which can be easily replaced with more complex chemical groups. The new catalyst was more than 50 times efficient than previous catalysts and just as easy to work with.



A catalyst (centre) based on iridium (blue ball) can snip a hydrogen atom (white balls) off a terminal methyl group (upper and lower left) to add a boron–oxygen compound (pink and red) that is easily swapped for more complicated chemical groups. The reaction works on simple hydrocarbon chains (top reaction) or more complicated carbon compounds (bottom reaction). The exquisite selectivity of this catalytic reaction is due to the methyl group (yellow) that has been added to the iridium catalyst. The black balls are carbon atoms; red is oxygen; pink is boron. UC Berkeley image by John Hartwig

To prove the utility of the catalytic reaction, Dr Bo Su and co-workers used it to add borane to a terminal, or primary, carbon atom in 63 different molecular structures. The borane can then be swapped for any number of chemical groups. The reaction specifically targets terminal C–H bonds, but works at other C–H bonds when a molecule doesn't have a terminal C–H.

One potential application, Hartwig said, is altering natural compounds.

'This is one type of chemistry that would allow you to take those complex structures that nature makes that have an inherent biological activity and enhance or alter that biological activity by making small changes to the structure.'

He said that chemists could also add new chemical groups to the ends of organic molecules to prepare them for polymerisation into long chains never before synthesised.

'It could enable you to take molecules that would be naturally abundant, biosourced molecules like fatty acids, and be able to derivatise them at the other end for polymer purposes.'

Chemists have long tried to make targeted additions to C–H bonds, a reaction referred to as C–H activation. One still unachieved dream is to convert methane – an abundant, but often wasted, by-product of oil extraction and a potent greenhouse gas – into methanol, which can be used as a starting point in many chemical syntheses in industry.

In 1982, Robert Bergman first showed that an iridium atom could break a C–H bond in an organic molecule and insert itself and an attached ligand between the carbon and hydrogen. While a major advance in organic and inorganic chemistry, the technique was impractical – it required one iridium atom per C–H bond. Ten years later, other researchers found a way to use a single atom of iridium or other transition metal, such as tungsten, as a catalyst, to break and functionalise millions of C–H bonds.

In 2000, Hartwig, a graduate student with Bergman in the late 1980s, published a paper in *Science* describing how to use a rhodium-based catalyst to insert boron at terminal C–H bonds. The boron could be easily replaced with other compounds. Subsequent improvements to the reaction and changing the metal from rhodium to iridium, allowed some manufacturers to synthesise drugs by modifying different types of C–H bonds. But the efficiency for reactions at methyl C–H bonds at the ends of carbon chains remained low, because the technique required that the reactive chemicals also be the solvent.

The new catalytic reaction allows chemists to stick chemicals in nearly any type of C–H bond. In the reaction, iridium snips off a terminal hydrogen atom, and the boron replaces it; another boron compound floats away with the released hydrogen atom. The team attached a new ligand to iridium – 2-methylphenanthroline – which accelerated the reaction by 50–80 times over previous results.

Hartwig acknowledges that these experiments are a first step. The yield of the reactions varies from 29% to 85%. But he is working on improvements.

University of California – Berkeley

‘Whirling’ state of matter in Nd

The strongest permanent magnets today contain a mix of the elements neodymium and iron. However, neodymium on its own does not behave like any known magnet, confounding researchers for more than half a century. Physicists at Radboud University (The Netherlands) and Uppsala University (Sweden) have shown that neodymium behaves like ‘self-induced spin glass’, meaning that it is composed of a rippled sea of many tiny whirling magnets circulating at different speeds and constantly evolving over time. Understanding this new type of magnetic behaviour refines our understanding of elements on the periodic table and eventually could pave the way for new materials for artificial intelligence. The results have been published in *Science* (https://doi.org/10.1126/science.aay6757).

Alexander Khajetoorians, Mikhail Katsnelson and Daniel Wegner found that neodymium behaves in a complex magnetic way not seen saw before in an element.

Quite differently from the spins of many atomic magnets, some alloy materials can be a ‘spin glass’, with randomly placed spins pointing in all kinds of directions. Spin glasses derive their name from the amorphous evolving structure of the atoms in a piece of glass. In this way, spin glasses link magnetic behaviour to phenomena in softer matter, such as liquids and gels.

Spin glasses sometimes occur in alloys, but never in pure elements. Surprisingly, Radboud researchers found that the atomic spins of a perfectly ordered piece of neodymium form patterns that whirl like a helix but constantly change the exact pattern of the helix. This is the manifestation of a new state of matter – ‘self-induced spin glass’.

‘In Nijmegen, we are specialists in scanning tunnelling microscopy. It allows us to see the structure of individual atoms, and we can resolve the north and south poles of the atoms,’ Wegner explained. ‘With this advancement in high-precision imaging, we were able to discover the behaviour in neodymium, because we could resolve the incredibly small changes in the magnetic structure. That’s not an easy thing to do.’

This finding opens up the possibility that this complex and glassy magnetic behaviour could also be observed in uncountable new materials, including other elements. Khajetoorians said, ‘It will refine textbook knowledge of the basic properties of matter. But it will also provide a proving ground to develop new theories where we can link physics to other fields; for example, theoretical neuroscience.’

‘The complex evolution of neodymium may be a platform to mimic basic behaviour used in artificial intelligence. ‘All the complex patterns which can be stored in this material can be linked to image recognition.’

With the advancement of AI and its large energy footprint, there is increasing demand to create materials that can perform brain-like tasks directly in hardware. ‘You could never build a brain-inspired computer with simple magnets, but materials with this complex behaviour could be suitable candidates’, Khajetoorians said.

Radboud University

3D-printed nasal swabs may ease supply chain

A Melbourne company has designed and 3D-printed nasal swabs that have been shown to be the equal of two commercially available swabs when recovering SARS-CoV-2 in vitro, according to the authors of research published in the *Medical Journal of Australia* (bit.ly/305JULX).

‘Rapid upscaling of laboratory testing for SARS-CoV-2 has led to an acute global shortage of nasal swabs’, wrote the authors from the Royal Melbourne Hospital, Peter Doherty Institute for Infection and Immunity, Melbourne Health, the University of Melbourne, the Victorian Infectious Diseases Reference Laboratory, Austin Health, 3DMEDitech and the Microbiological Diagnostic Unit Public Health Laboratory.

Using specifications made available by US investigators, 3DMEDitech prepared and 3D-printed four prototype designs. Further modifications were made in consultation with the researchers.

‘To assess the ability of the 3DMEDiTech 3D-printed swab to detect SARS-CoV-2, an in vitro validation study was conducted’, the researchers wrote.

‘This study: (i) assessed the recovery of SARS-CoV-2 from different transport media using the ‘Design G’ 3D-printed swabs, and (ii) compared the ability of 3D-printed swabs to recover SARS-CoV-2 with two swabs currently used in Australia to collect specimens for the diagnosis of COVID-19.

‘A flocked nasopharyngeal swab was taken with the Copan Eswab as the standard of care, followed by a mid-nasal swab in the other nostril, using the 3D-printed swab. Both swabs were placed into individual tubes of 1 mL Liquid Amies transport media. The order in which swabs were collected was randomised 1:1. Participants were asked to complete a brief survey on the levels of discomfort with each swab.

‘There was 100% categorical agreement of SARS-CoV-2 detection from each concentration of mock sample between the Copan Eswab, Kang Jian swabs and 3DMEDiTech ‘Design G’ 3D-printed swabs in the three different transport media’, they found.

‘In addition, SARS-CoV-2 was detected at all timepoints, across all swab/media combinations.’

The local production of swabs may solve supply problems globally, the researchers concluded.

‘The widespread availability of 3D-printing capacity may enable many countries to ensure ‘sovereign supply chains’ of swabs, and the scalability of the technology means that, depending on local capacity, thousands of swabs can be produced per day’, they wrote.

‘This may provide onshore manufacturing solutions to swab shortages in an unpredictable international market for both high- and low-income countries.’

Medical Journal of Australia

Detecting coronavirus in the environment

Professor Breadmore (centre) and PhD candidates Mostafa Adel Atia Abuzeid (right) and Pavan Kumar Chadalawada (left).

Researchers at the University of Tasmania, in partnership with GreyScan Pty Ltd, are using trace detection to develop a tool that rapidly and accurately detects coronavirus and other surface viruses in the environment. The project aims to provide proof-of-concept for the world's first mobile virus detection device, GreyScan's TVD-1, through laboratory research that will develop the chemistry needed to identify SARS-CoV-2 in the field.

This initial study is supported by $260 000 in co-funding from the CSIRO Innovation Connections Grant scheme and industry partner GreyScan Pty Ltd.

University of Tasmania ACROSS Director Professor Michael Breadmore FRACI CChem said the project expanded on the trace explosives detection technology invented by his team and commercialised, manufactured and deployed by GreyScan.

'Fifteen years ago, we were asked to rapidly detect explosives and reduce a 30-minute process to 30 seconds, to help make Australia and the world safer, which we were able to do with GreyScan', Breadmore said.

'We will use what we learnt about how to do chemistry exceptionally quickly and apply this to virus detection. Our research will develop a way to collect, analyse and detect viruses from surfaces within a few minutes.

'It is not possible to implement existing diagnostic approaches in a time that is suitable for rapid screening. Our approach is truly unique in the world and the diagnostic space.'

Studies have found that SARS-CoV-2 remains viable on some surfaces for many days, and asymptomatic carriers of the virus may continue to shed viral loads that can cause sickness in others.

There is significant need for environmental testing for COVID-19 to determine whether hospitals, schools, surfaces and personal protective equipment are clear of the virus. There are no current means to check how effective cleaning protocols are or to know whether the virus is present or not.

GreyScan CEO Samantha Ollerton said the research represented the first step towards developing the TVD-1, which could be used to detect the virus in airports, public transport systems and places of mass gatherings, as well as being deployed in the testing of people.

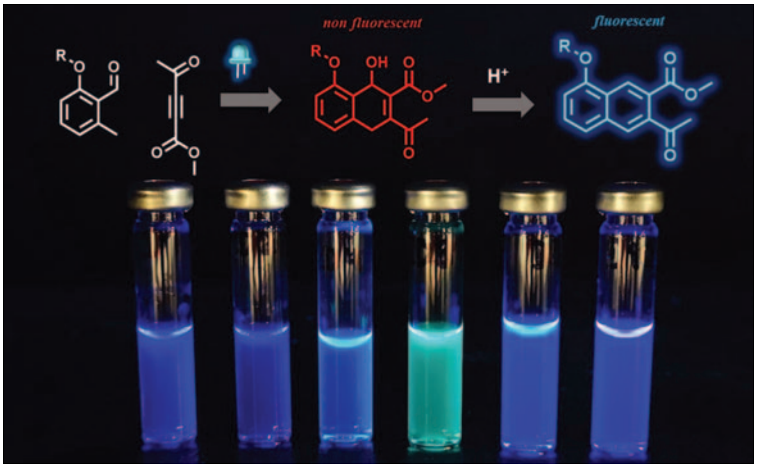
'The use of contact tracing and people testing will be augmented by the capability of the TVD-1, providing fast, accurate detection that can be used by anyone anywhere. This is a product for the future fight against this and any other viruses that we encounter in our lifetimes.'

Professor Anna King (Wicking Dementia Research and Education Centre, Tasmania), who is also part of the team, explained that biosensors played an important role by binding to and detecting viruses such as SARS-CoV-2.

'We will be developing multiple types of biosensors that can bind to the virus in different ways, as well as the systems that best allow us to detect even the smallest amounts of the virus.'

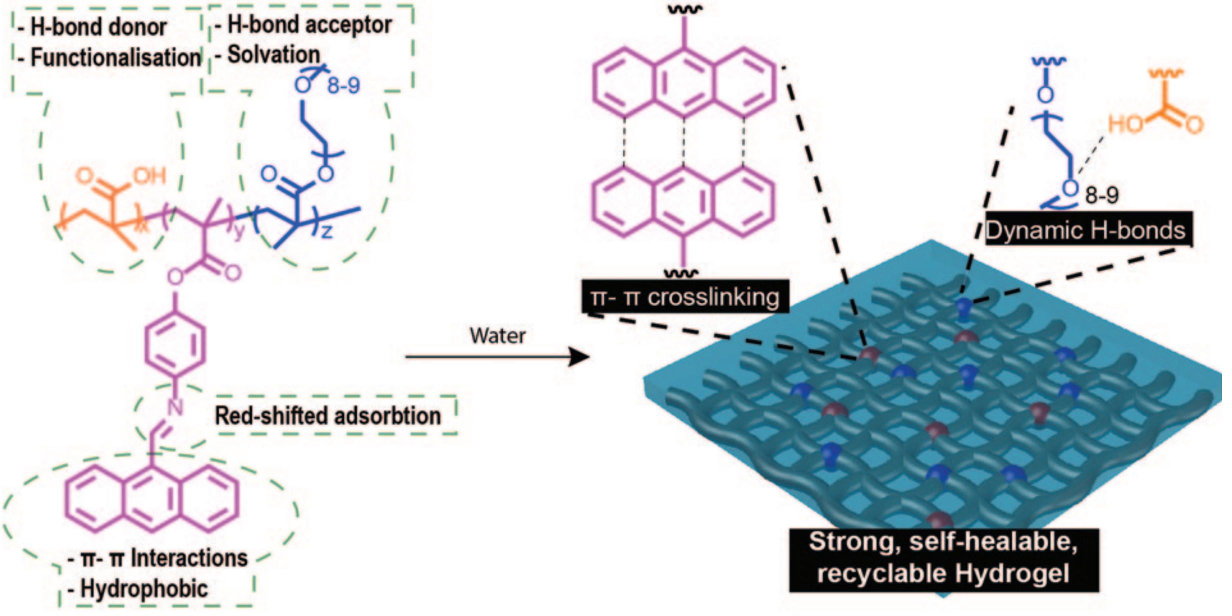
University of Tasmania

Acid-triggered fluorescent turn-on



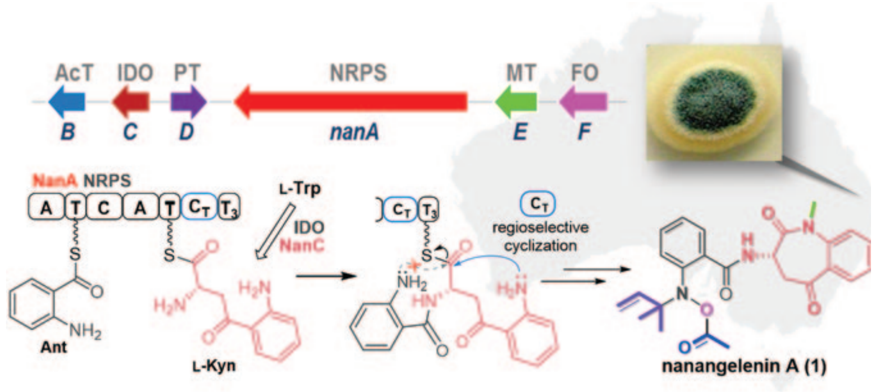
Fluorescent probes are a ubiquitous tool in imaging and sensing, providing the ability to preferentially target and image specific chemical environments in three dimensions. Photoreactions that directly result in a fluorescent product enable simple monitoring via a visual feedback, but have the drawback of competitive absorption by the fluorophore and potential photo bleaching. Queensland University of Technology's Soft Matter Materials Laboratory team have circumvented these drawbacks in a novel photoligation system with on-demand fluorescence turn-on (Feist F., Rodrigues L.L., Walden S.L., Krappitz T.W., Dargaville T.R., Weil T., Goldmann A.S., Blinco J.P., Barner-Kowollik C. *J. Am. Chem. Soc.* 2020, **142**, 7744–8). In this new system, non-fluorescent stable intermediates are formed from the light-induced ligation of *o*-quinodimethanes with electron-deficient alkynes. When desired, the intermediates can be quantitatively converted into highly fluorescent naphthalenes by E1 elimination. This approach uses the strong driving force of a non-fluorescent photoproduct towards aromatisation to form a stable fluorophore. In addition, the elimination reaction can be performed in an aqueous buffer solution at pH 4.2, which triggers the fluorescence turn on. The combination of spatiotemporal control and a highly efficient light-induced process with a gated fluorescence feedback offers great potential in surface functionalisation, particle synthesis, and biomedical and sensing applications.

Wonder gel



Interest in photoresponsive hydrogels has been growing recently due to their excellent biocompatibility and similar physiochemical properties to biological soft tissues. However, the photoresponsive hydrogels reported so far suffer from poor mechanical properties and cannot be recycled due to the presence of a covalent network. In response to such limitations, researchers at the Australian National University have proposed a supramolecular design strategy to demonstrate a new type of versatile photoresponsive hydrogel (Jiang Z., Li Tan M., Taheri M., Yan Q., Tsuzuki T., Gardiner M.G., Diggle B., Connal L.A. *Angew. Chem. Int. Ed.* 2020, **59**, 7049–56). The hydrogels were constructed by incorporating a benzyl imine-linked anthracene group into a hydrogen-bonded polymeric matrix. This enabled a doubly dynamic hydrogel held together by both hydrogen bonding and π–π interactions. This double cross-linked supramolecular hydrogel can be made by a versatile and scalable synthetic method and exhibits a unique combination of high-strength, rapid self-healing, and fast visible-light-driven shape changing in both wet and dry states. Furthermore, as all interactions are dynamic, the structures can be recycled and reprogrammed into different 3D objects.

