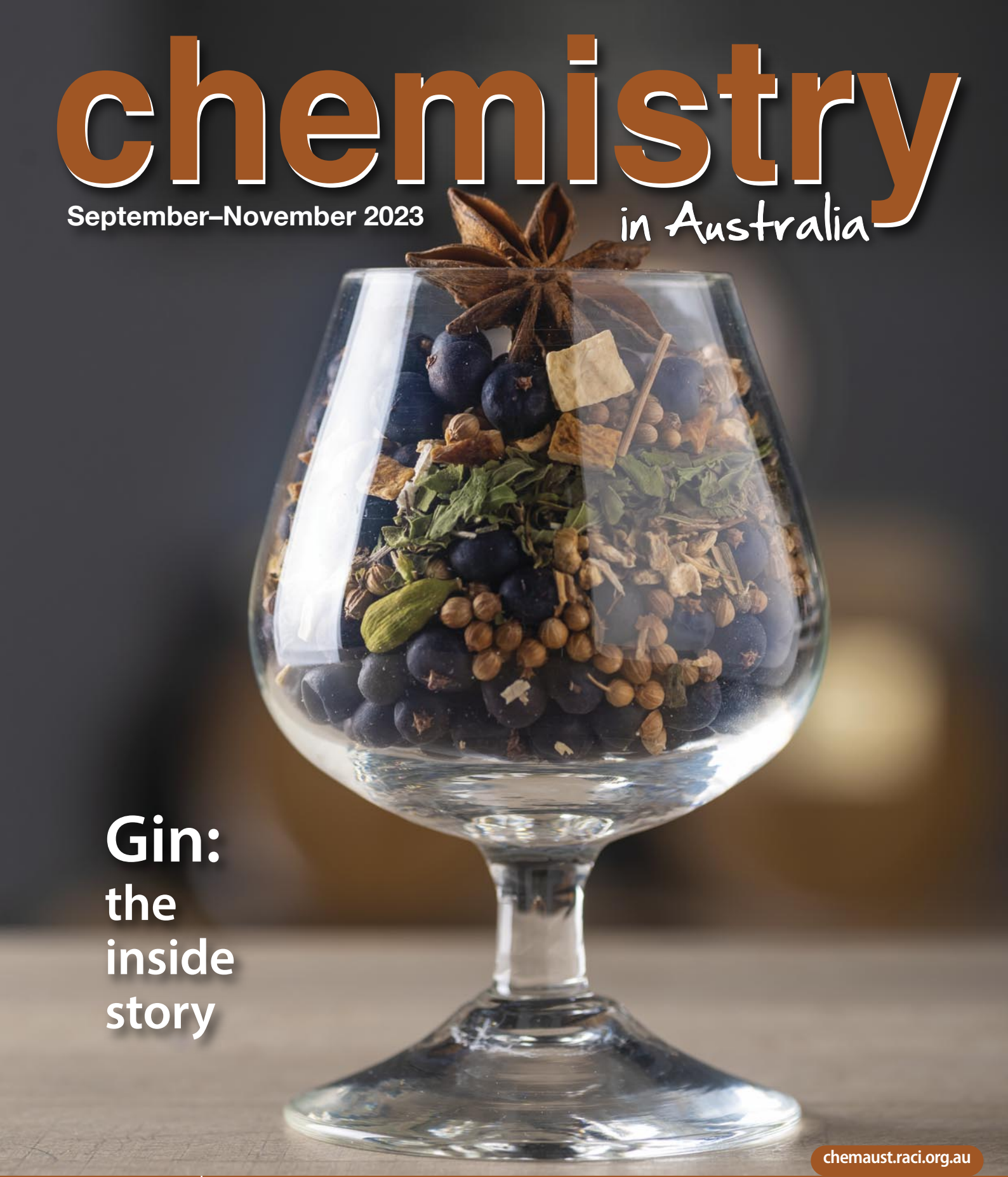
chemistry in Australia

September–November 2023



Gin: the inside story

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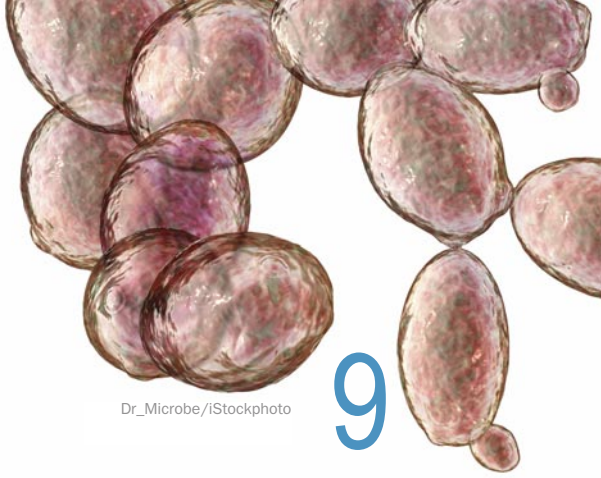

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cover story

Gin production: art and science (and a splash of tonic)

From medicinal uses to a craft explosion, gin's history – and its list of ingredients – is long and varied.

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NMI scientists delve into the significance of measurement in the health sector, from pet food to pharmaceuticals.

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Cheers to communicating chemistry

I first started working with RACI (as an editorial assistant) in 1996. Later that year, Robert Curl, Harold Kroto and Richard Smalley received the Nobel Prize in Chemistry for their discovery of fullerenes.