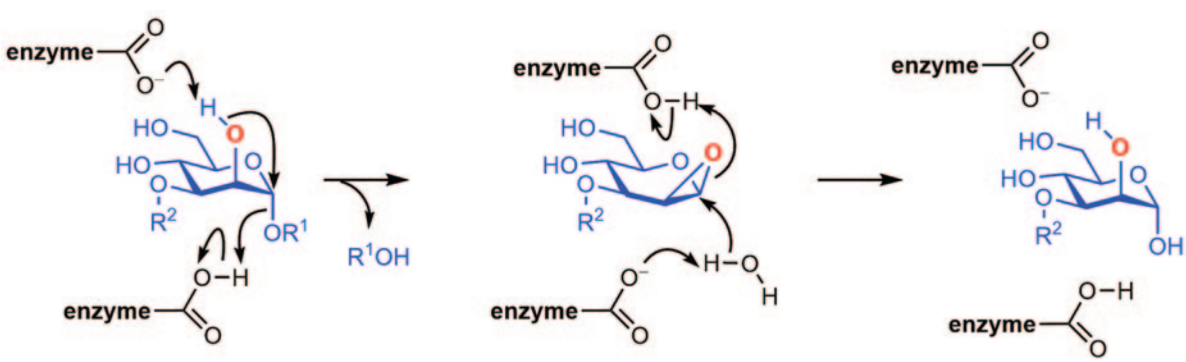
Australian fungus makes rare benzazepine alkaloids



The 1-benzazepine scaffold features in a number of clinically important drugs, including the ACE inhibitor benazepril, but it is very rarely observed in natural products. Recently, a group of researchers from the University of Western Australia, Macquarie University and Microbial Screening Technologies reported the discovery of a fascinating new 1-benzazepine-containing natural product, nanangelenin A, from a novel species of Australian fungus, *Aspergillus nanangensis* (Li H., Gilchrist C.L.M., Phan C.-S., Lacey H.J., Vuong D., Moggach S.A., Lacey E., Piggott A.M., Chooi Y.-H. *J. Am. Chem. Soc.* 2020, **142**, 7145–52). The team used genomic and retrobiosynthetic analyses followed by heterologous pathway reconstitution in *A. nidulans* to elucidate the detailed biosynthetic pathway to nanangelenin A. They showed that the unusual non-ribosomal peptide synthetase (NRPS) NanA incorporates anthranilic acid (Ant) and L-kynurenine (L-Kyn), which is supplied by a dedicated indoleamine-2,3-dioxygenase NanC encoded in the gene cluster. Using heterologous in vivo assays and mutagenesis, they confirmed that the C-terminal condensation (C_T) and thiolation (T_3) domains of NanA are responsible for the regioselective cyclisation of the tethered Ant-L-Kyn dipeptide to form the unusual benzazepine scaffold in nanangelenin A. They also showed that non-enzymatic cyclisation of a surrogate synthetic peptide (Ant-L-Kyn-*N*-acetylcysteamine) yielded the alternative kinetically favoured benzodiazepine scaffold.

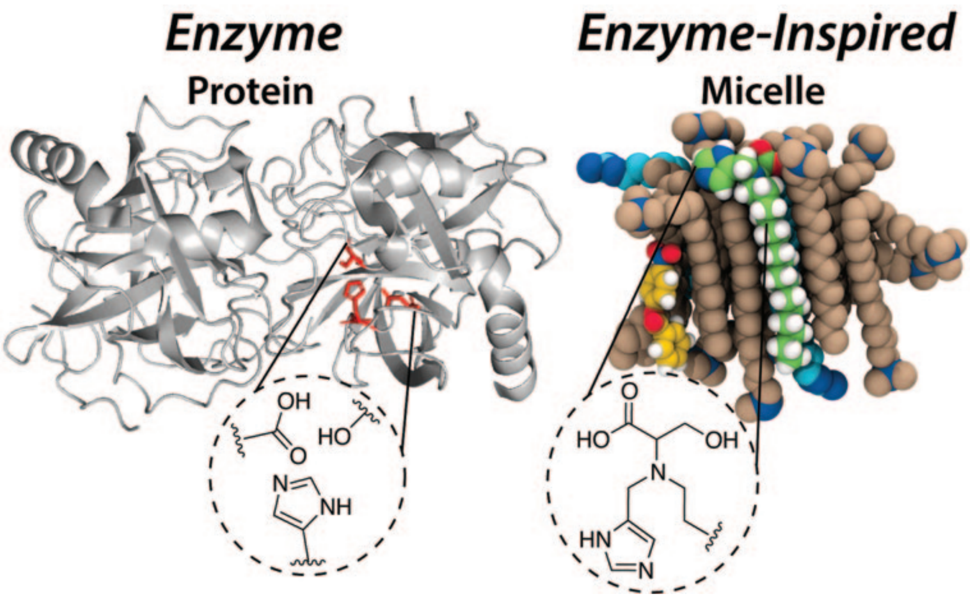
Spring-loaded intermediate in biological catalysis

Glycosidases are abundant enzymes in nature, with more than 1 million sequences described to date. Glycosidase-catalysed cleavage of a glycosidic linkage with retention of anomeric stereochemistry occurs through a two-step double-inversion mechanism that until now had been ascribed just two mechanisms, using either an enzymatic nucleophile via a covalent glycosyl enzyme intermediate or neighbouring-group participation by a substrate-borne 2-acetamido neighbouring group via an oxazoline intermediate. A third mechanism has now been reported for family GH99 enzymes by Spencer Williams (University of Melbourne) and colleagues from Spain, UK, France and Canada: neighbouring group participation by a mannose 2-hydroxyl via an epoxide intermediate (Sobala L.F., Speciale G., Zhu S., Raich L., Sannikova N., Thompson A.J., Hakki Z., Lu D., Shamsi Kazem Abadi S., Lewis A.R., Rojas-Cervellera V., Bernardo-Seisdedos G., Zhang Y., Millet O., Jiménez-Barbero J., Bennett A.J., Sollogoub M., Rovira C., Davies G.J., Williams S.J. *ACS Cent. Sci.* 2020, **6**, 760–70). Evidence for the mechanism includes reactivity of an epoxide mimic, quantum mechanics/molecular mechanics modelling of the reaction coordinate on the enzyme, and, most directly, kinetic isotope effects that directly implicate nucleophilic participation by the 2-hydroxyl.

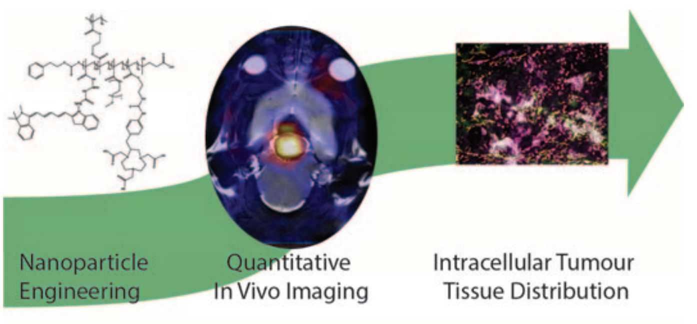


Enzyme-inspired self-assembling surfactant catalysts

Enzymes carry out their life-giving reactions by gathering together a remarkably intricate arrangement of functional groups. It is the precisely defined protein structure of enzymes that establishes these interactions. However, it is also this protein structure that makes enzymes susceptible to deactivation by heat, salts and organic solvents. This problem has sparked interest in the design of enzyme-inspired catalysts that collect complimentary functionalities without relying on delicate protein assemblies. A diverse team of researchers from the Australian National University and the University of Melbourne has recently developed a new, enzyme-inspired catalyst system that employs multi-functional surfactants to carry out catalysis (Nothling M.D., Xiao Z., Hill N.S., Blyth M.T., Bhaskaran A., Sani M., Espinosa-Gomez A., Ngov K., White J., Buscher T., Separovic F., O'Mara M.L., Coote M.L., Connal L.A. *Sci. Adv.* 2020, **6**, eaaz0404). Using the hydrolase enzyme family as inspiration, the team led by Luke Connal designed a series of surfactant molecules that each incorporates specific aspects of the enzyme's functional core. When added to water, the functional surfactants self-assemble into micelles, drawing the active headgroups into proximity and amplifying their reactivity for ester hydrolysis. Experimental and computational analysis reveals exceptional rate enhancements and a catalytic mechanism similar to that of the native enzymes. These findings could underpin the design of new organic catalysts for challenging reaction settings, including laundry detergents and biodiesel production.



Nanomedicines for brain cancer

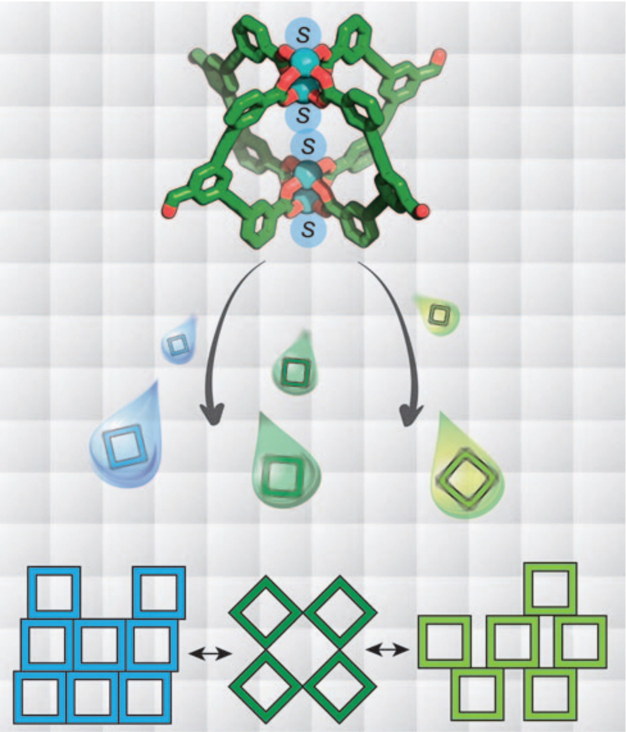


A key benefit of nanomedicines is their ability to be precisely tailored for specific applications, with their design informed by the individual biology of specific patients. However, functional flexibility often comes hand-in-hand with synthetic complexity, and the ability to understand the intricate interplay between synthetic materials and biology becomes increasingly important. Researchers at the University of Queensland in collaboration with scientists at CSIRO and the University of Melbourne have developed new methodologies to evaluate how nanomaterial design can significantly affect its interaction with the brain (Houston Z.H., Bunt J., Chen K.-S., Puttick S., Howard C.B., Fletcher N.L., Fuchs A.V., Cui J., Ju Y., Cowin G., Song X., Boyd A.W., Mahler S.M., Richards L.J., Caruso F., Thurecht K. *ACS Cent. Sci.* 2020, **6**, 727–38). One key factor that prevents successful treatment of brain cancers is the poor transport of therapies across the blood–brain barrier. Using simultaneous positron emission tomography/magnetic resonance imaging and coupling to complex models of brain cancer, the team was able to show that precisely engineered nanomedicines could effectively cross the blood–brain barrier and accumulate in tumour tissue. Importantly, the homogeneous distribution achieved throughout the tissue offers a glimpse into how to design better next-generation therapies, including where they might fit into a treatment regime for patients.

Shedding (vacuum ultraviolet) light on Jupiter's atmosphere

Chemical processing in the stratospheres of the gas-giant planets is driven by incident vacuum ultraviolet (VUV) light. Ethane (C_2H_6) is a critical participant in this atmospheric chemistry but, until recently, its VUV photochemistry had not been well established, largely because its longest wavelength absorption features occur at wavelengths shorter than those afforded by any commercial laser system. An international team led by Christopher Hansen at the University of New South Wales has employed the Dalian Coherent Light Source VUV free-electron laser in China and several state-of-the-art chemical dynamics techniques to shed light on the VUV photochemistry of ethane in the wavelength range of 112–126 nm (Chang Y., Yang J., Chen Z., Zhang Z., Yu Y., Li Q., He Z., Zhang W., Wu G., Ingle R.A., Bain M., Ashfold M.N.R., Yuan K., Yang X., Hansen C.S. *Chem. Sci.* 2020, **11**, 5089–97). Contributions from at least five primary photofragmentation pathways yielding CH_2, CH_3 and/or H atom products were identified and characterised, generating new photochemical knowledge that should help to rationalise hitherto unexplained aspects of the atmospheric ethane/acetylene ratios revealed by the Cassini–Huygens fly-by of Jupiter.

Playing cage-Tetris to generate switchable porous solids



Molecular solids based on cage compounds have recently emerged as an attractive class of porous materials, owing to their solution processability and intrinsic porosity. However, the Aristotelian postulate 'nature abhors a vacuum' holds true for these materials, in that crystallisation or 'cage-Tetris' often leads to crystal packings that do not retain porosity in their solvent-free form. Now, researchers at the University of Adelaide have clarified how solvent determines solid-state integrity and overall porosity in cage compounds through energy-landscape calculations and adsorption analyses of several solvatomorphic solids of a particular metal–organic cage (Bloch W.M., Babarao R., Schneider M.L. *Chem. Sci.* 2020, **11**, 3664–71). They found that the structural flexibility of these materials can be correlated with their lattice energy and, furthermore, that certain solvatomorphs can undergo on/off porosity switching in response to solvent guests. In addition, the researchers showed that covalent extensions of the cage architecture facilitate control over the crystal packing of the resulting cage solid. This systematic study highlights the solvent dependence and synthetic versatility of molecular cages in the generation of solution-processable porous solids.

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.

Understanding diversity in learners

At the University of New England, more than half of our chemistry students study online. Students can be located anywhere in the world, and our demographic includes a high proportion of low socioeconomic, Indigenous, remote, rural, mature age and 'first in family' students. Our online students typically work full time and have family responsibilities. For most of them, studying online is the only opportunity they have to participate in tertiary education. As a provider of online education, we are very experienced in supporting student learning in this mode, and we were more than ready for the COVID-19 crisis and the 'pivot' to online learning.

Our biggest challenge was probably our typical on-campus student. These students are primarily school leavers living at the university, in college. Their experience and interest in studying online is limited and they are hesitant to engage this way. Teaching staff also believe that online learning for this demographic is generally not a good idea. However, since lectures and labs were cancelled and on-campus students were sent home, our on-campus first year chemistry cohort has had a dramatic increase (approximately 1200%) in interaction within the online discussion forums. Enrolment and achievement so far are comparable with last year's cohort.

What is this telling us? First, that these students were forced online for learning support, but that the support was there and they have adjusted. More importantly, I think this highlights that if student needs are met, they can succeed. To me this emphasises how important it is to acknowledge and understand diversity in learners.

Every student is completely unique, the result of a complex set of factors and influences affecting them since birth. We are seeing that online remote learning has challenged many students, in good and bad ways. Some have realised that this a great option for them; some have run screaming. For me, what this crisis has cemented in my mind is that the uniqueness of learners needs to be built into our education system from the ground up, and tertiary education is no exception. It is easy to teach university students who are capable, interested and resilient. They will succeed with or without us, and believing ourselves to be effective educators when our able and motivated students do well will not help to improve outcomes for other students. All too often, our judgement of how a discipline should be taught and how a student should present is based on our own inherent interest and abilities. However, our teaching and learning strategies need to be based on the actual abilities and backgrounds of our students. This is intimately connected to empathy. The average academic was a successful and highly motivated student. Relating to students with low self-efficacy (which I believe is the cause of most negative study behaviours) is difficult.

We need to re-evaluate not only what we teach, but who we teach and why we teach. We should keep the bar high, but we need to help all of our students reach the bar.

When students with low self-efficacy, capacity and interest (and, boy, does that happen often in chemistry) are inspired and succeed, then we can pat ourselves on the back. We need to re-evaluate not only what we teach, but who we teach and why we teach. We should keep the bar high, but we need to help all of our students reach the bar. Our students do not start on a level playing field but I think that, without realising it, we teach as though they do. We have all been shifted out of our comfort zones and my hope is that as educators, we will develop greater empathy and understanding of the challenges many of our students face. I say that, instead of assuming the worst, it is time expect the best.

Erica Smith is a senior lecturer in the Faculty of Science, Agriculture, Business and Law; School of Science and Technology at the University of New England.

Rethinking online chemistry teaching

When it comes to teaching and learning, I have always been a creature of change. I have significant problems just leaving things as they are as I can't help but wonder what it would look like done a different way. With this in mind, you might be tempted to believe that the recent COVID-19 crisis and the sudden shift to online learning would be something that I might even enjoy. You would be wrong! However, from the utter chaos that has been 2020, some hard-won lessons have been learned about several traditional teaching modes at the University of Sydney.

Rethinking the tutorial tasks became even more critical when we discovered that our exams would now all be open-book and online, as it meant that our questions required higher-order language ...

Lectures

Like many institutions in the last few decades, the University of Sydney uses a large number of active learning opportunities (through in-class worksheets) in our lectures. As such, before COVID-19, we had become somewhat used to a high level of active participation during lecture timeslots. I, for one, miss this terribly. However, this has also provided a golden opportunity to ask why we teach what we do. Is that content essential? Does that slide actually add anything? Do I cover this learning outcome adequately? I can't speak for anyone else, but I've turned into a highly precise surgeon/butcher of late, and I've had little mercy.

Tutorials

Before the COVID-19 crisis spread outside of China, institutions with high numbers of international student were already trying to assist students stuck overseas by the Australian travel bans. During this time, I was tasked with supporting the transition of all of our first-year tutorials online. My response was pretty much to buy every iPad in Sydney and to quickly teach everyone who stood still for more than 20 seconds how to use Zoom. The online transition of the tutorials also provided a great time to rethink the questions being used. Rethinking the tutorial tasks became even more critical when we discovered that our exams would now all be open-book and online, as it meant that our questions required higher-order language (e.g. explain, discuss, justify). Beautifully, this need to better prepare students for these higher-order questions gave me an excellent excuse to start jettisoning old algorithmic tutorial questions for those that required students to think and hold arguments. The horror!

Laboratories

Anyone who has heard me speak knows that I firmly believe that the only point of labs is to develop skills (both technical and transferable). Nothing quite drives that home, like trying to create online quizzes using technique simulations in an attempt to 'teach' practical skills. I have never been surer that you can't replace these vital activities because there is just no suitable replacement. The laboratories indeed are the differentiating aspect of our wonderful field, and this entire crisis has driven that even further home for me.

Overall, it's easy to get stuck into the spiral of mourning this year. But I would advocate using this chance to finally break away from some nasty habits that have settled in over the years. I'm not saying we change everything tomorrow, but I'll be damned if this pandemic hasn't placed a whole new list of targets for future me to gleefully attack in the future. Viva la revolución!

Stephen George-Williams MRACI CChem is a lecturer (Chemistry, Education Focused) at the University of Sydney.

Reyne Pullen MRACI CChem (reyne.pullen@sydney.edu.au) is currently working as an education-focused lecturer at the University of Sydney, where he is teaching into first- and second-year chemistry units and conducting chemistry education research in his classroom. He has previously undertaken chemistry education research at the University of New South Wales, Monash University and the University of Tasmania, and participated in various science communication and outreach activities in Tasmania.

iStockphoto/imaginima

Growth of chemistry research in Asia, 1980–2020

Since the inception of the Federation of Asian Chemical Societies 40 years ago, the Asian region has become the epicentre of chemistry, say Tom Spurling and John Webb.

We were among the 2500 chemists from all around the world who gathered in Taipei last December to celebrate the 40th anniversary of the Federation of Asian Chemical Societies. We attended the 20th General Assembly of the Federation and then the 18th Asian Chemical Congress (AsiaChem). The high quality of the chemistry being presented at the Congress caused us to reflect on the extraordinary progress we have been part of over the last 40 years.

Neither of us was present at the Federation's inaugural meeting in Thailand in 1979, but we have been active in the Federation since the 1980s (John Webb as a project director and Tom Spurling as president from 1989 to 1991).

In the late 1970s and early 1980s, despite having more than 50% of the world's population, the Asian region contributed only 19% of the chemistry papers in the Web of Science database. Only three countries from the Asian region, Japan (12.7%), India (4.8%) and Australia (1.7%), contributed more than 1% to the world output.

At that time, UNESCO and many national aid agencies were very conscious of the important role that the application of chemistry had in developing the social, economic and environmental wellbeing of nations. As we noted in our presentation at last year's Timor-Leste Studies Association Research Conference, in 2015 the United Nations General Assembly Resolution 70/1 set 17 Sustainable Development Goals for 2030, and at

least eight of these goals require chemistry capability for their achievement.

It was during the 1970s that the Chemistry section in UNESCO was expanding from its school science origins to include higher education and research. It was fortunate for our region that the person in the UNESCO Headquarters in Paris responsible for this development was Dr John Kingston, an Irish-born chemist with degrees from Trinity College, Dublin, and the University of New South Wales, Sydney.

Research and training were the central themes of the program with an emphasis on capacity building and the development of endogenous capabilities. UNESCO provided small grants for activities such as workshops and training courses as well as contacts in the region. Projects were to be local and the benefits of that research were to be locally based. To achieve this, Kingston mobilised chemists in other countries as collaborators (M. Mohinder Singh, *FACS Newsletter* 1988, No. 1, pp. 3–7).

His Australian experience led him to readily engage chemists in many countries in establishing and delivering programs through regional networks. The first such network, established in 1974, was the regional network for the chemistry of natural products in South East Asia. This research theme was an inspired choice, since the chemistry of extracts from plant species peculiar to a country's biodiversity provided unique opportunities for local chemists to select and control their research.

Over time, the regional network approach was extended to other regions such as South Asia and other areas of chemistry such as inorganic and analytical chemistry and, in time, training courses for instrumentation.

The success of the network approach prompted the UNESCO Division of Scientific Education and Research to propose, in 1978, that a Federation of Asian Chemical Societies be established. The model was the already established Federation of European Chemical Societies, widely seen as being valuable in the construction of the post-World War II scientific environment within Europe. UNESCO thought of Asia as all those parts of the world that weren't Europe, Africa or the Americas! This definition included countries from Iran to New Zealand and from Australia to Japan. An information notice was sent to the national chemical societies of the region in February 1978 asking them to prepare to present their ideas at a meeting to be arranged later in the year. By October 1978, UNESCO had responses from Australia, Hong Kong, Indonesia, India, Iraq, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, Sri Lanka and Thailand. UNESCO arranged for a working group meeting to be held in Bangkok in December 1978, and working group members at this meeting agreed on draft statutes to be presented at an inaugural function in August 1979 at Mahidol University, Bangkok. A glittering ceremony, attended by Her Royal Highness Princess Chulabhorn of Thailand and other dignitaries, opened the inaugural meeting.

The following 11 societies agreed to be founding members of the Federation of Asian Chemical Societies: Royal Australian Chemical Institute, Hong Kong Chemical Society, Indian Chemical Society, Iraqi Chemical Society, Korean Chemical Society, Malaysian Chemical Society, Integrated Chemists of the Philippines, Institute of Chemistry Ceylon, Singapore National Institute of Chemistry, Indonesian Chemical Society and the Chemistry Section, Science Society of Thailand (replaced by the Chemical Society of Thailand in 1981). Of the missing two of the original 13 respondents to the UNESCO invitation, the Chemical Society of Japan and the New Zealand Institute of Chemistry joined the Federation in 1981.

The objectives of the Federation have evolved over the years and in 2019 the general objective was put succinctly as being:

> *… to promote the advancement and appreciation of chemistry and the interests of professional chemists in the Asia Pacific.*

The FACS website listed 31 member societies in late 2019, with member societies covering most of east and south-east Asia but fewer across west Asia. The chemical societies of central Asia as well as Iran are not yet members of FACS. Some of the listed member societies, such as those from Iraq and Mongolia, are mostly inactive in FACS matters. There is clearly some way to go to achieve a fully inclusive FACS that extends across Asia.

An examination of the table above, showing the situation in 1980, indicates that in these early days there was considerable scope for the 'advancement of chemistry'. Many member society countries accounted for less than 0.1% of the global

Chemistry research publications (as percentage of global research publications) of FACS member countries, 1980

Country	Percentage	Country	Percentage
Australia	1.7	Nepal	<0.1
Bangladesh	0.1	New Zealand	0.3
Mainland China	0.1	Philippines	<0.1
Hong Kong	0.1	Singapore	<0.1
India	4.8	South Korea	<0.1
Indonesia	<0.1	Sri Lanka	<0.1
Iraq	0.1	Taiwan	0.13
Japan	12.7	Thailand	<0.1
Malaysia	0.1		

Data from clarivate.com/products/web-of-science.

Chemistry research publications (as percentage of global research publications) of FACS member countries, 2018

Country	Percentage	Country	Percentage
Australia	2.1	New Zealand	0.2
Bangladesh	0.1	Philippines	<0.1
China Mainland	32.9	Singapore	0.9
Hong Kong	0.7	South Korea	4.0
India	7.0	Sri Lanka	<0.1
Indonesia	0.1	Taiwan	1.4
Iraq	0.1	Thailand	0.5
Japan	5.7	Turkey	1.2
Malaysia	0.7	Vietnam	0.3
Nepal	<0.1		

Data from clarivate.com/products/web-of-science.

Impact measure (category normalised) of chemistry papers from selected countries, 2018

Country	Citation impact
China	1.28
USA	1.26
Germany	1.1
India	0.85
UK	1.17
Japan	0.8
South Korea	0.97
Australia	1.26
Taiwan	0.87
Singapore	1.89

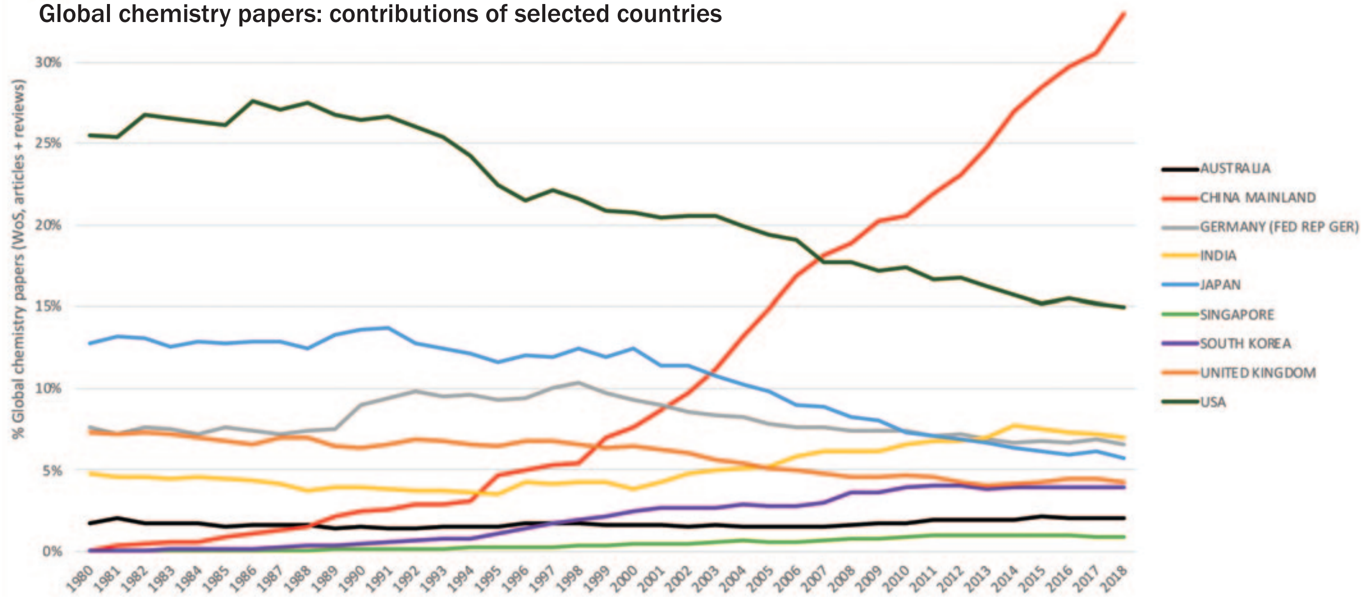
production of research papers in the chemical sciences. But much was to change.

During the past 40 years, the economies of many, but not all, countries in Asia have grown strongly. When FACS commenced in 1980, only Japan and Australia were in the top 20 economies of the world. In 2018, China, Japan, India, Korea, Australia, Indonesia and Turkey were all in the top 20 countries by nominal GDP with Taiwan just outside the top 20 economies (data.worldbank.org/indicator/NY.GDP.MKTP.KD).

While we can all marvel at the extraordinary economic growth in our region in the past 40 years, we should not forget that some of the countries represented in our Federation have not yet participated in this growth. These are Cambodia and Timor-Leste, who are members of FACS, and Bhutan, Myanmar and Lao PDR.

As noted earlier, in 1980 the region covered by the Federation contributed only 19% of the world's output of chemistry papers. The situation in 2019 is quite different from that of 40 years ago. Our region now produces about 56% of the world output. Curiously, this is about the same as the percentage of the world who live in this region! The global scientific output in chemistry has continued to grow across this period but the contributing countries have changed appreciably. Some key examples are shown in the graph: in 2018, China contributed close to 35% of world chemistry literature in the database; the US has dropped to about 15%. Such data is sometimes contested in terms of the relative importance of these publications. Citation data, however, confirms that much of the chemistry research literature from Asia is well cited. The final table lists the Category Normalized Citation Impact (CNCI) for the chemistry papers from selected countries. The CNCI of a document is calculated by dividing the actual count of citing items by the expected citation rate for documents with the same document type, year of publication and subject area.

Global chemistry papers: contributions of selected countries



In the 40 years of the Federation's life, our region has become the epicentre of world chemistry! In this new global configuration of chemistry, the Federation has a unique opportunity. This has some implications for the program of FACS.

In this new global chemical milieu, the Federation has to cater for the needs of the high-performing countries. This means:

- conferences such as AsiaChem
- attracting more IUPAC specialist conferences to our countries
- promoting one or more high-impact journals.
- considering sponsoring its own specialist conferences.

The Federation also needs to foster chemistry in the countries that have not yet reached their potential. Here, we refer to countries in the Federation, such as Cambodia, Mongolia, Papua New Guinea and Timor-Leste, as well as those not yet in the Federation. We have noted above the skewed geographic distribution of member countries and recognise the need to consider expanding the Federation to include other potential member countries within Asia, such as Iran, Uzbekistan, Kazakhstan, Myanmar, Bhutan and Laos.

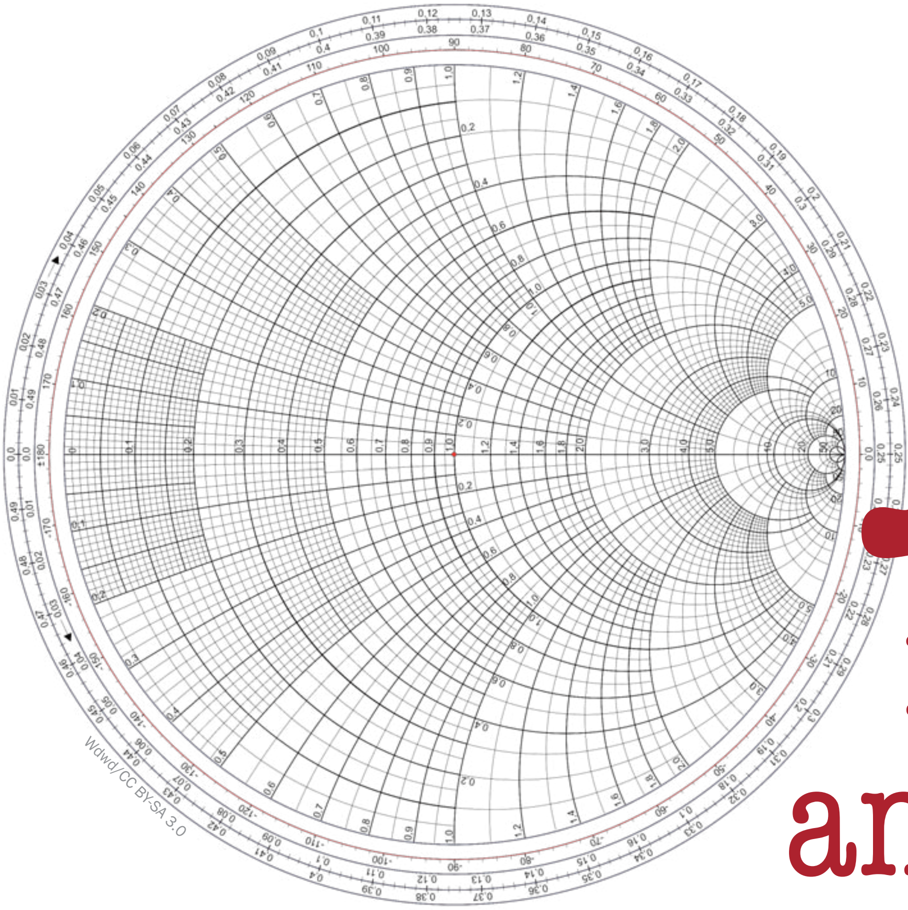
Finally, we recall the important role of the Federation in stimulating regional cooperation to assist countries to develop their capacity in chemistry and chemical education. The chemical society of the newest country in Asia, Timor-Leste, became a member of the Federation at the Taipei meeting. We are familiar with the situation regarding chemical education and chemical research in Timor-Leste. The secondary school system has a modern curriculum based on the Portuguese curriculum but the schools (both public and private) lack even the most basic laboratory facilities and equipment. The same is true of the only public university in Timor-Leste, the National University of Timor-Leste in Dili.


The chemical society of the newest country in Asia, Timor-Leste, became a member of the Federation at the Taipei meeting.

The National University of Timor-Leste in Dili opened for classes in late 2000. Faculties include Exact Sciences; Engineering, Science and Technology; and Medicine and Health Sciences.

We should remember that in the 1970s and 1980s, various countries' aid programs contributed significantly to the building of chemical capacity in the region. The National University of Timor-Leste urgently needs a general-purpose science laboratory with equipment to enable them to teach chemistry, physics and biology. Can FACS be an agent to develop an aid program to achieve this?

Thomas H. Spurling FRACI CChem and **John M. Webb** FRACI CChem are at the Centre for Transformative Innovation, Swinburne University of Technology. They thank Adam Finch for assistance with the bibliographic data.