Two years later, on accepting the Dalton Medal at Manchester University, Kroto said:

> *Scientific discoveries matter much more when they're communicated simply and well – if you can't explain your work to the man in the pub, what's the point?*

Well said, Harry Kroto. Science is a tough and competitive gig, and research funding can be difficult to come by. The more non-scientists who appreciate and respect scientists and their work (and perhaps even vote for it), the better.

My career has largely revolved around the core of Kroto's statement. In my work, the layperson has often been a young science student using a textbook. And although *Chemistry in Australia* is read largely by chemistry professionals, the field of chemical sciences is so broad that most readers would essentially be layreaders sometimes.

At the end of this year, I will finish my role as editor of *Chemistry in Australia*, which I have held since 2009. My key goal was to produce not only a magazine about chemistry professionals and their work, but one that extended to their broader interests beyond chemistry. I hope I have achieved some measure of that.

Next year, I plan to explore some other avenues of editing and publishing. I hope my successor finds both challenge and satisfaction in the magazine editorship, as I have done.

I've worked closely with Catherine Greenwood and Guy Nolch to produce close to 200 issues of *Chemistry in Australia*. Catherine and Guy, thank you for being such a great team – it's been a wonderful journey and I will miss our collaboration immensely.

… thank you to all of the contributors who have shared their writing – many regularly, and some for many years. The pulse of this magazine is in your stories.

Thanks to those hard-working committee members, past and present, who have volunteered their time, expertise and advice to keep the magazine running smoothly. In particular, I'm most grateful for the abundant generosity and encouragement of committee chairs the late David Wood, Sam Adeloju and Richard Thwaites; and for the longstanding support and advice of Ian Rae.

Thank you to section editors Matthew Piggott, David Huang, Reyne Pullen and Damien Blackwell, who have generously commissioned research and education highlights and book reviews for each issue.

Thank you to everyone at the RACI – at the National Office, and all the branches and divisions around the country – who has supported the magazine.

Last but not least, thank you to all of the contributors who have shared their writing – many regularly, and some for many years. The pulse of this magazine is in your stories.

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ISSN 0314-4240 e-ISSN 1839-2539

Vale Don Watts

When I was an undergraduate at the University of Western Australia, Don Watts was one of my lecturers. He was a brilliant and inspiring teacher. When I commenced Honours and then PhD degrees, he treated students as important, junior peers. He broke down barriers between staff and students. As an example, I remember a staff–student squash tournament. Don, being a former state squash champion, agreed to the student committee's handicap conditions – having his two legs tied together by about half a metre of rope! All to no avail for us students because he still beat all comers! Proof that 'old age and cunning will always beat youth and enthusiasm'.

It is with a sense of privilege that I remember Don – along with the many other outstanding and inspiring lecturers and researchers who blessed me at the University of Western Australia.

Stephen Grocott FRACI CChem

Brian Schmidt's big ideas on Australian R&D

This was an excellent and thought-provoking article (June–August 2023, p. 34). I commend Professor Schmidt. Outside of foundational/curiosity R&D, I make the following suggestions as supplementary ideas to Schmidt's submission.

- Greatly increase the R&D tax rebate for business R&D. Greatly simplify the bureaucratic nightmare of the regulatory and approval processes.
- If Australian university R&D is to be deployed, then it will almost certainly be deployed in or by Australian businesses. Therefore, we need to better align business needs and opportunities with university R&D. Therefore, for business R&D that is spent at universities (and perhaps other institutions like CSIRO and ANSTO), double the R&D tax rebate. Identify other simple incentives and rewards for industry funding and engagement.
- If this is too much for the Commonwealth to fund, then restrict it to priority areas – but don't change those areas too often – no more often than, say, a rolling 5–10-year timeframe.
- If we want postgraduates to be industry/business ready, then reward industry/business for funding their projects.
- And above all, please, please make all administrative processes (submissions, approvals, monitoring) simple and very fast. It is better to accept the risk of a small amount of rorting or diffuse application than to exclude a lot of great opportunities by burdening them with process. Perfect is the enemy of good.

Of course, any changes need bipartisan political support and, for a few areas of vested interests, to be divested.

Stephen Grocott FRACI CChem

Industrial chemists and RACI

Anthony Zipper's letter 'Industry membership – some thoughts for food' (June–August 2023, p. 5) struck a familiar note with me. I was an industry chemist, fee-paying member of RACI for all the 46 years I was eligible for membership. During that time I lived in remote places, overseas, and was otherwise generally unable to attend city-centric institute events. I can recall only one instance nearly 50 years ago when an employer saw intellectual benefit in me attending an RACI conference. My industry employers generally liked to see a direct link between items discussed and papers read to their own specific technologies before paying for the considerable cost of sending someone to a meeting or conference. Many employers do not see that there is intellectual stimulation to be derived from learning things outside the confines of the employer's technology that may spark problem-solving ideas for the company.

For most of my career, the monthly *Proceedings of the RACI* and later *Chemistry in Australia* was my one link to my profession, the thing that reinforced my feeling of being a chemist and gave me the feeling of being a part of a wider community. With publication of *Chemistry in Australia* now being only four times a year, this opportunity for industry chemists working and living outside the inner metropolitan areas has been reduced severely. If full membership results in a member receiving *Chemistry in Australia* only, then the current price of an issue is between $42.50 and $73.75, depending on membership grade. According to Anthony Zipper, approximately half of RACI's membership works in industry. Industry members certainly deserve a better deal.

Given the diversity of industries in which chemists in Australia are employed, it is difficult to fashion a 'one size fits all' approach to industry that encourages membership of its chemists and their engagement with RACI. RACI management should have the freedom and flexibility to negotiate individual packages that best suit the company and the chemists it employs. For instance, with fewer young people studying STEM subjects, employee retention may become more significant in a company's thinking. Thoughtfully crafted packages may assist a company in holding on to valued employees.

There is another aspect. Industry chemists should be encouraged, perhaps through a survey, to say what they want from RACI. I must confess my own failing in this regard. I can't recall making my own feelings and wants as a professional chemist known to RACI through all my working life. I now regret not having done so.

Tom Smith FRACI CChem

Recognising industry members

A.F. Zipper expresses concern about the recognition of RACI members based in industry (July–August 2023, p. 5). I wonder whether he has considered the recognition that 'industry' has accorded RACI.

I have only ever held one industrial post. That was from 1983 to 1987 with the then State Electricity Commission of Victoria at its R&D centre in Richmond, the Herman Research Laboratory. The advertisement for the post in *The Age* said that applicants should have qualifications recognised by RACI. After I had been at Herman Research Laboratory for about a year, I applied for another industrial R&D post (which I was offered and declined) and that also specified 'qualifications recognised by RACI'. In an organisation having parallel subprofessional and professional staffs, promotion from the former to the latter could be brought about by further study to obtain RACI postnominals.

Clifford Jones FRACI CChem

'Your say' guidelines

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

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Send letters to wools@westnet.com.au.

STEM enrolments rising, work towards equity continues

-The Australian Government's 2023 STEM Equity Monitor, released in July, shows that the number of students enrolling in science, technology, engineering and mathematics (STEM) subjects in their final year of school has increased, and nearly reached gender parity.

The data is promising and highlights an opportunity to engage students much earlier in their schooling journey in STEM through programs like Future You, an educational program developed and led by the Australian Government's Women in STEM Ambassador, Professor Lisa Harvey-Smith.

'There is a tremendous opportunity for every child in Australia to contribute to tackling global challenges like climate change, and it is people with STEM skills who will create the technologies that take us there.

'We need to ready young people for the jobs of tomorrow, where it's predicted that half of workers will need to know how to work with digital systems – a critical skill embedded in STEM studies', said Harvey-Smith.

From 2020 to 2021, year 12 STEM subject enrolments increased by almost 3000 students, with more than half of these being girls. Girls make up a large proportion of students enrolled in the biological and earth sciences but remain underrepresented in IT, physics and engineering.

'Australia imports more than 50% of our engineers from overseas because young people are not choosing engineering pathways. Research tells us that this is because they don't understand what an engineer does, and they aren't aware of all the different specialities within STEM.

Future You is working to increase participation in STEM subjects and careers by eliminating stereotypes about the type of people who work in STEM and increasing awareness about STEM careers among children aged 8–12, parents and educators.

'It's not just girls who feel that STEM may not be for them. Damaging stereotypes, negative perceptions and other obstacles are holding many children back from following a career pathway in STEM, but programs like Future You can support greater understanding of relevant STEM pathways for all', said Hilary Schubert-Jones, program manager for Future You.

The STEM Equity Monitor 2023 report provides insights into equity in STEM, and where future efforts are best focused. Investing in education programs such as Future You is an integral part of ensuring Australia continues to progress towards a more equitable STEM workforce.

Professor Lisa Harvey-Smith, Women in STEM Ambassador.

Future You Australia

Record-breaking intake of STEM ambassadors to Parliament

A growing number of parliamentarians seeking regular expert advice on complex science and technology issues has seen Science & Technology Australia appoint a record-breaking 26 new STEM Ambassadors in 2023.

The STEM Ambassadors program was created by Science & Technology Australia (STA) in 2019 to expand access to expert advice on exciting opportunities emerging from science, technology, engineering and maths.

The 2023 intake of STA STEM Ambassadors will meet regularly with their matched federal MP or senator over the next two years.

STA Chief Executive Officer Misha Schubert said a record-breaking number of MPs and senators joined the program in 2023 to deepen their access to expert insight on emerging capabilities.

'We're at a remarkable point in history where an explosion of complex science and technology advances are about to dramatically reshape our economy, our lives and our jobs', she said.

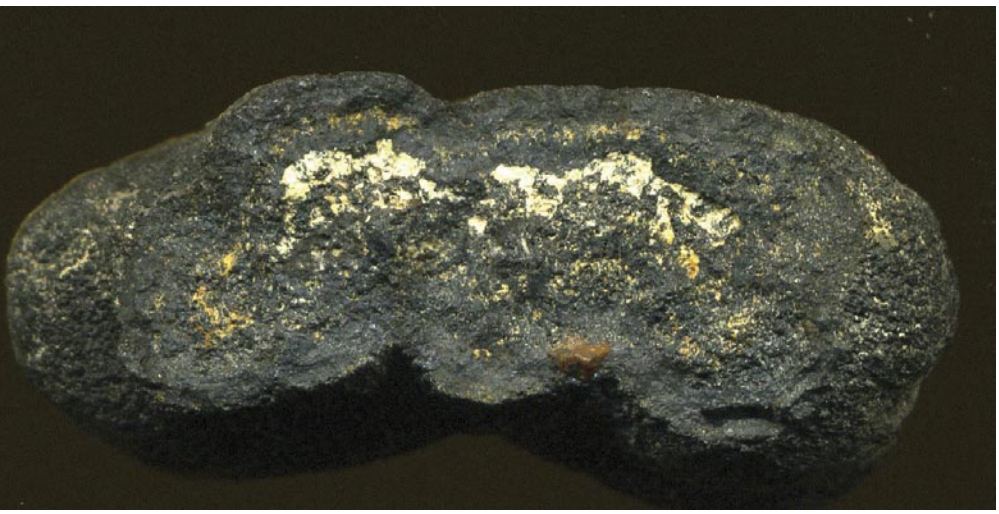
'And what we're seeing in response is a strong surge in the need for expert advice as lawmakers seek to keep pace with those developments and learn more about new technologies and their implications.'