A is for analogue

From slide rules to crime scene analysis, the nomogram has served as a trusty tool.

BY **BEN SELINGER**

Metaphor is important in science. We need a picture in our mind, for ourselves and so we can share it with others. We need a picture even when there can be no true picture, as for atoms and in quantum mechanics. Our brains are analogue processors. We might believe the result of a complex digital calculation but we can't visualise the answer, except as analogue. The very basic idea of analogue is to model a complex situation so as to be able to analyse it.

The icon of analogues is the slide rule. Numbers are replaced by lengths and the scales are compressed by logarithms. As chemistry students, we slung slide rules in our pockets as student doctors hung stethoscopes around their necks.

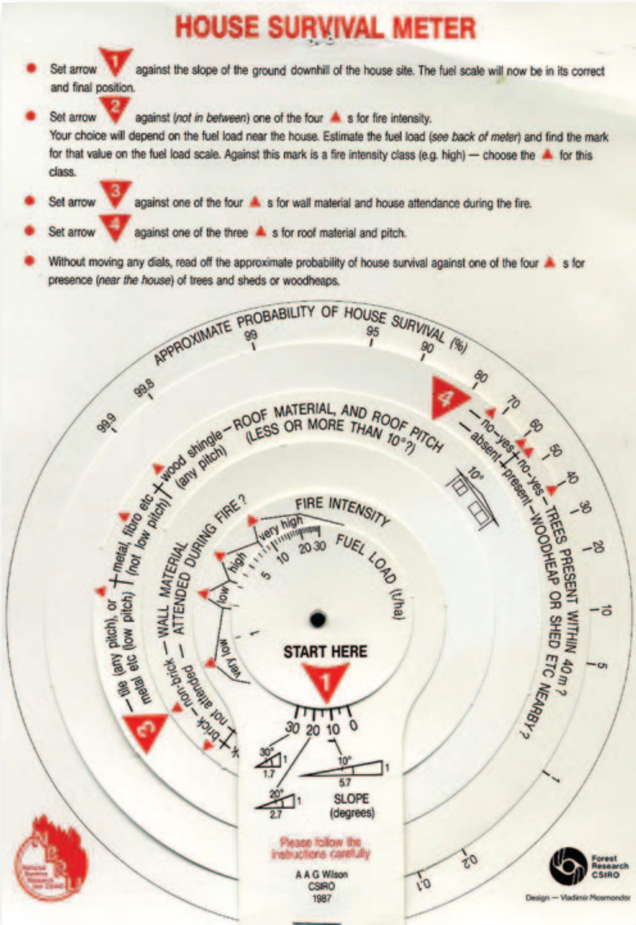
Logarithmic compression is a fact of life, not just a handy invention. All our biological sensors are logarithmic. Hearing (decibels), light (lux), intensity of spices (scovilles). How else could our senses encompass magnitudes ranging a millionfold?

Our response to drugs has the dose plotted logarithmically (LD_{50}). We also compress our manufactured sensors – think earthquakes (Richter scale) and acidity (pH). Even economists do it logarithmically (marginal utility).

Curta slide rule

In 1947 came an upmarket slide rule, the Curta, invented by Austrian Curt Herzstark. This cylindrical mechanical calculator had a beautiful form and has a fascinating history. It looked something like a wide coffee or pepper grinder that fitted neatly into the palm of one hand. There was only a single Curta at Sydney University Chemistry in the late 1950s. We touched it with awe. The Curta survived until the early 1970s because of a precision of 11 or 15 significant digits, only then matched electronically.

While the slide rule was a general-purpose device, dedicated graphical



A 1987 ‘house survival meter’ for bushfire.

The Curta type II (manufactured from 1954 until about 1970).
Rick Furr (www.vcalc.net)

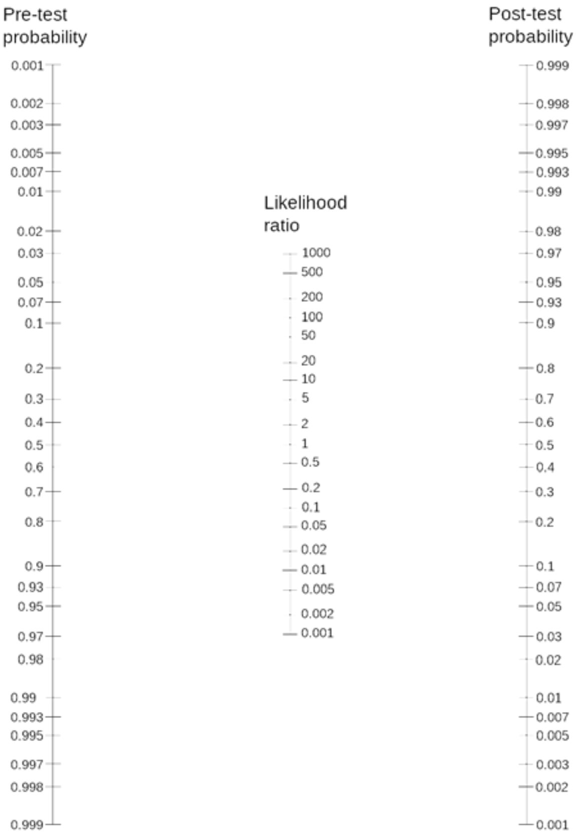
analogue devices were developed for specific complex situations. One from CSIRO in the 1980s allowed calculation of the risk to a house from bushfire. Another, from my work with vacuum pump systems, provided (inter alia) the distance moved by a gas molecule before colliding with another as dependent on the degree of vacuum obtained by a pump – essential for studying radiationless electronic energy decay.

Some, like that from the erstwhile Commercial Banking Co of Sydney (now NAB), were very simple converters. Long before unit pricing, they allowed various package sizes to be compared for price.

My Jeppesen slide graphic computer for aircraft navigation was a present from an engineering friend. Even in today’s digital world, the aircraft data presentation is analogue. Doomed Dreamliner pilots might well have wished they had one.

I was overjoyed to receive my first (teaching) analogue electronic computer (differential analyser) at ANU. Instead of converting numbers into lengths on a ruler (as per slide rule), this machine converted numbers into voltages. At its heart was an electronic chip for very high gain amplifiers. By providing feedback from the output to the input via resistors or capacitors, the chip would either add voltages or integrate them. By connecting the chips via a spaghetti of wires, any differential equation (algebraically solvable or not) could be simulated and the result displayed. The early nuclear reactors were modelled this way, but our applications were more benign, mainly chemical (and biological – Michaelis–Menten) kinetics and quantum mechanics (finding eigenfunctions for a particle in a box that could be changed smoothly from rectangular to parabolic and then place a bump in the middle (e.g. ammonia)).

The icon of analogues is the slide rule. Numbers are replaced by lengths and the scales are compressed by logarithms.



A nomogram for determining relationships between pre- and post-test probabilities and likelihood ratio. Mikael Häggström/CC BY-SA 3.0

The very basic idea of analogue is to model a complex situation so as to be able to analyse it.

Probes, photons and Poisson

I met my first nomogram on a page from a book my father had enlarged and copied over and over again for his student lectures on production engineering quality control at Sydney Technical College (now University of NSW). He gave me the book, saying, 'In stats, you know, it's the future'. The nomogram was a Poisson distribution.

As it turned out, this distribution was to lead to an experiment that halved the time I needed for my doctorate in Stuttgart, Germany (Poisson distribution of fluorescent probes in soap micelles – invisible microspheres of soap molecules suspended in water, in 1964). The second was in an entirely different application, whereby I was analysing and fitting single photon fluorescent decay data in my research at Minneapolis, USA (in 1969), assuming the same Poisson statistics.

Most dramatically, when I met my future wife at Prince Henry Hospital, she was doing a blood count, counting red blood corpuscles in diluted blood under a microscope with a Coulter counter. The counter was a microscope slide with a rectangular grid in which the blood cells were distributed in number per square, in exactly the same way as fluorescent probes were distributed in number in (invisible) soap micelles.

Testing probabilities

A currently popular nomogram is based on Bayes theorem. This nomogram has three scales arranged so that if you know the values of two of the variables, you can obtain the value of a third (on its scale) by running a straight line between the two known points to intercept the third scale. A search on Google for 'nomogram' brings up mostly medical diagnostic and surgical option optimising uses (e.g. www.barbecuejoe.com/scan.htm).

Nomograms for mammograms

Consider a woman in her 40s or 50s with no family history of breast cancer. Women in this group have a probability of having breast cancer of 0.8%. If a woman from that cohort really has breast cancer, the probability is 90% that she will have a positive mammogram. If a woman does not have breast cancer, the probability is 7% that she will have a positive mammogram.

Now, one of the women in this cohort has a positive mammogram; what is the probability that she has breast cancer? An international survey of doctors gave answers ranging virtually across the whole percentage range. (Answer at the end of the article!)

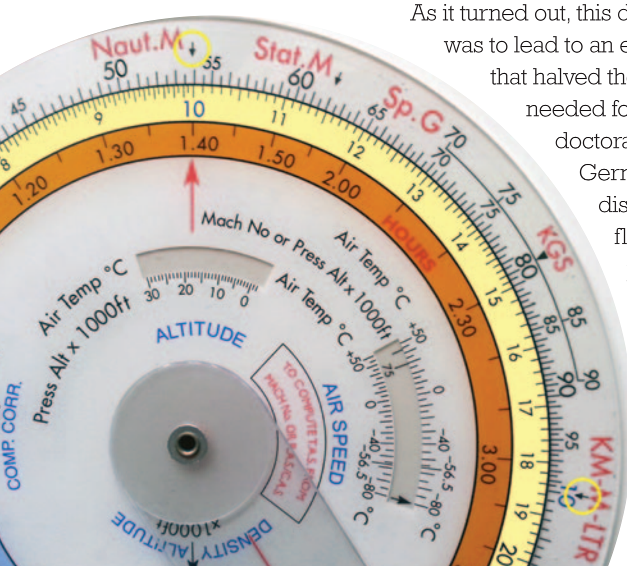
The nomogram exposes the error of emphasising the test performance while ignoring the population base and prevalence of disease.

Nomograms for COVID-19 testing regimes are now appearing (e.g. Watson J., Whiting P.F., Brush J.E. *BMJ* 2020, doi: 10.1136/bmj.m1808).

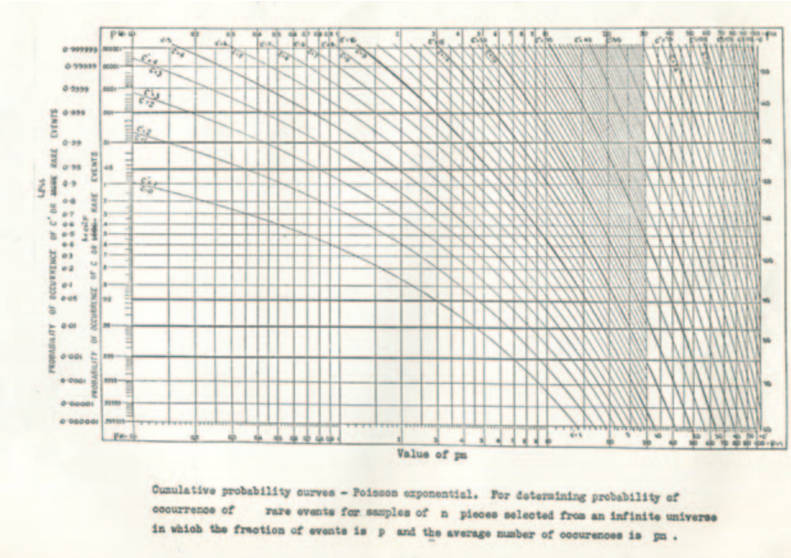
Crime scene investigation

Forensic scientists have been testing and arguing about the value of this Bayesian approach on crime scene investigations. With DNA identification, the odds ratios are so high, it is with incidental failure/perversion of process where any error will lie.

However, in virtually all other non-DNA evidence situations the questions are again:



Analogue slide graphic computers are still used as flight training products. Abuk SABUK/CC BY-SA 3.0



Poisson paper – not for wrapping fish and French fries. It shows the probability that an event will occur at least a certain number of times for particular numbers of occurrences. Herbert Selinger

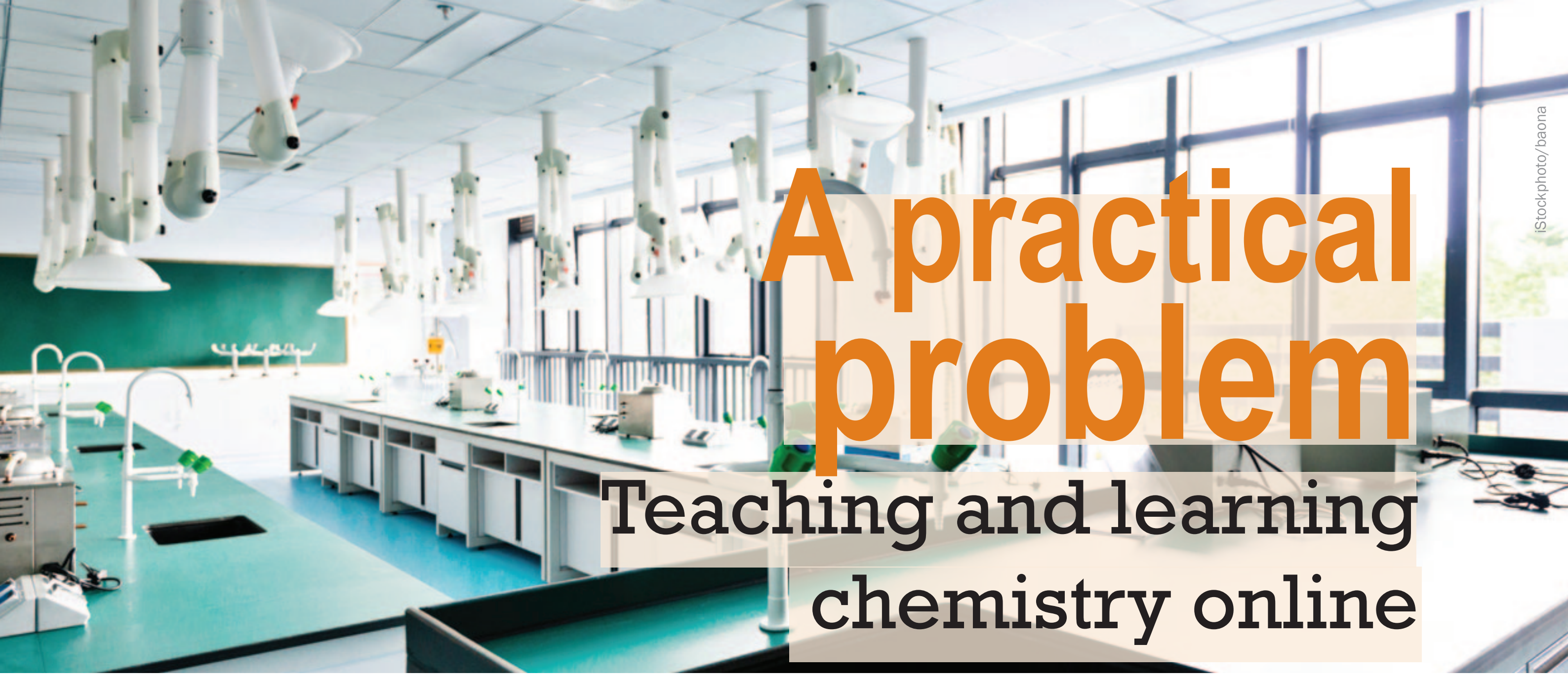
- What did we know before? (How many possible suspects? Which database of broken glass samples is appropriate?)
- How good is our test/investigation (likelihood ratio)?
- And what do we know after the investigation? (How far have we narrowed down the suspect list? Is that glass sample unique enough?)

Unlike doctors, the judges and jury in the courtroom are not experts in judging the quality of the argument, but rely on expert witnesses assessing their own evidence. This is a situation with which they are never very happy. Being allowed to play with a ruler crossing three columns with numbers is unlikely to compensate.

Ben Selinger FRACI CChem is Emeritus Professor of Chemistry at ANU and, along with ANU colleague Associate Professor Russell Barrow, released the sixth edition of *Chemistry in the marketplace* (CSIRO Publishing) in June 2017. To convert from a probability to an odds ratio, divide the probability by 1 minus that probability. So if the probability is 90% or 0.90, then the odds ratio is 0.9/0.1 or 9 to 1. Answer: 9%.

Further reading

Fagan T.J., 'Letter: Nomogram for Bayes theorem', *N. Engl. J. Med.* 1975, vol. 293, p. 275.
Glasziou P., 'Which method for bedside Bayes?', *EBM Notebook* Nov/Dec 2001, vol. 6, p. 164.
Decks J.J. and Altman D.J., 'Diagnostic tests 4: likelihood ratios', *BMJ* 17 July 2004, vol. 329, pp. 168–9.
Bianchi M.T. and Alexander B.M., 'Evidence based diagnosis: does the language reflect the theory?', *BMJ* 26 August 2006, vol. 333, p. 442.
Strogatz S., 'Chances are', *New York Times*, 25 April 2010.
Moroney M.J., *Facts from figures*, Penguin Books, 3rd edn, 1956.



iStockphoto/baona

A practical problem

Teaching and learning chemistry online

BY **MADELEINE SCHULTZ**, **ANDREW ALLSEBROOK**, **MAGDA WAJRAK** AND **SEAMUS DELANEY**

Practical activities have been one of the most difficult challenges for science teaching and learning during the COVID-19 crisis. Four secondary and tertiary chemistry educators share their approaches here.

Quality teaching involves active, interactive classes; for example, through the use of in-class response systems. Despite the disruptions of COVID-19, in-class polling has been continued by many teachers through online interfaces; this has been supplemented with live chat functions to replace face-to-face interactions. Both secondary and tertiary teachers are running live tutorials and seminars, using screen-sharing applications with integrated polling and quizzes. The following replacements for hands-on practical activities have been adopted as part of remote teaching by both secondary and tertiary teachers in Australia in recent months.

- Students view **video recordings of experiments** in which they see data being collected. On the basis of the videos, they write observations, complete data analysis and write a report. This has been the most popular emergency response to moving practicals online. Videos were made in the last few days before laboratory closure by teachers, technical and academic staff, demonstrators and others; in some cases, videos had already been made. The length of these videos varies from 10 seconds for critical concepts to 25 minutes for a whole experiment.
- **Simulations** (e.g. free offerings from PhET Interactive Simulations, the Royal Society of Chemistry or commercial packages) are integrated with structured worksheets to form an assessment task. In many cases, these were already being used as formative assessment tasks.
- **Activities at home** can replace introductory practicals that emphasise observation and record keeping. This can involve performing 'kitchen chemistry' tasks with household items to allow a hands-on experience, or making observations based on a video or other resource, with the option for student choice. The structure of the assessment task must be carefully designed to support skills for later experiments, including drawing flow diagrams, evaluating risks, recording observations and interpreting observations in terms of molecular level explanations.
- Certain chemistry experiments (such as crystallography, molecular modelling and NMR predictions) can be run as **live, online practicals** with staff explaining while students operate the software.

For all of these delivery modalities, demonstrators or teachers are typically available to answer student questions. When students are required to complete identical online tasks, issues of collusion and cheating arise; however, face-to-face practicals are also susceptible to this.

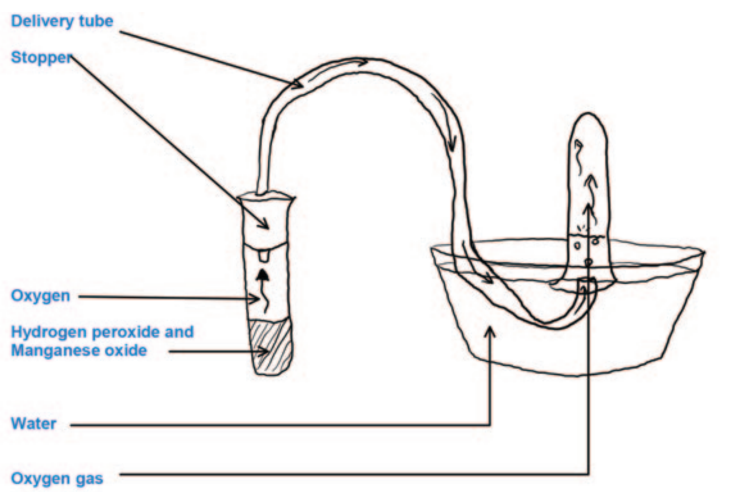
Approaches in tertiary education

The tertiary context involves large classes (especially at first year) with more than 1000 students in many cases, so solutions must be scalable. Tertiary learning traditionally involves lectures in large groups, which are no longer possible. Institutions have adopted either synchronous online sessions, in order to retain a normal timetable and allow live interaction, or asynchronous recordings to allow maximum flexibility. All universities already recorded lectures so this option is still available to students in any case.

Academic staff were very concerned that students would find it challenging to learn chemistry without the laboratory, which is the best learning environment for chemistry (https://doi.org/10.1021/acs.jchemed.9b00764). We all wanted to maintain a rich learning environment online, but our assessment structures include marks for practicals so these needed to be replaced. Two examples where the existing structure was already blended are detailed below; one opted for a live, timetabled experience while the other chose an asynchronous solution.

At Edith Cowan University, the transition to an online environment commenced in 2018 with the implementation of electronic lab notebooks. For 2020, we ran Virtual Live Lab Classes almost exactly like our face-to-face sessions, using Teams Meetings and OneNote. Video recordings of the experiments were provided. Demonstrators checked attendance, monitored students' work live online and commented directly within students' lab reports during the sessions. They could communicate either with all students in the particular 'bench' or with individual students. Students could ask questions while completing their lab reports (see example below).

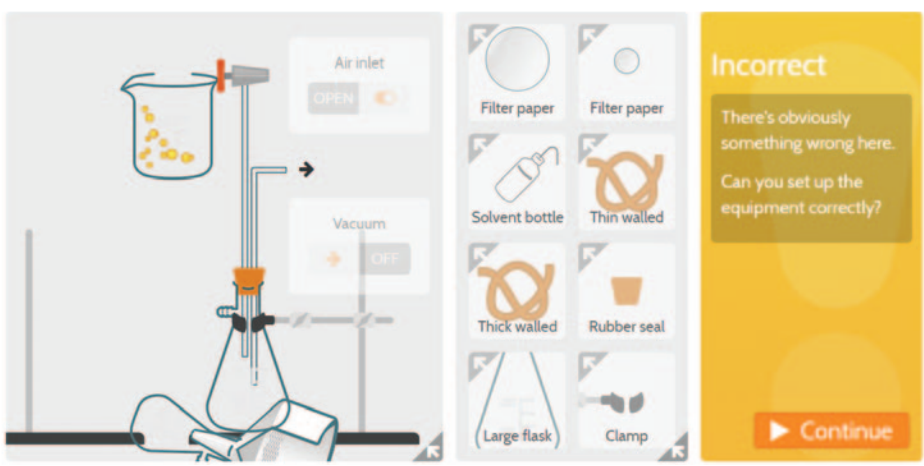
The University of Queensland had already integrated commercial online pre- and post-lab quizzes from Learning Science Ltd, which provided the backbone for the transition to online practicals. These activities included simulations of experimental techniques, practice calculations and data processing (see screenshot below). For 2020, data arrays were created and introduced into post-lab quizzes, replacing students' data entry. This enabled each student to receive unique data sets, reducing potential collusion opportunities. Resources provided included short annotated videos (less than one minute) of key practical observations with supporting textual notes, and links to a library of interactive simulations. Each practical



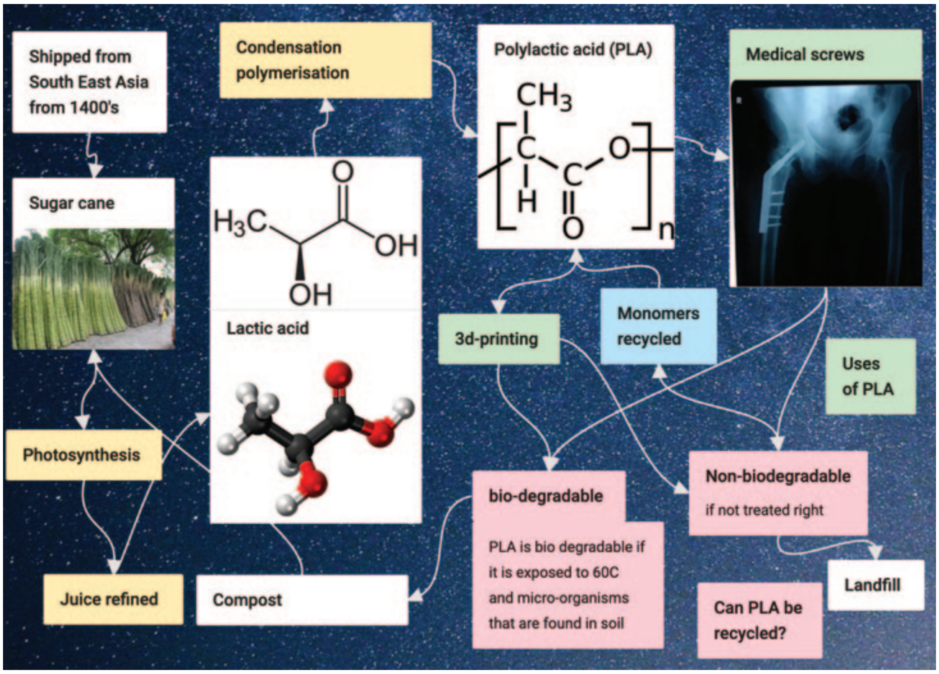
Observations for making oxygen gas.

Answer:
- We added the hydrogen peroxide to the test tube
- Dropped in some the manganese oxide into the hydrogen peroxide
- Placed another delivery tube and stopper into the test tube containing the manganese and hydrogen peroxide mix
- The oxygen gas produced travelled through the delivery tube
- Oxygen was caught in the test tube that was semi submerged in water
- We tested for the presence of oxygen gas through use of a heated splint test

A tertiary student lab report in OneNote.



A Learning Science Ltd laboratory simulation used at University of Queensland.



A small group activity preparing a systems map in Padlet.

was open for a week for students to complete in their own time.

Approaches in secondary education

Senior secondary chemistry teachers were given about four days' notice to design and implement a remote learning program. Complicating matters was a lack of information on changes to the usually strictly enforced, mandated curriculum and assessment procedures. In addition, teachers were acutely aware of inequitable access to online resources, particularly for students in low socioeconomic status and rural schools. Despite these challenges, teachers interviewed over this period reported largely positive experiences, and described a willingness, even after returning to the classroom, to continue utilising the best aspects of online learning to augment the chemistry classroom experience.

Finding a balance of synchronous and asynchronous online experiences in each school was challenging. Most teachers were concerned about their limited ability to have students 'present' in online sessions. With an underage cohort, government policies limited which platforms could be used. One experienced teacher, normally confident to teach through class discussion supported by a textbook, felt extremely displaced when told by their leadership team to prepare numerous videos of narrated slides to replace their live teaching.

Most teachers reported that senior chemistry students wanted to engage with their teacher, and were more confident to ask questions, participate in live class discussion and engage in group activities online. One teacher gave an example of running a small group activity across multiple Padlet pages (see example above) in which each group had a space to collaborate on a systems thinking map of a chemical process (https://doi.org/10.1021/acs.jchemed.9b00266). The teacher moved between the different groups and their pages, providing feedback and guidance.

Enhancing practical activities through pre- and post-online engagement

Many teachers described setting meaningful pre-lab activities (e.g. risk assessments, annotating material lists and methods, demonstrating design thinking for scientific investigations) and post-lab activities (e.g. performing calculations with and interpreting second-hand data, and making observations from videos). These activities would normally take up precious laboratory time at school, or be neglected altogether because of time constraints. There was general consensus among the teachers that online pre- and post-activities relating to practical work should be the new normal.

The priority of all teachers in all contexts is always student learning and the student experience. Staff are acutely aware of challenges that many students face in the current situation with job losses and unanticipated changes. Our main goal was to try to minimise stress for students in the transition to online learning without compromising the learning outcomes. Most schools and institutions adopted a combination of the above options, tailored to the content and context. A common theme for replacing laboratory experiences across secondary and tertiary levels has been to emphasise the pre- and post-laboratory activities, which should prepare students for their eventual return to the laboratory. Some of these online activities will be retained beyond the current emergency because they offer valuable contributions to learning.A beautiful part of this stressful time has been the cooperation of the chemistry education community, and the general willingness to share. Some of the shared resources are available at chemnet.edu.au/node/377. The time required to set up a good learning experience and follow up with individual students has been enormous, and sharing approaches can save some effort. Overall, this has actually been positive for the community as a common experience and challenge that has reopened broader communication about laboratory learning.

Madeleine Schultz FRACI CChem is a senior lecturer in the School of Life and Environmental Sciences, Deakin University. **Andrew Allsebrook** is a lead demonstrator, School of Chemistry and Molecular Biosciences, University of Queensland. **Magda Wajrak** MRACI CChem is a senior lecturer in the School of Science, Edith Cowan University. **Seamus Delaney** MRACI is a lecturer in the School of Education, Deakin University.

Mentoring: success encouraging success

'I got the job!' Four words that give me joy every time I hear them.

I have the pleasure of being the national coordinator of RACI's Mentoring Programme, which has grown over the last couple of years to also offer the wider RACI Careers Development Programme.

Through webinars, podcasts, training, blogs, workshops, facilitated networking and more, we're reaching hundreds of students every year with the message that 'anyone can find a great job if they just know how'. Because finding a job *is* a job, and like anything else it involves skills that can be learned.

In the RACI Mentoring Programme, we match (mostly) university undergraduate and postgraduate mentees one-on-one with a mentor who suits their area of interest. Working in this fashion, we aim to help our students better understand the workplace (improve their 'workplace readiness'), develop the skills to find and capture great jobs quickly, and develop their networks.

This is an appeal to each and every one of our members: we know that you have something to offer.

Responding to COVID, we've moved our offerings entirely online, including the wonderful new 'Chemraderie' online networking initiative. And both of our most recent online webinars have set consecutive records for attendance.

Over recent years, more than 90% of our mentored students have graduated with jobs waiting for them. That's significantly better than the national employment average.

Consider this: the national median period of unemployment for recent graduates is four months – worse for STEM students. Even being conservative, if we can help a young person develop the skills and network to find a job within one month of graduation, then at a starting salary of (say) $60 000, that makes $15 000 difference to the life of that young RACI member.

In many cases, our mentees have leveraged their mentoring experience to land dream jobs. They testify to the transformative effect that this focused support has offered them. After graduation, many of them have stayed to become active early career RACI members. And this year, the first former mentee returned as a mentor, to share what she has learned.

The RACI Mentoring Programme is about so much more than money, more even than just jobs. It's about inspiration, discovering exactly that right path, and developing the confidence to go out, and find and capture the opportunities before they are even advertised.

'Even with all the information available on the internet today, I've found that the mentees are still unsure about the diverse range of opportunities available to chemistry graduates', says Heidi Doak, one of our founding mentors. 'My own experience has been a useful resource for me to discuss mentees' questions about job seeking and chemistry careers. The time commitment has been very flexible, and it's been great to meet the other mentors and learn from their experiences too.'

2021 is going to be a major year for the RACI Mentoring Programme. We hope to extend from our current five states and territories (ACT, New South Wales, Queensland, South Australia and Victoria) into the rest of Australia. We also hope to extend beyond students and recent graduates to offer our support to early career chemists as well.

All of this is built on the efforts of our wonderful volunteer mentors. Giving just one hour a month of their time, they get the chance to make a huge difference in the lives of their mentees.

So we're reaching out to our membership nationally. We're asking for your help. The main thing that is challenging the growth in the RACI Mentoring Programme is the need for more mentors. If we want to continue to grow into 2021, we need you.

For all of our academic members, we ask that you spread the word: the RACI Careers Development Programme has a huge amount of resources, and its free. And for our industry, commercial, academic, government and active retiree RACI members, we ask this:

- Would you like to share the benefit of your experience? There is a chemist out there right now who wants to listen.
- Can you offer an hour a month of your time, in person or online? There is a chemist who wants to talk.
- How can your network serve to inform and assist a fellow RACI member? Even at the graduate level, most jobs are found through networks.

This is an appeal to each and every one of our members: we know that you have something to offer. Our membership has such a wealth of knowledge and experience that it cannot be measured. If you would like to feel that warm glow of knowing that you made a difference, or if you just want to learn more, I ask that you reach out to us at mentoring@raci.or.au.

Dave Sammut FRACI CChem is the principal of DCS Technical, a boutique scientific consultancy providing services to the Australian and international minerals, waste recycling and general scientific industries. He's also Adjunct Senior Lecturer at the University of NSW, and National Co-ordinator of the RACI Mentoring Programme.

2019 Royal Society of Chemistry Australasian lecture tour

It was an honour and a real pleasure to be awarded the 2019 Royal Society of Chemistry Australasian lectureship. It gave me a great opportunity to visit a lot of campuses in New Zealand and Australia and catch up with old colleagues and meet new colleagues. I found out about the award mid-year and unfortunately due to teaching commitments had to wait until almost October before starting the tour. I managed to pack in 15 different sites and had a great time at each of them. My topic was 'From ultrafast processes in solar cells to prediction of meat quality: using spectroscopy and computational methods to understand complex systems'.

I started the tour by going to the North Island in New Zealand. In late September, I spoke at the University of Auckland to the New Zealand Institute of Chemistry (NZIC) after a quick look around the impressive Auckland Chemistry facilities. I had some lively questioning after the talk and a very nice meal with members of the Auckland branch of the NZIC. I would like to thank the organisers – particularly Bob Andersen – who organised everything very well.

The next morning, I drove to Hamilton to deliver my seminar. Graham Saunders gave me a nice tour of the facilities and there was a good turnout of students at the talk, which appeared to go down quite well. I also had a chat about low-frequency Raman spectroscopy with Vic Arcus after the seminar and I hope we will get some interesting science going from that.

A couple of days later, I spoke at Massey. It was great to catch up with Simon Hall (an old collaborator) and other Otago alumni, such as Mark Waterland and Paul Plieger. After the seminar, I had a long chat with some food technology guys about the possibilities of using vibrational spectroscopy in their research – and that was a great opportunity for dialogue.