'Through this unique program, we match MPs and senators with their own STA STEM Ambassador to give them regular access to a powerful network of Australian STEM experts to inform policy development.'

'We're delighted to welcome our 2023 STA STEM Ambassadors and thank them in advance for sharing their expertise and developing a strong working relationship with their MPs and senators.'

Science & Technology Australia

Leading European scientists urge moratorium on deep-sea mining



Pelagite (deep seafloor manganese nodule, 8–9 millimetres thick) from the Pacific Ocean seafloor. Some portions of the deepest seafloors of the world have common to abundant dark-coloured, manganese-rich nodules. James St John

Rising global hunger for rare minerals is driving commercial interest in deep-sea mining and its potential exploitation on a massive scale. The International Seabed Authority (ISA) could soon give the green light for wholesale industrial development of the deep oceans. In an urgent appeal, Europe's science academies warn of the dire consequences on marine ecosystems and challenge the business case for deep-sea mining on any scale until recycling potentials have been fully explored.

Several European countries are sponsors of mining contracts with the ISA, and Norway is planning to exploit minerals within its own exclusive economic zone and extended continental shelf.

Supporters of deep-sea mining maintain that increased rare minerals demand in 'green technologies' such as wind, solar and batteries cannot be met from terrestrial sources. Having examined forecasts, the European Academies of Science Advisory Council (EASAC) is sceptical that deep-sea mining is necessary to cover the needs for critical materials.

'The narrative that deep-sea mining is essential to meeting our climate targets and thus a green technology is misleading', said Michael Norton, EASAC Environment Director. 'Deep-sea mining would not provide many of the critical materials needed for the green transition and other high-tech sectors. In addition, recycling rates can be vastly improved, and future technological innovation has not been adequately considered in forecasts.'

Should the ISA decide to allow commercial mining to proceed this year, millions of square kilometres of the seabed could be affected. 'Though major gaps remain in our understanding of the environmental impacts in such remote environments, very large areas of the seabed will be damaged and the biota killed. There is also a risk of substantial secondary effects from the large amounts of sediment released', explained Professor Lise Øvreås, of Bergen University, Norway. 'The seabeds have taken thousands of years to form, and the damage will be irreparable on similar timescales.'

Questions also remain on carbon cycles and genetic resources. How to evaluate and mitigate such effects is a huge challenge for the ISA, which has a legal duty to avoid serious harm to the marine environment.

'There is no agreement on what constitutes serious harm or how to measure environmental impact, so it is difficult to see how ISA can fulfil its mission', said Lars Walløe, Chair of EASAC's Environment Steering Panel. Only now is work starting on setting some physical indicators for environmental thresholds but key ones such as effects on biodiversity and ecosystem services are not even under review.

Professor Peter Haugan, Policy Director at the Institute for Marine Research in Bergen, Norway, added: 'The ocean was the origin of life on Earth. With so much biodiversity, it would be reckless to dive into deep-sea mining and destroy these ecosystems which are so vital to our survival. It also completely counteracts recent decisions to protect biodiversity in the Convention on Biological Diversity and the new "High Seas Treaty". We should pause to reflect instead of rushing to an early decision that will later be regretted.'

EASAC also notes that nation states have large areas of deep sea and its minerals in their exclusive economic zones and may go ahead irrespective of the lack of an international consensus. Any exploitation should be properly monitored and incremental. Knowledge and experience should be shared with the international community as an imperative.

EASAC concludes that the science supports parties such as the European Commission and some member states in their call for a moratorium until scientific standards for environmental protection are developed in line with the international conventions in place.

European Academies Science Advisory Council

Completely defining the process of methylation

UNSW Sydney researchers have completely defined the essential cellular process known as methylation. The study, published in the *Proceedings of the National Academy of Sciences* (doi.org/10.1073/pnas.2215431120) emphasises the essential role of methylation in the synthesis of proteins.

Dr Joshua Hamey and Professor Marc Wilkins, from the School of Biotechnology & Biomolecular Sciences, have completely defined what proteins in a yeast cell carry methyl groups, where the tag is found, and what machinery has been used to put them there.

'There are some aspects of the cell that have been comprehensively understood for a while now, such as the DNA sequence of many genomes', said Dr Hamey. However, other systems, such as the cell's chemical tagging of proteins, are almost never systematically understood.

Through a review of the existing literature on methylation, the pair came to the conclusion that we do know the vast majority of this process, and there's very little left to be discovered.

'We've proposed a near-complete picture of this system', said Hamey. 'And while it implies that there's not more detail to be discovered in this area, it opens up exciting new questions about the system as a whole and what this methylation tag actually does.'

Within a cell, proteins can be tagged with small molecules, which serve as units of information or data. But until now we have never known how many of any type of protein tag the cell has and how the cell puts them there.

The system of methylation includes enzymes that modify another protein by adding a methyl group, and 'tagging' it. The addition of methyl groups can affect how some molecules act in the body and changes to the methylation patterns of genes or proteins can influence a person's risk of developing certain diseases, including cancer.

Over the years, Wilkins, Hamey and others discovered more features of this process, until fewer and fewer features were being identified.