The next day, I went down to Wellington and spoke at Victoria University. This was organised by Nate Davis and I had a good discussion with some of his students and those of Justin Hodgkiss. As a member of the MacDiarmid Institute, I found it was nice to be able to showcase some of the work made possible by the funding and collaborative interactions that have come from being part of MacDiarmid. After a get-together in Milk and Honey (a local on-campus café), I may have imbibed a few quiet drinks with some of Justin's group for a very pleasant evening chatting about science.

It was very valuable to discuss how different places teach and how they organise research funding and research effort, and of course see the cool science they all do.

After this initial tour, I really started to appreciate how great an opportunity this was to visit and see a lot of campuses in a way you might not if attending a conference at them. It was very valuable to discuss how different places teach and how they organise research funding and research effort, and of course see the cool science they all do.

The next tour kicked off with the seminar in Christchurch where I saw the nice new facilities that have been built for Chemistry. I caught up with some of the guys in engineering who are working on battery technology. Then I went to Brisbane and gave two talks. This was extremely accommodating of both University of Queensland and QUT and I am grateful to Philip Sharpe and Anja Goldmann for making this possible. At the University of Queensland, I spoke with Elizabeth Krenske about density functional theory and then was able to see around Paul Burn's fantastic facilities. I also was able to see the ultrafast laser lab run by Evan Moore. Later in the day, I got a chance to talk to Anja and her team about the research at QUT.

The next day, I spoke at Charles Darwin University in Darwin, hosted by Vinuthaa Murthy. This was a smaller venue but I was able to meet some wonderful high school teachers at dinner. I then took a few days off and reconvened with a talk at the University of South Australia in Adelaide. Jonathon George hosted my visit and I had a wonderful discussion with him about his very ingenious organic synthetic chemistry. I also saw Tak W. Kee's rather ingenious 2D electronic spectroscopy system, which uses optical flats to reduce errors due to optical dispersion. I had just read a very nice paper describing its operation (*J. Phys. Chem. A* 2020, vol. 124, p. 1053).

In Melbourne, I gave seminars at Monash University and the University of Melbourne. At Monash, I was able to catch up with Alan Bond – who coordinated a lot of the meetings in Australia, for which I am very grateful. As well as meeting Alan and many of the other staff, I chatted with Doug MacFarlane about his electrocatalysis work. It was a lovely visit and we also had a delightful meal at Alan's favourite restaurant. Finally on this leg, I visited the University of Melbourne and talked with Ken Ghiggino, Trevor Smith, James Hutchinson and Paul Mulvaney among others. I would like to thank James for hosting me, and Paul and his team for the after-seminar function (funded by Exciton Science). It was really good fun to see so many home-built laser-based experiments.

In December, I was invited to the inorganic meeting IC19 at Wollongong; this was a great meeting and it gave me a chance to catch a few venues for the lectureship. Before the conference, I spoke at the University of New South Wales and caught up with David Black and Albert Fahrenbach (who worked for Amar Flood in Indiana; Amar did his PhD with me at Otago). I also talked at Macquarie University and had great discussions with Fei Liu and her colleagues.

The final leg of the tour was to Perth, in February this year. I spoke at Curtin University and the University of Western

Spectroscopy and computational methods in complex systems

Vibrational spectroscopy is a potent method of analysing molecular structure within small volumes and at fast timescales.

Using a suite of spectroscopic methods, and by studying a series of complexes (metal-based donor–acceptor systems) in which parameters are carefully controlled, it is possible to develop design principles for excited state properties so that one can enhance electronic absorption and increase excited state lifetimes. The understanding of how these properties, both ground and excited state, are modulated by driving force and effective conjugation is not straightforward.

The use of computational chemistry in modelling properties of compounds has become ubiquitous in modern chemistry. However, these do not always predict molecular behaviour effectively, and unpicking the extent of deviation between theory and experiment reveals some interesting problems in our reliance on computational methods. Our studies on the spectroscopy of donor–acceptor and π,π^* systems highlight these issues.

Our experimental development, originally aimed at understanding ground and excited state properties of metal complexes and other donor–acceptor systems, has provided us with tools that are amenable to analytical spectroscopy. We have used these tools in the study of primary produce and pharmaceuticals. More recently, we have used low-frequency Raman spectroscopy to evaluate crystallinity (and order in general) in structures as varied as solar cell polymers to active pharmaceutical ingredients.

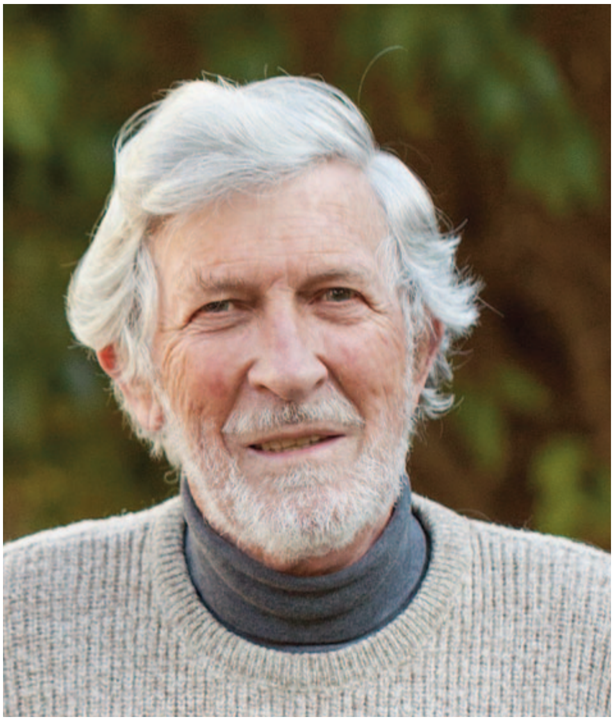
Australia. It was great to chat with Max Massi and Paul Low among others and also interesting to see how their buildings (which are relatively new) were operating. I gave my final talk of the lectureship in March at Otago University.

I thank all of the people who took the time to chat with me during these visits – some were organised at pretty awkward times and yet the turn out to the seminars was great as was the enthusiasm of the people I met. I actually felt quite positive about chemical sciences in Australia and New Zealand after the tour, as I saw such diversity in the science that was being conducted but also the organisation of the departments. So, a huge thanks to the Royal Society of Chemistry, RACI and the NZIC for supporting this speaking tour.

Professor Keith Gordon is a lecturer in the Chemistry Department, University of Otago, New Zealand. His research interests focus on understanding the properties of conducting polymers, nanostructured electromaterials, such as found in dye-sensitised solar cells, dairy products and pharmaceuticals by using spectroscopy and computational chemistry.

Ian McWilliam (1933–2020)

Inventor of the flame ionisation detector



Dr Ian McWilliam AO made one of the most important inventions in modern instrumental chemical analysis, the flame ionisation detector (FID).

Born in Griffith, New South Wales, on 4 November 1933, Ian died in Melbourne on 9 May 2020. He attended the University of Melbourne, completing his BSc(Hons) in chemistry in 1955.

Mr R.A. Dewar, the leader of the Physical Methods Section of the Imperial Chemical Industries of Australia and New Zealand (ICIANZ) Central Research Laboratories, had recently returned from a trip to the ICI laboratories in England. Impressed with the potential applications of gas chromatography, he considered that a detector more sensitive than the ICI thermal conductivity detector was needed, so set up a project to try to develop this new detector. As Ian said in his article 'The Origin of the Flame Ionization Detector' (*Chromatographia* 1983, vol. 17, pp. 241–3), 'It was my good luck (and the company's, as it happens) that I joined ICIANZ at that time and was put onto this project'. Remarkably, by mid-1957 Ian's laboratory prototype was operative, and Ian lodged an Australian provisional patent application on 4 July 1957. More than 40 manufacturers have made FIDs under licence with the considerable royalties going to ICIANZ.

In 1965, the Shell Group of Companies in Australia established two research fellowships at Monash University, the first to be awarded in 1965 and the second in 1968. Ian took two years leave of absence from ICIANZ to take up the second one in 1968 and this led to his Monash DSc in 1974. In November 1969, he was offered the position of Head of the Technical Services Section at the ICIANZ Central Research Laboratories but declined in favour of an academic career.

Ian joined the Swinburne College of Technology as a senior lecturer in 1970. At that time, there was an influx of fresh young staff (mainly newly graduated PhDs from the University of Melbourne). He was an inspiration to them as the college moved towards degree status. In 1972, Ian travelled overseas on a Churchill Fellowship 'To examine current and proposed new approaches to teaching of chemistry at the tertiary level and to assess relevant requirements in buildings and equipment'. In 1973, he was awarded an ARGC (Australian Research Grants Committee – the forerunner of the ARC) grant for his project 'The Study of Aerosols using a Flame Ionisation Detector'. He was the first researcher in a College of Advanced Education to receive an ARGC grant. He was promoted to principal lecturer in 1973 and associate professor in 1992.

Over his long stay at Swinburne, Ian was a leader in developing courses for industrial chemistry, scientific instrumentation and the use of computers in chemistry. He urged Swinburne to encourage more research activities and worked closely with his colleagues both within and outside the College. In 1976, he was invited to write five chapters in the standard analytical chemistry textbook *Modern methods of chemical analysis* edited by Pecsok, Shields and Cairns. Those who sought Ian's advice or assistance – be they students or staff – were favoured with generous commitments of time and thoughtful insights. He made a great contribution to Swinburne's reputation as a leader in 'industry ready' chemists.

He was very active in the Australian Scientific Industry Association, an assessor for NATA and a member of various Victorian government technology advisory committees. In this capacity, he represented the industry in trade missions to Nanjing (1984) and Bangkok (1990).

Ian joined the RACI in May 1958 and was elected a Fellow in September 1970. He was awarded the Rennie Memorial Medal by the RACI in 1962 and the K.L. Sutherland Memorial Prize by the Australian Academy of Technological Science and Engineering in 1992. He was made an Officer of the Order of Australia in 1984 for his services to science and technology.

In 2019, the international firm Eurofins Environment Testing Australia & New Zealand named a meeting room in their new Melbourne laboratory the Ian McWilliam Room. Ian and his wife Gwen both attended the naming ceremony.

Ian is survived by his wife, four children and four grandchildren.

Tom Spurling FRACI CChem works at Swinburne University of Technology and **Bob Laslett** FRACI CChem is a former colleague of Ian.

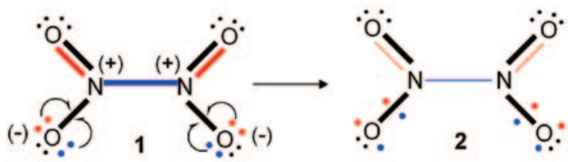
Richard (Dick) David Harcourt (1931–2020)

Developer of increased valence bond theory

It is a great, though sad, honour to write an obituary for Dr Richard David Harcourt, School of Chemistry, University of Melbourne. He passed away at Epworth Hospital in Richmond, Victoria, on Thursday 9 April 2020. He was 88.

In 1963, Dick gained a PhD from Monash University, becoming Monash University's first PhD graduate. From 1963 to 1964, he was a postdoctoral fellow in the School of Chemistry at the University of Melbourne, before moving to the Department of Physical Chemistry in 1965, where he was first a lecturer (until 1968) and then senior lecturer.

Late in 1959, Dr Brown (subsequently Foundation Professor of Chemistry at Monash University) suggested that Dick should test a theory proposed by others to explain why the chemical bond between the two nitrogen atoms of $O_2N–NO_2$ (dinitrogen tetroxide) was long and weak. From that day onwards, NO_2 and its dimer N_2O_4 became Dick's favourite molecules, and with which he worked on and off for nearly 60 years:



I had been following Dick's scientific work in theoretical chemistry before we met personally for the first time in Glasgow, UK, in 1996. I subsequently visited him in 1998 at the University of Melbourne for six weeks, where I stayed for a sabbatical as a Wilsmore Fellow. During these six weeks, I learned a lot about theoretical chemistry from Dick in a very productive and enjoyable time. In the following years, we also published approximately 30 scientific papers together, and a book on quantum chemistry – *Quantum chemical methods in main-group chemistry* (Wiley, 1998).

Theoretical quantum chemistry can be divided into molecular orbital theory and valence bond theory. Although the two methods in their purest and absolute form produce identical results when describing the chemical bond, the first one is more popular among computational chemists nowadays because of the easier mathematical algorithms. Despite this, Dick developed valence bond theory further and introduced the theory of increased valence bond ('increased valence theory' or 'increased valence bond theory'). This novel theory within the valence bond concept offers chemists a theoretically sound concept to understand chemical bonding qualitatively and quantitatively. The beauty of increased valence bond theory is that it offers both a pictorial approach to the complex world of the chemical bond (one could say: 'A picture is worth a thousand words') and a physically correct description of the electronic structures of molecules in terms of wave-functions.

Portrait of Dr R.D. Harcourt, drawn by his granddaughter Alice.

This new concept was developed and introduced by Dick and he often referred to it as the 'primitive patterns of understanding'. His work has been published in numerous peer-reviewed publications, including international scientific journals, a book (*Qualitative valence-bond descriptions of electron-rich molecules*) and several book chapters (e.g. doi.org/10.1016/S1380-7323(02)80013-9).

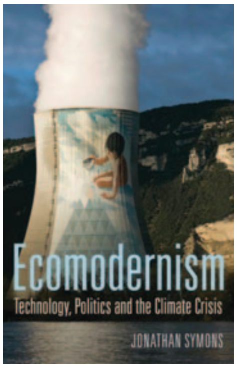
Dick's increased valence bond theory has also found its way into many general chemistry textbooks (e.g. E. Riedel, *Moderne Anorganische Chemie*, 3rd edn, de Gruyter, 2007) and undergraduate teaching. At my university (Ludwig Maximilian University of Munich), we teach increased valence bond theory both at undergraduate ('primitive patterns of understanding') and graduate levels (wavefunctions for increased valence bond structures).

In addition to Dick's outstanding contribution to valence bond theory, he also contributed Bohr–Orbit descriptions and electronic energy transfer studies to modern physical/theoretical chemistry.

Dick published more than 175 peer-reviewed papers in international scientific journals, many as the sole author. Australia in general and the University of Melbourne in particular are fortunate to have had Dick for so many years as a great and world-wide known scientist. Dick's contributions to physical sciences, particularly his life-time achievement of the development of increased valence bond theory will continue to benefit generations to come.

Dick will be missed by all of us.

Professor Dr Thomas M. Klapötke, Ordinarius, CSci CChem FRSC



Ecomodernism: technology, politics and the climate crisis

Symons J., Polity Press, 2019, paperback, 224 pp., ISBN 9781509531202, $30 (approx.)

Ecomodernism: technology, politics and the climate crisis is a most interesting book. It attempts to paint a picture of a fairer world than the one we live in. The issues of climate change and climate mitigation are intimately related to your world view and your sense of morality and justice for all people, but particularly those living in emerging economies.

Basically, the developed world, inter alia, wants to stop India and China from belching out the products of coal combustion. It seeks to dissuade Indonesia from burning rainforests to grow foodstuffs and Brazil from firing large areas of the Amazon catchment, again for agricultural activities, as well as drowning rainforest below dams for hydroelectricity generation on the Amazon River (which, alas, will yield more carbon dioxide and methane than a coal-fired power station). Author Jonathon Symons advocates not sanctions and punishments, not restricting or limiting emerging economies, but, through global assistance, lifting these economies past their current situations, using technology to achieve their ends and ambitions in ways that are good for them, good for the developed world and good for the planet. Pie in the sky? Well, no, it doesn't have to be. During the AIDS crisis, nations cooperated and there was a concerted international effort aimed at finding and implementing scientific and technological solutions to the crisis. To a very large extent, this worked.

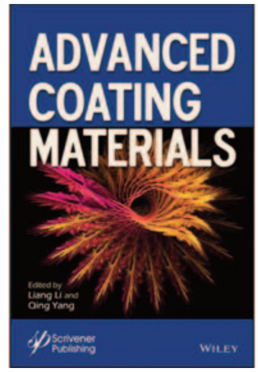
The ecomodernist view is one of optimism. It holds that an ecologically viable future can flow from transformative investment in technological innovation, including nuclear power, and global human development. The movement is controversial in that it is opposed to the Green movement's calls for greater harmony with nature. Which is right? Well, both and neither, I suppose. Read the book and make your own judgement.

Jonathon Symons is a senior lecturer in international relations at Macquarie University, New South Wales. He has written an extensively referenced and cogent text that combines a number of facets of the climate crisis in a creative and logical way. This book is well worth reading by scientists and non-scientists in order to broaden and clarify their views on approaches to dealing with climate change.

R.J. Casey FRACI CChem

The ecomodernist view … holds that an ecologically viable future can flow from transformative investment in technological innovation …

Advanced coating materials



Li L., Yang Q. (Eds), Scrivener–Wiley, 2019, hardback, 546 pp., ISBN 978111940750, $354, e-book, ISBN 9781119407638, $284

Advanced coating materials is a multi-authored text containing 14 stand-alone chapters, each ending with extensive reference lists. Contributors range across Japan, Australia, India, Ukraine, The Czech Republic, South Africa, Chile, Nigeria, Pakistan, Turkey and Spain. The two editors, Liang Li and Qing Yang, are professors at, respectively, the Soochow University and Zhejiang University, China. Surprisingly, their contribution to the work appears to reside only in the editing and there were no other contributors from China, most of Europe (except Spain but still including the UK) or the Americas. Perhaps this is a little disappointing, given these countries' history of research in coatings.