Together, Hamey and Wilkins systematically analysed all the existing literature on the process of methylation in yeast. 'We found a way to catalogue the evidence for and against there being "more" to discover in the biological system of methylation', said Wilkins.

In any methylation process, there is a connection between two proteins (the enzyme carrying the methyl group and the protein being methylated), that make up the core unit of this system. 'So if there was more to be discovered, there's essentially going to be an interaction between these two proteins that we don't know about', said Hamey.

Through this systematic process, they came to the conclusion that methylation is essentially completely understood in the model organism yeast.

A large number of these methylation events are very important for controlling the cell's response to external signals, as well as signalling inside the cell. These signalling processes are important for controlling the state of the cell – in particular the machinery that builds proteins.

'As a result of our systematic review we can say that this system seems to be mostly about controlling the way that the cell makes proteins, which is central to how the cell functions', said Hamey.

Having a complete picture of methylation, and its essential role in protein synthesis, opens up new avenues for how we may able to control aspects of cell growth and behaviour.

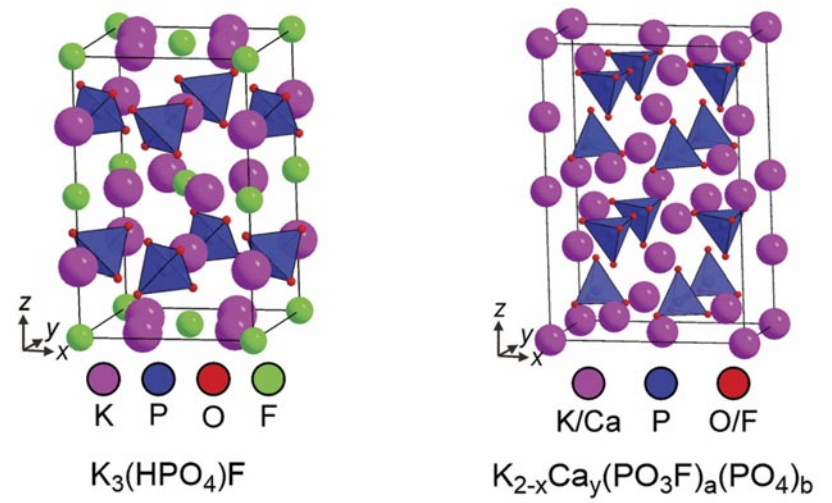
'We focused our work on the yeast cell – which has many similarities to the human cell but is simpler to study – and the findings have direct implications for the manipulation of yeast in things like brewing, baking and biofuels and also how yeast and fungal infections in patients – such as candidiasis and tinea – can potentially be treated,' said Wilkins.

'What's more, now that we have this complete map, we are able to ask systematic questions about why this system evolved and its function in controlling central biological processes,' said Hamey. 'These are the questions we are now tackling.'

UNSW Sydney

Image: *Saccharomyces cerevisiae* yeast
Dr_Microbe/iStockphoto

Hazard-free production of fluorochemicals



Using high-precision techniques, such as X-ray diffraction, the researchers unlocked key insights into the composition of Fluoromix and structures of the fluorinating species. The diagram shows structures of crystalline constituents of Fluoromix, which serve as fluorinating reagents. Professor Michael Hayward

Chemists have developed an entirely new method for generating critically important fluorochemicals that bypasses the hazardous product hydrogen fluoride (HF) gas. The findings, published in *Science* (science.org/doi/10.1126/science.adi1557), could have an immense impact on improving the safety and carbon footprint of a growing global industry.

Fluorochemicals have a wide range of important applications – including as polymers, agrochemicals, pharmaceuticals and the lithium-ion batteries in smartphones and electric cars – with a $32 billion global market in 2018. Currently, all fluorochemicals are generated from the toxic and corrosive HF in a highly energy-intensive process. Despite stringent safety regulations, HF spills have occurred numerous times in the last decades, sometimes with fatal and detrimental environmental results.

To develop a safer approach, chemists at the University of Oxford alongside colleagues in Oxford spin-out FluoRok, University College London, and Colorado State University, took inspiration from the natural biomineralisation process that forms teeth and bones. Normally, HF itself is produced by reacting the crystalline mineral fluorspar (CaF_2) with sulfuric acid under harsh conditions, before it is used to make fluorochemicals. In the new method, fluorochemicals are made directly from CaF_2, completely bypassing the production of HF: an achievement that chemists have sought for decades.

In the novel method, solid-state CaF_2 is activated by a biomineralisation-inspired process, which mimics the way that calcium phosphate minerals form biologically in teeth and bones. The team ground CaF_2 with powdered potassium phosphate salt in a ball-mill machine for several hours, using a mechanochemical process that has evolved from the traditional way that we grind spices with a pestle and mortar.

The resulting powdered product, called Fluoromix, enabled the synthesis of more than 50 different fluorochemicals directly from CaF_2, in up to 98% yield. The method developed has the potential to streamline the current supply chain and decrease energy requirements, helping to meet future sustainability targets and lower the carbon footprint of the industry.