I was absolutely intrigued that one chapter, 'Nanotechnology in paints and coatings', which I greatly enjoyed, ran to 56 pages with 38 authors. Another chapter, 'Polymeric materials in coatings for biomedical applications', made an interesting, enjoyable, diverting and apposite read as I sat in a hospital room awaiting my wife's return from hip-joint replacement. It listed 12 authors for a 26-page chapter! Readability of the text is generally fine, although editing using a good grammar and spelling checker could have been useful in places. In particular, there seemed to be a dearth of 'the' before nouns in several chapters, presumably because the word is not required in some authors' birth languages. This is distracting for native English speakers and should have been picked up in editing.

The book centres on three themes: materials, method, fabrication and design; coating materials utilising nanotechnology; and a series of case studies of applications of advanced coating materials. This makes good sense of answering the basic questions of What are they?, How might you use them?, and What are some applications? Inevitably with such multi-authored works, there is some duplication. This is not a serious problem, however, since I expect most readers will home in on those sections or chapters of particular interest rather than read cover to cover. Referencing at the end of each chapter would provide a useful guide to further information for neophytes. Coverage is comprehensive and includes, inter alia, research into polymeric materials, carbon resins and high-temperature materials used in varnishes, adhesives and coatings.

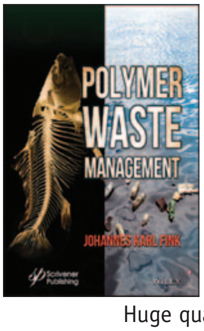
Traditional coating technology exists to protect infrastructure from corrosion and erosion, to enhance performance of machinery and other equipment, and, not least, to add colour and enjoyment to our lives. Recent major advances in what could be called 'high-tech' coatings have allowed further significant advances to occur, particularly in the automotive and medical device industries, but also in energy generation and environmental science and engineering. This

book will give you a sense of how revolutionary and efficacious these developments can be.

Surfaces of solids are atypical of the bulk solids behind them. They are where corrosion, erosion and other reactions occur. If I were an atom sitting on a solid surface, I'd just love to be warmly protected by one of these advanced coating materials!

So, who might usefully read this book? Almost everybody with an interest in coating science and technology will find interesting material in it. This could range across disciplines including chemistry, physics, engineering, materials science and biomedical sciences. Researchers, those working on advanced coating systems, and end users of such materials should find it valuable. Those involved in selection/specification of a material for a particular application may find it a useful source of information on possible alternatives. I don't see much application as a student text (although bits, particularly those on nanotechnology and biomedical technology, could find application). The big plus for this book is that it scans a very wide field at an advanced level. Different people will get different messages from it. However, it is always useful to have a look over the fence just to see what is going on nearby. This book aids this.

R.J. Casey FRACI CChem



Polymer waste management

Fink J.K., Scrivener–Wiley, 2018, hardback, 350 pp. ISBN 9781119536086, $246

Polymer waste management is a most interesting and informative book, extensively covering the wide area of scientific and societal concerns of what the world (including all Australians) should do about the very large amounts of plastics wastes generated by modern existence.

Huge quantities of plastic litter find their way onto our streets, whence into the oceans, or into mixed-waste recycling streams where, alas, they all too often end up in landfill. In the ocean, plastics endanger marine life, while micro-plastics readily enter the food chain, adding a certain 'je ne sais qua' (let's call it zest) to marine elements of our diet.

The front cover of the book features, among other things, a picture of a fish skeleton. Its significance is far too subtle for me, but perhaps it is a reminder not to overindulge in fish! Plastics deposition to landfill is simply wasting resources: at the very least, there is the option of burning to recover their latent energy. Like Bunyan's pilgrim, there seems to be a breaking forth of a lamentable cry of 'What shall I (we) do?' Unfortunately, all too often, this can lead to panic and ill-conceived interventions, particularly when various Asian nations decline to continue 'solving' our waste problems.

This is where *Polymer waste management* is so useful and relevant. It begins with careful analysis of the problems, explores techniques to identify and separate plastic waste streams, investigates models to characterise waste streams and highlights some of the special problems plastics present in waste streams. Plastics pollution of marine and terrestrial environments rounds out an excellent discussion of the general aspects of polymer waste management. Methods of recycling, some familiar and some less so (to me) are well covered, along with various processes to regenerate monomers from plastic wastes. If you don't fancy breaking plastic waste down to monomers, you can go part way and break it down to make fuels for transport and lubricating oils. Fink provides good information on how to achieve this.

The book finishes with a very extensive chapter, a real tour de force, of case studies of specific plastic materials. Each of the six chapters is extensively referenced and, more-or-less, stand alone. Above all, what really impressed me was the manner in which the author blended together the chemistry, technology and management of polymer wastes. It is applied chemistry at its best!

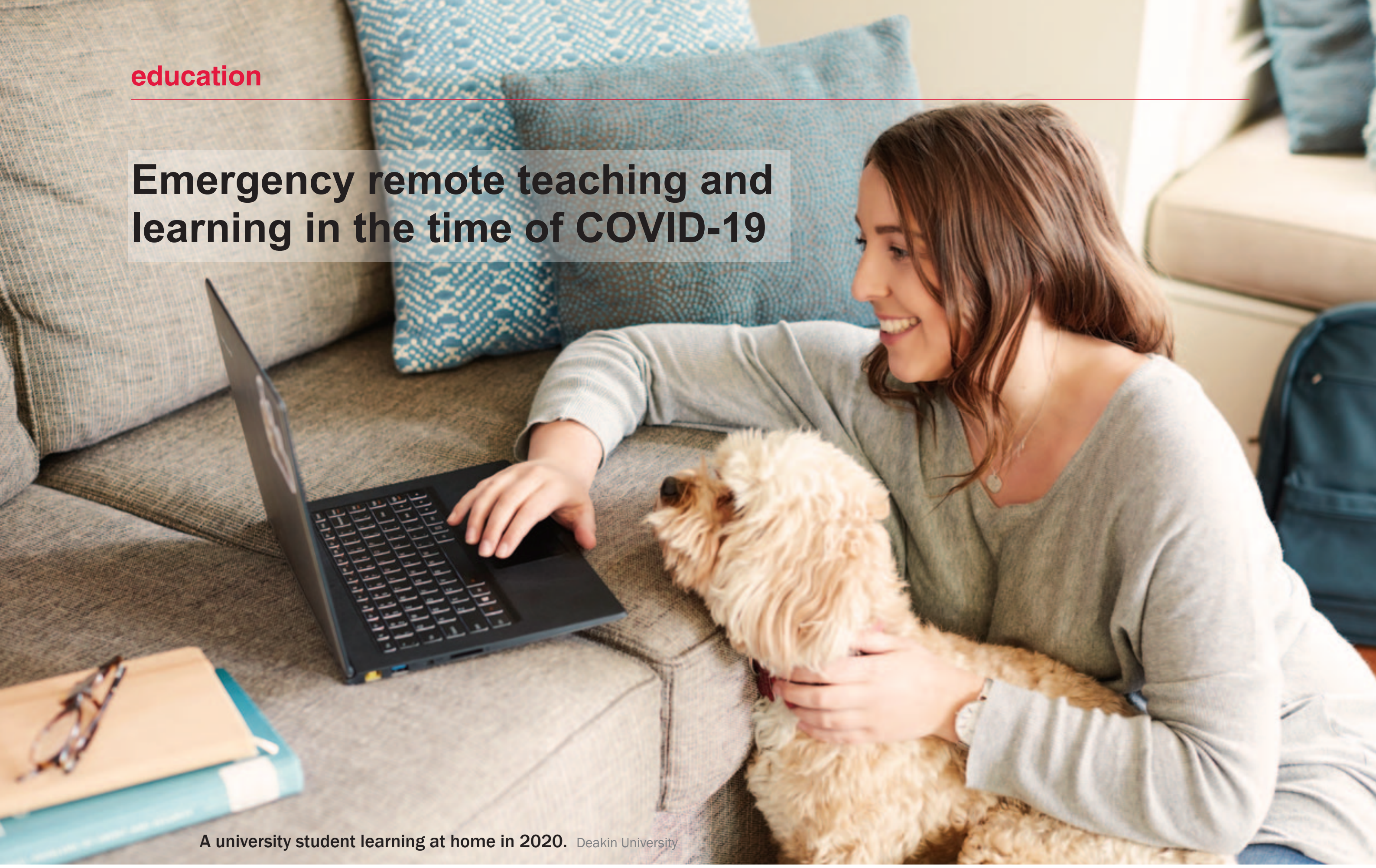
Author Johannes Fink is Professor of Macromolecular Chemistry at Montanuniversitat, Leoben (Austria). He has a long-term (more than 30 years) interest in polymer science and technology and has written extensively in the field. He is well qualified and experienced to write this book and has done a very fine job to untangle and clarify a complex web at the intersection of science and technology with societal values and mores. Above all, chemists will revel in the chemistry!

Higher education students in chemistry, chemical and civil engineering, environmental and sustainability sciences, and those involved in waste policy management studies will find this a great text for courses covering polymer waste at both undergraduate and postgraduate levels. Those aspiring to undertake research in this field will find its chapters, and particularly their references, a very useful starting point. Scientists, engineers, environmental and sustainability scientists, as well as policymakers and waste management executives, will find much of interest in this book. It is well worth your attention.

R.J. Casey FRACI CChem

... what really impressed me was the manner in which the author blended together the chemistry, technology and management of polymer wastes.

Emergency remote teaching and learning in the time of COVID-19



A university student learning at home in 2020. Deakin University

After a disastrous Australian bushfire season during the summer of 2019–2020, it was almost a relief to be back at school. A return to normality. But that did not last long. By 22 March, Australian students had been asked to study from home, with the implementation of emergency remote teaching (ERT). Teachers and students are to be congratulated on their response to the social distancing restrictions. Australian schools have now resumed face-to-face classes, while most other institutions are still using either ERT or a blend of face-to-face and ERT.

ERT uses a variety of resources, including online learning and web-based communication media, but it would be wrong to call it online learning. Teachers are doing a fantastic job, but emergency remote teaching and learning is an ad hoc reaction to challenging circumstances, not a proactive plan ab initio with careful instructional design and planning, using a systematic model for design and development. Australia does have a tradition of remote teaching and learning; for example, the Alice Springs School of the Air since 1951. True online learning, distance learning and mobile learning are pedagogies, which are purposefully and deliberately designed for learning to occur and with flexibility of location.

Before 2020, some schools and most tertiary institutions were already using learning management systems. Common learning management system features include announcements, asynchronous discussion threads, real-time chats, email, the ability to post documents and other digital resources as course content, online quizzes and other assignments, and an online grade book. As part of ERT, schools and tertiary institutions have increased their use of videoconferencing and related platforms. A big advantage of these videoconferencing packages is the ability to both see and talk to participants in the meeting. There is also often the ability to have a text-based chat in addition to the audio-visual link.

ERT cannot fully replicate a classroom learning environment. In a videoconference, a teacher can only monitor and supervise a single online space, whereas in a physical classroom, a teacher can use physical separation to talk to students at one table, while other groups are engaged in various activities elsewhere in the same room. ERT has resulted in a decrease of the quality and quantity of one-on-one teacher-student interactions and feedback. Furthermore, the need for all videoconferencing participants with a diversity of abilities to be engaged in the same task and at the same pace is frustrating for both teachers and students.

ERT has other problems, too. The reliance on online technologies will exacerbate the poorer learning outcomes due to the digital divide and socioeconomic disadvantage: some families have limited ownership of internet-capable devices, or live in areas with poor internet access, or have difficulty finding enough distraction-free spaces for parents telecommuting from home and students studying at home. Many educators have serious concerns about the validity of online examinations and the reality of cheating, which would normally be minimised in face-to-face

classes and on-campus examinations.

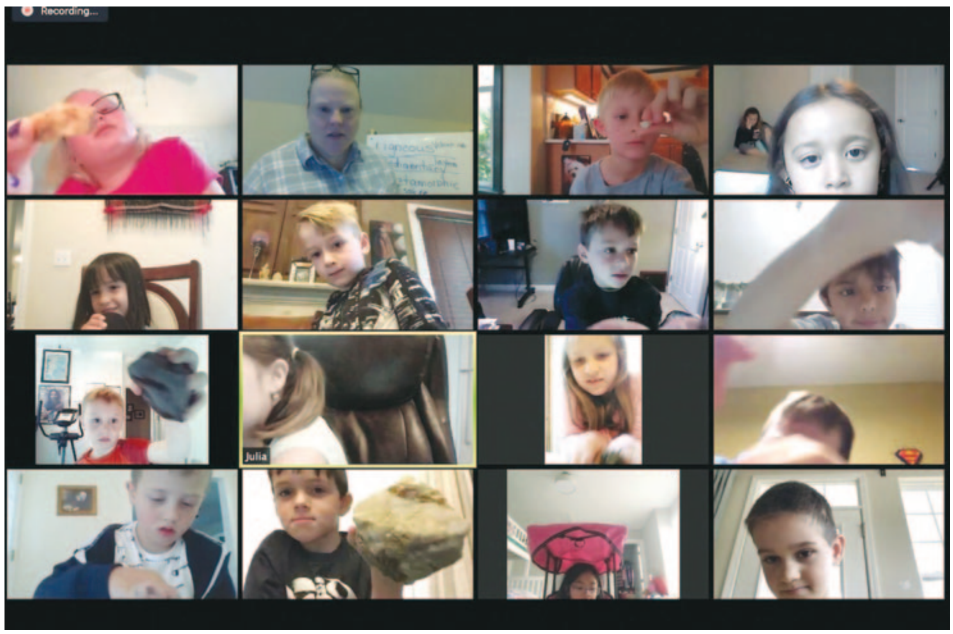
But the single biggest difference between ERT and regular classrooms is the ability to undertake laboratory learning activities, which are the signature pedagogy in chemistry education (February 2012, p. 39; September 2013, p. 35; February 2016, p. 36). Some classes have replaced hands-on laboratory activities with simulations or videoed demonstrations, while others have deferred these activities until later in the school year, with the recommencement of face-to-face classes

Despite the shortcomings of emergency remote teaching and learning, not all is gloom and doom. Teachers have been voluntarily working unpaid overtime so that their students can continue learning. There has been unprecedented cooperation and willingness to share resources, and commercial publishers and major museums have made many of their resources freely available to the community. And the experience from school closures in New Zealand after the 2011 Christchurch earthquakes is that ERT for a term or so will not have any long-term detrimental effects on students' learning.

Kieran F. Lim (林百君) FRACI CChem (kieran.lim@research.deakin.edu.au) is an associate professor in the School of Life and Environmental Sciences at Deakin University.

Australia does have a tradition of remote teaching and learning; for example, the Alice Springs School of the Air since 1951.

A school student learning at home by two-way radio in 1954. Alice Springs School of the Air



A Zoom meeting in a Year 1 classroom. Saint Catherine of Siena Catholic School

From soil microbiology to wine composition

In 1986, I commenced the oenology degree as a distance education student at Charles Sturt University (CSU). One of my first subjects was vineyard establishment and I was intrigued at the then practice to 'dip–rip' the soil followed by extensive spraying with a weedicide/herbicide, essentially to ensure that vine growth would not be restricted through competition with the previous growth in the parcel of land. Such a strategy was perhaps understandable, given the then urgent need to expand grape production. The practice would of course be detrimental to the natural soil microflora, something that would detract from the concept of the site's terroir potential.

During my time as Director of the National Wine and Grape Industry Centre, the plant pathology researchers carried out a one-year study of the microbiological population of a biodynamic vineyard. A more active and disperse population was found in the biodynamic vineyard than in vineyards maintained by conventional crop management methods. This was in the early days of biodynamic cultural practices in Australia, and the trial was not continued owing to lack of funding support.

In 2012, researchers at Stellenbosch University (South Africa) described a detailed study of the 'vineyard yeast microbiome' on three adjacent vineyards, each planted to Cabernet Sauvignon but managed by different cultural practices: conventional, integrated pest and disease management, and biodynamic (*PLoS ONE* 2012, vol. 7(12), e52609). The results demonstrated that the least cultivated vineyard (biodynamic) had significantly higher species richness, with some yeasts having what the authors termed 'biocontrol potential'. The data analysis also showed that the species distribution was not uniform with marked intra-vineyard fluctuation.

The fundamental question is whether there is any evidence that the vineyard yeast population has any effect or influence on the fermentation and final wine character. In Australia and most new-world wine countries, it is common practice to inoculate the grape juice or must with a selected strain of *Saccharomyces cerevisiae* to minimise any activity from the indigenous yeasts on the grapes. Otherwise, it was argued that the wine might show unusual aromas, 'like a European wine'! On the other hand, a winemaker of a top shelf Chardonnay from Burgundy, when asked if he ever inoculated a ferment with a commercial strain of *S. cerevisiae*, responded 'if I want to drink Coca-Cola, I would go to Australia … or Bordeaux'!

The argument over inoculated versus indigenous fermentation often overlooks that *S. cerevisiae* can be found in the indigenous yeast population. In a parallel Stellenbosch study to the one described above, the authors examined the changing indigenous yeast population and fermentation kinetics during small-scale fermentations (*S. Afr. J. Enol. Vitic.* 2015, vol. 36, pp. 243–51). The initial total yeast population for the biodynamic vineyard was higher than for the conventional and integrated vineyards, and indigenous *S. cerevisiae* was detected, albeit at a low percentage of the total. Fermentation started immediately for the biodynamic vineyard, whereas there was up to a two-day lag with the conventional and integrated vineyards with the fermentation taking about twice as long to complete. *S. cerevisiae* was only detected two days after the onset of the fermentation.

Exploring the proposal that indigenous populations of *S. cerevisiae* display biogeographic patterns, researchers from the University of Basilicata and the University of Florence collected several isolates from Aglianico del Vulture (Basilicata) and Sangiovese (Tuscany). The isolates were inoculated into the red grape must from both varieties. Distinct regional or biogeographic patterns were found. For example, some yeasts from Aglianico did not complete the fermentation when inoculated into Sangiovese. In essence, the best results were obtained with yeast strains that were adapted to each viticulture area (*Front. Microbiol.* 2016, vol. 7, article 1018).

In a separate study, the University of Basilicata researchers selected three indigenous strains of *S. cerevisiae* from three separate regional vineyards and inoculated Primitivo must from each vineyard with the strain relevant to that vineyard. A parallel fermentation was carried out in each cellar using a commercial active dried *S. cerevisiae* yeast. The fermentations were monitored for effectiveness and influence on chemical composition, and sensory analysis or liking preference was also performed. Generally, the 84 consumers preferred the combination of winery/indigenous yeast as reflecting the 'typical traits of Primitivo wine', opening up the feasibility of utilising cellar-specific indigenous strains to produce a wine that is unique to the winery (*Fermentations* 2019, vol. 5, article 87).

A recent review by researchers at the University of Melbourne (*Front. Microbiol.* 2019, vol. 10, article 2679) provides a succinct summary of this expanding field of endeavour. The review clearly underpins the role that microbial biogeography plays in influencing wine characteristics. One question that has always intrigued me is the time it takes for a vineyard to develop and maintain a stable microbial system. Our vineyards are 'young' in comparison to many in Europe. The impact of a changing climate on this microbial diversity needs also to be considered.

Research is slow, with several years needed to check the stability of the site's microbiology. Recently, I came across a proposal for a microbiome-on-a-chip as a possible means for evaluating plant-microbiota research (*Trends Microbiol.* 2017, vol. 25, pp. 610–13). I would be happy to chat about this with anyone who may be interested.

Geoffrey R. Scollary FRACI CChem (scollary45@gmail.com) has been associated with the wine industry in production, teaching and research for the last 40 years. He now continues his wine research and writing at the University of Melbourne and the National Wine and Grape Industry Centre at Charles Sturt University.

Forays of Finlayson

The things that chemists do when they are not doing chemistry can make interesting reading, and I came across a particularly interesting example in Tim Bonyhady's *The enchantment of the long-haired rat*. To get the rat out of the way first, it is an Australian rodent *Rattus villosissimus* that has attracted the attention of zoologists because of the great fluctuations in its populations, breeding massively after rains and then apparently disappearing. The chemist, to whom Bonyhady devotes most of a chapter, was Hedley Herbert Finlayson (1895–1991).

At age 15, Finlayson was a cadet in the department of chemistry at the University of Adelaide but he also maintained a home laboratory in which he dabbled in explosives and claimed to have discovered one that was more than 20% more powerful, and moreover more economical, than any then in use. I never found out what this material was, but I did learn that in 1910 he discovered another of its properties: that it was extremely shock sensitive. The explosion cost him the 'tops of three fingers and the thumb of his left hand', according to the Adelaide *Advertiser*. Undeterred, Finlayson continued his investigations and a second explosion in 1913 cost him the rest of his left hand, part of his right thumb and also his right eye. Professor Edward Rennie, with whom he worked at the university, wrote to the paper to say that Finlayson's work at the university had no connection whatever with explosives.

In his history of the Adelaide department, *Discoveries by chemists* (1987), Rupert Best writes that Finlayson stayed with the department for many years, as assistant lecturer and demonstrator. He never graduated but did hold a scholarship in 1918 for work on the pigments of *Drossera whittakeri* and the investigation of grass tree resins. On this latter subject, Finlayson published papers in the *Journal of the Chemical Society* in 1920 (with Rennie and W.T. Cooke) and 1926 (as sole author). In the 1920 paper, the authors wrote 'this investigation has been carried out by us as a special committee appointed for the purpose by the Australian Commonwealth Institute of Science and Industry'. It wasn't clear why the Executive Committee of this body, a precursor of CSIR and thus of CSIRO, that made the grant, was interested in the grass trees (*Xanthorrhoea*). It was known at the time that the resin (also known as yacca gum) could be used in varnish, and that treatment of the resin with nitric acid yielded picric acid, used as a dye and an explosive. The Adelaide group examined the gums of several species of *Xanthorrhoea*, from which they isolated small quantities of coumaric acid, *p*-hydroxybenzaldehye, paeonol (2-hydroxy-4-methoxy acetophenone) and citronellol. Some species had red resin, others yellow, and although the researchers did not say so, there was a hint of chemotaxonomy about their work.

Before long, Finlayson's organic chemistry gave way to a growing interest in the mammals of central Australia. While he continued as (what we would now call) a professional officer in the chemistry department, he financed research and collecting

H.H. Finlayson investigated the resin of grass trees.

Before long, Finlayson's organic chemistry gave way to a growing interest in the mammals of central Australia.

trips in South Australia and the Northern Territory and he became honorary curator of mammals at the South Australian Museum. There is a fascinating account of Finlayson's life in the *Australian Dictionary of Biography*, in which his 1935 book, *The Red Centre: man and beast in the heart of Australia*, is praised and it is noted his photograph collection is now held by Northern Territory Archives and his mammal collection in Alice Springs.

Finlayson published five papers on his mammal work in *Nature*, and I found two of them specially interesting. In 1932, he responded to a remark by a British zoologist that 'the kangaroo is never known to utter any kind of sound'. Finlayson wrote under the heading 'Vocal Powers of Kangaroos' to say that he identified several sounds made by macropods, one being a 'short, clear-cut bark or cough, made as a warning signal by a member of a "mob", when suddenly disturbed'. He issued another challenge to received wisdom in 1948, this time that 'one of the most prominent items of anatomical evidence in support of the antiquity of man in Australia has been a fragment of a human molar' found in the Wellington Caves of New South Wales. On the contrary, he argued, the tooth 'was derived from the posterior half of the upper fourth premolar or seccator, of the right side, of *Macropus (Protemnodon) anak* Owen, a giant Pleistocene "wallaby", remains of which are already known from the caves'. He promised that an illustrated account would follow, but I'm not sure it ever did.

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.

Global Science on YouTube

The coronavirus pandemic has proven that the world is capable of a global crisis response. But can we now expect our leaders to pay as much attention to scientific advice for other challenges?

Former President of Ireland and UN High Commissioner for Human Rights, Mary Robinson, and President of the International Science Council (ISC), Daya Reddy, discuss these issues in the inaugural episode of Global Science published online in June.

Global Science is an initiative of the ISC and the Australian Academy of Science. The ISC is a non-government organisation comprising 40 international scientific unions and associations and more than 140 national and regional scientific organisations. It builds on the Australian Academy of Science's established and leading science communication effort, which has shown there is a thirst for accurate and engaging science content.

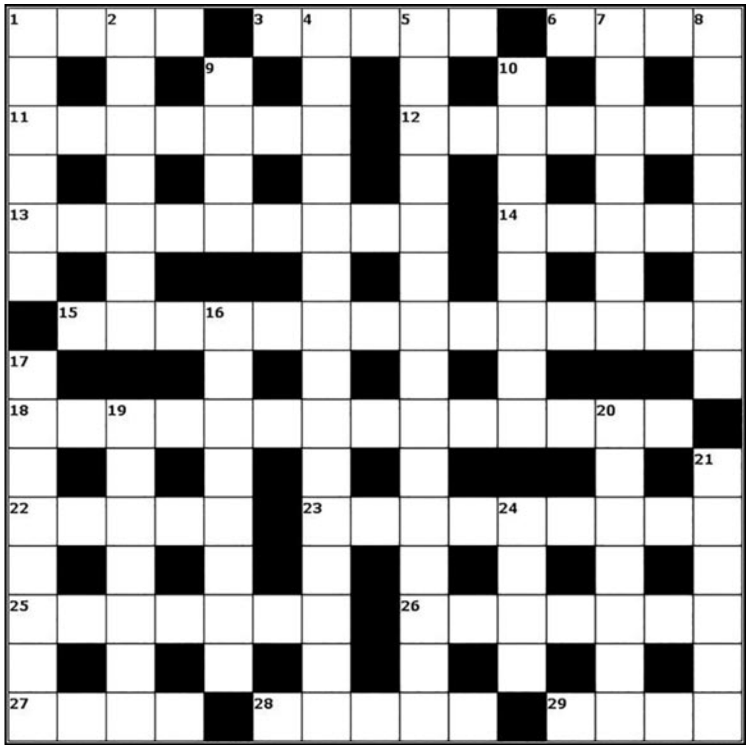
By tapping into the ISC's extensive network, each fortnight Global Science will broadcast interviews with the world's best scientists and some of our greatest thinkers. Hosted by Australian journalist and clinical psychologist Nuala Hafner, the 20-minute conversational episodes will entertain and inform viewers on the most notable scientific issues that society faces today.

Australian Academy of Science Chief Executive Anna-Maria Arabia said the Academy is proud to be partnering with the ISC on the initiative: 'It is absolutely crucial that people understand the role of science during this time of crisis and beyond. Global Science will tackle the big questions of our time with the world's leading scientific voices.'

The first episode of Global Science also explores how scientists accounted for the universe's missing matter, in an interview with Associate Professor Jean-Pierre Macquart from Curtin University.

The series is available at Global Science TV on YouTube.

Australian Academy of Science



Across

1 Suit picking up KKKKK. (4)
3 Turns around orbital in sulfur. (5)
6 & 27 Across Difficult government has to be obeyed. (4,4)
11 Clue holding last word after nickel returns count. (7)
12 See 23 Across.
13 Retap ooze to make a constant boiling point mixture. (9)
14 Recent three elements. (5)
15 Compounds with the general structure ROOH or reddish epoxy compounds. (14)
18 Braking radiation blurs terms? Hang about! (14)
22 Additional three elements. (5)
23 & 12 Across Current titanium distress over a cold temp breaking a range of configurations near the transition state. (9,7)
25 Meditation was once Spooner's compound. (7)
26 61365352: the most stable polymorph of calcium carbonate. (7)
27 See 6 Across.
28 Where actors are beginning. (5)
29 Two elements undiluted. (4)

Down

1 Describing a torsion angle between 30° and 150° which ill can twist. (6)
2 Institute cerium/titanium/yttrium/oxygen/sulfur reaction. (7)
4 Help! Help! No hint a mixture changes colour. (15)
5 Peculiar central order for something tiny. (7,8)
7 Recognised everybody is unsettled. (7)
8 D-glucose sorted ex reaction. (8)
9 Dredge fine earth. (4)
10 $R_2C{=}N{-}O^{\bullet}$ product only I mix. (8)
16 Booked and waited on rhenium. (8)
17 Sober bar fly soaks up some rays. (8)
19 Acetaldehyde systematically fussy after the change. (7)
20 Egg on anger with a $-C{\equiv}N$ functional group. (7)
21 Most peculiar! Not even set changes. (6)
24 Unit cellar detected. (4)

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

CRC Association: 'Continuing Collaboration' webinars

The CRC Association is continuing its webinar series on how organisations can work productively through the coronavirus pandemic.

Past and scheduled webinars include:

- 'Continuing collaboration: Partnering through the crisis', presented by Prof. Valerie Linton (University of Wollongong), Mr David Chuter (Innovative Manufacturing CRC) and Dr Tony Peacock (CRC Association)
- 'Operating a safe cyber environment with a dispersed, home-based workforce', presented by Rachael Falk, CEO, Cyber Security CRC
- 'Managing your data remotely', presented by the Australian Research Data Commons.

View the Eventbrite page (bit.ly/2UTuQwD) to view forthcoming webinar details as they are added and subscribe to the CRC Association YouTube channel to view previous webinars.

The CRC Association typically charges non-members for its webinar offerings; however, in light of coronavirus, everyone's attendance is welcome.

IChemE online courses

In response to COVID-19, IChemE has accelerated plans to offer some of its most popular training courses online.

Each course will be delivered on a modular basis and comprise live sessions with trainers, supplemented by independent study and pre-recorded content. These online courses are based on the same learning outcomes as our face-to-face programs, taught by our expert trainers and using peer-reviewed materials.

The courses are being offered at a reduced rate, with further discounts available to IChemE members and employers booking multiple places. The number of places available on each course is capped and early booking is advised.

New courses, new course dates and additional time zones will be announced in the coming weeks. For further information, contact Matt Stalker (mstalker@icheme.org).

American Chemical Society webinars

Hundreds of webinars presented by subject matter experts in the chemical enterprise.
acs.org/content/acs/en/acs-webinars.html

Kindness – building a better chemistry culture

Chemistry World and the Inclusion and Diversity team at the Royal Society of Chemistry are proud to offer the first of a free monthly webinar series to support the chemical sciences community in response to and beyond the COVID-19 pandemic.
chemistryworld.com/webinars

RACI retirees virtual lunch

Our first lunch last month was a success with three states represented. Feel welcome to come and solve the problems of the world and join other like-minded retired chemists. This event is hosted by the Victorian Branch and all retirees across the country are invited to join in.
raci.org.au/Web/Events--News/Events/Events

RACI Qld National Trivia Night

3 July 2020
To join, simply like RACI Qld Branch on Facebook.

ACT Stay-at-Home Science: Crystal Growing Competition

Register by 31 July
raci.org.au/Web/Events--News/Events/Events

Chemraderie national networking

Join Chemraderie, the RACI national networking event. It's a monthly opportunity to connect with chemical scientists nationally. Places are limited to 50 so please register today.
raci.org.au/Web/Events--News/Events/Events

RACI Career Development Programme webinars

'What I wish I knew …'
23 July 2020
raci.org.au/Web/Events--News/Events/Events

'Lessons from recent graduates'
25 July 2020
raci.org.au/Web/Events--News/Events/Events

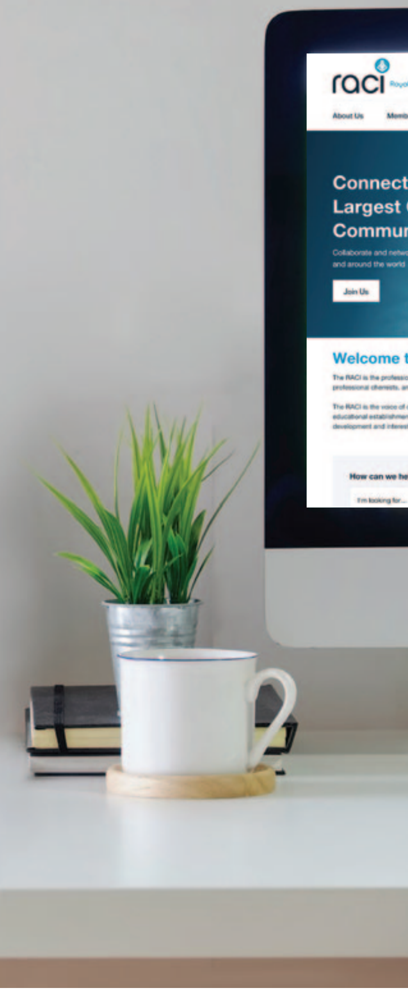
raci

Royal Australian Chemical Institute

The wait is almost over. Your new website is launching soon.

We're introducing a fresh new look, easier management of your memberships, simpler access to conferences and events, be a source of information on chemical sciences and awards, enable networking, and provide a host of educational resources.

We would like to feature as many of you as possible on our new website. We currently have an opportunity for members to provide images and testimonials that will be used throughout the new website. If you would like to participate, please email communications@raci.org.au



SCI Australia essay competition

SCI

where science meets business

To encourage Australian STEM students to demonstrate their written communication skills, the SCI Australia Group is offering essay prizes to BSc (or equivalent) Honours students for original work carried out as part of their Honours project. As a kindred society of the SCI, the RACI is proud to promote this event.

The competition is open to all BSc or equivalent Honours students of chemistry, chemical engineering or a related discipline attending an Australian university.

Competitors will be required to submit an essay describing the work conducted in their Honours project. They will be required to include contextual aspects of their project, key results and findings, and a discussion about the relevance and applicability of their work to the wider community, particularly the business and industrial community. They should comment if any of their work is being published in peer-reviewed scientific journals or is the subject of a patent application.

The essay should be approximately 2000 words in length but not longer than 4000 words. For more information about the application, please read the Award's judging criteria (at website below).

The essay should be submitted electronically as a Microsoft Word document to the Chair of the SCI Australia Group, Dr Richard Thwaites (Richard.thwaites@bigpond.com).

Up to three prizes will be awarded, valued at $250, $500 and $750.

In addition, prize winners will be offered one year's free membership to SCI, which will include access to the monthly publication *Chemistry & Industry*, and be eligible to obtain other SCI publications at a substantial discount.

The top three winning articles will also be published at www.soci.org.

Applications deadline is 30 October 2020.

To apply and for information about judging criteria, visit www.soci.org/awards/society-prizes/australia-essay-competition.