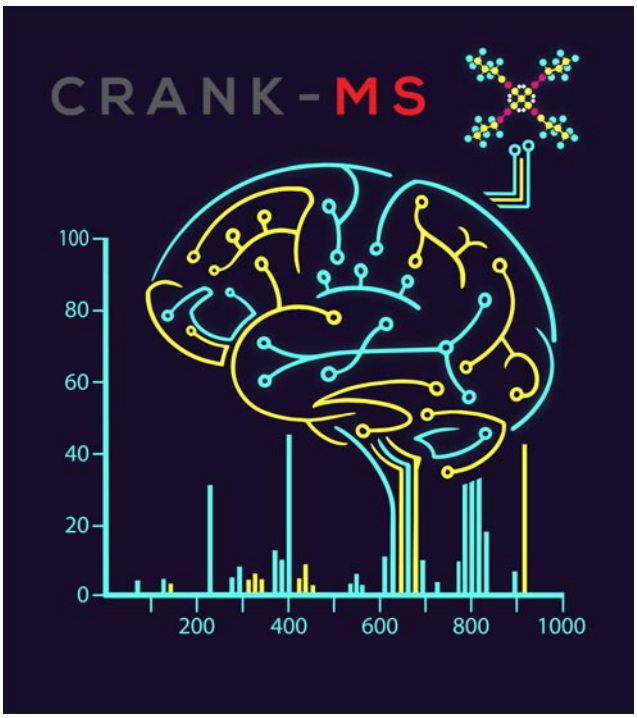
Excitingly, the solid-state process developed was as effective with acid-grade fluorspar (>97% CaF_2) as it was with synthetic reagent-grade CaF_2. The process represents a paradigm shift for the manufacturing of fluorochemicals and has led to the creation of FluoRok, a spin-out company focusing on the commercialisation of this technology and the development of safe, sustainable and cost-effective fluorinations. The researchers hope that this study will encourage scientists around the world to provide disruptive solutions to challenging chemical problems, with the prospect of societal benefit.

Lead author Professor Véronique Gouverneur, from the Department of Chemistry, University of Oxford, who conceived and led this study said, 'The transition to sustainable methods for the manufacturing of chemicals, with reduced or no detrimental impact on the environment, is today a high-priority goal that can be accelerated with ambitious programs and a total re-think of current manufacturing processes. This study represents an important step in this direction because the method developed in Oxford has the potential to be implemented anywhere in academia and industry, minimise carbon emissions, for example by shortening supply chains, and offer increased reliability in light of the fragility of global supply chains.'

University of Oxford

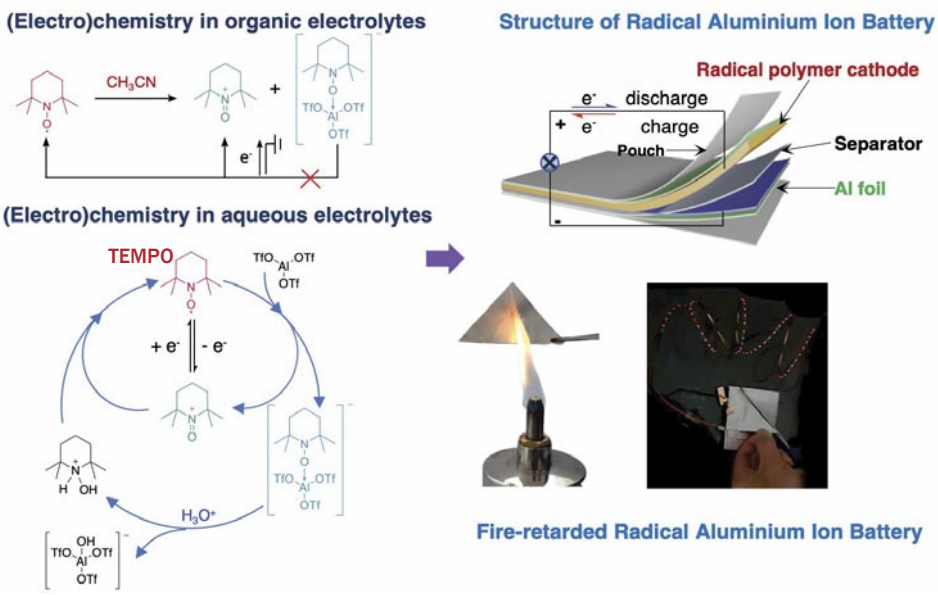
AI predicts Parkinson's disease early with metabolomics data

Parkinson's disease is the fastest growing neurological disease, with 38 Australians diagnosed daily. The disease is typically diagnosed by the onset of motor symptoms such as slow movement, a resting tremor, stiffness and balance issues. There is no specific test and early non-motor symptoms such as apathy and constipation that pre-date clinical diagnosis can often be overlooked or misdiagnosed. Recently, a team of researchers from UNSW Sydney and Boston University (USA) developed an artificial intelligence (AI) tool that can predict Parkinson's disease with 96% accuracy up to 15 years before clinical diagnosis (Zhang J.D., Xue C., Kolachalama V.B., Donald W.A. *ACS Cent. Sci.* 2023, **9**, 1035–45). By analysing mass spectrometry-based metabolomics data from blood samples collected years before diagnosis, AI was used to identify key metabolites, such as a triterpenoid with potential neuroprotectant properties that may be associated with preventing the disease, and a synthetic chemical associated with an increased risk. Using AI to detect Parkinson's disease early may ultimately enable better disease management and intervention strategies, which can help to improve patient quality of life and reduce healthcare costs. The AI tool, titled CRANK-MS, is publicly available on GitHub.



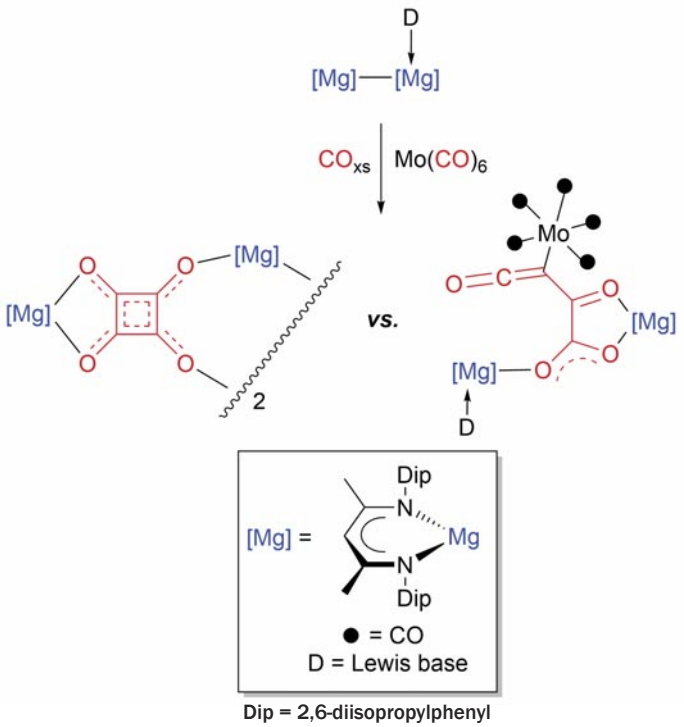
Radical aqueous aluminium batteries

An international collaboration between Flinders University and Zhejiang Sci-Tech University (China) has reported the first aqueous aluminium radical battery (Jiang S., Xie Y., Xie Y., Yu L.-J., Yan X., Zhao F.-G., Mudugamuwa C.J., Coote M.L., Jia Z., Zhang K. *J. Am. Chem. Soc.* 2023, **145**, 14 519–28). Stable radicals such as TEMPO have been widely used as organic cathodes in batteries due to their high voltage output. However, radical materials have never been applied in aluminium-ion batteries due to a lack of understanding of their (electro)chemical reactions in aluminium-based electrolytes. The team discovered that irreversible disproportionation and electrochemical redox reactions of TEMPO radicals in an organic Lewis-acid electrolyte containing $Al(OTf)_3$ prevents their application in aluminium-ion batteries. Surprisingly, the irreversible redox reaction that occurs in organic electrolytes becomes reversible when the electrolyte is switched to an aqueous one. Density functional theory calculations further confirmed that the Lewis acid $Al(OTf)_3$ promotes disproportionation of TEMPO in both organic solvents and water, but that this process is reversible in the latter. The team then demonstrated the first aqueous aluminium radical batteries, which were fire retardant and air stable, and delivered a stable voltage output of 1.25 V and a capacity of 110 mAh g^{-1} over 800 cycles with only 0.028% loss per cycle.



CO squared

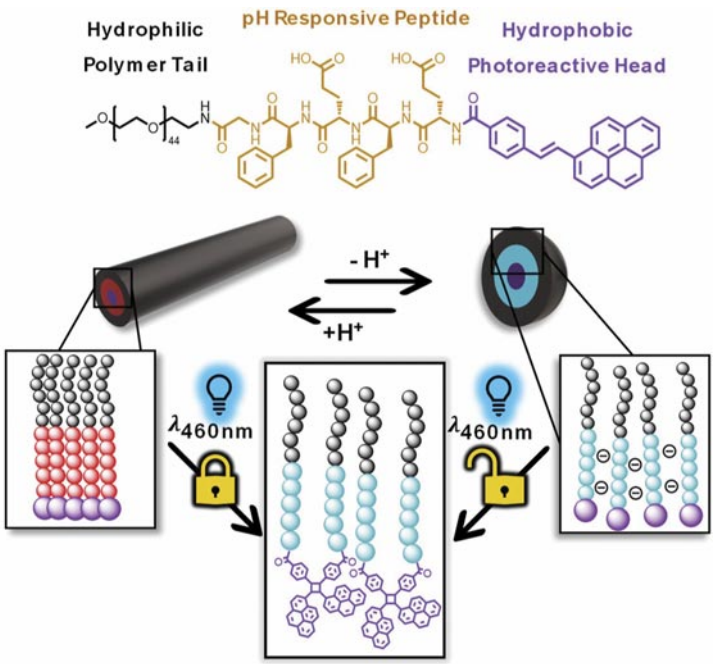
Studies of the reductive oligomerisation of carbon monoxide under mild homogeneous conditions have been used to shed light on the mechanisms of industrial processes such as Fischer–Tropsch, in which the molecule acts as a C_1 building block in the formation of value-added products, including higher alcohols. In this respect, and in recent years, the group of Cameron Jones at Monash University has used its reactive dimagnesium(I) compounds to selectively reduce CO to the oxygenates, $[C_nO_n]^{m-}$ (n = 2, 3 or 6; m = 2 or 6). Collaborating with theoretician Laurent Maron from the University of Toulouse (France), the team has now shown that selective reductive tetramerisations of CO can also be achieved, by combining dimagnesium(I) activation by simple Lewis base coordination with a cooperative heterobimetallic strategy (Yuvaraj K., Mullins J.C., Rajeshkumar T., Douair I., Maron L., Jones C. *Chem. Sci.* 2023, **14**, 5188–95). The two CO-derived product types, magnesium squarates and metallo-ketenes, are unprecedented as isolated species. Moreover, the distribution of the two product types can be readily manipulated by altering the reaction conditions. This control over CO homologation processes will be exploited to selectively access higher CO oligomers in future studies.



Dip = 2,6-diisopropylphenyl

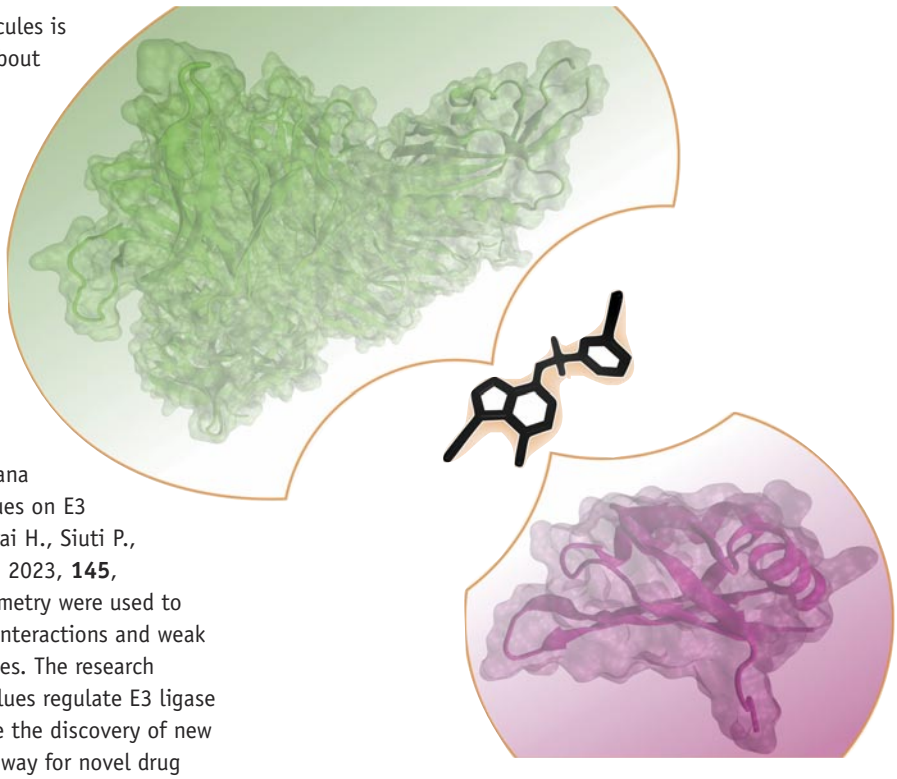
Self-assembled photoligation

Bioorthogonal chemistry relies on chemical ligations that occur efficiently under mild conditions in water. Expanding the limited toolbox of such reactions typically involves covalent modification of reactive functional groups. Inspired by the controlled reaction environments that enzymes provide, researchers in the Queensland University of Technology's Soft Matter Materials Laboratory led by ARC DECRA Fellow Hendrik Frisch and PhD student Bailey Richardson explored a fundamentally different approach that makes inefficient reactions highly efficient within defined local environments (Richardson B.J., Zhang C., Rauthe P., Unterreiner A.-N., Golberg D.V., Poad B.L.J., Frisch H. *J. Am. Chem. Soc.* 2023, **145**, 15 981–9). In contrast to what occurs in enzyme-catalysed reactions, in this new approach the targets of ligation themselves control the self-assembled environments. Targeting [2 + 2] photocycloadditions, which are often inefficient at low concentrations and hindered by oxygen, short β-sheet-encoded peptide sequences were inserted between a hydrophobic photoreactive styrylpyrene unit and a hydrophilic polymer. At high pH, these polymer conjugates self-assembled into micelles, which enabled efficient ligation, overcoming the concentration limitations and oxygen sensitivity of [2 + 2] photocycloadditions. At low pH, the assembly turned into 1D fibres, altering the photophysical properties and halting the photocycloaddition. Thus, changing the pH reversed the morphology and controlled photoligation, enabling a switch 'on' or 'off' under constant irradiation as a function of pH.



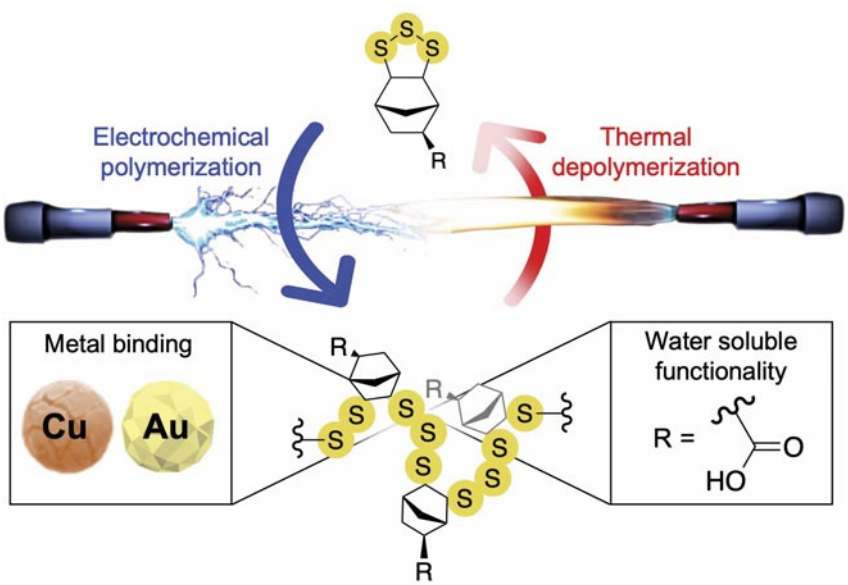
Reprinted with permission from Richardson B.J., Zhang C., Rauthe P., Unterreiner A.-N., Golberg D.V., Poad B.L.J., Frisch H. *J. Am. Chem. Soc.* 2023, **145**, 15981–9.

Unveiling mechanisms of molecular glues for targeted protein degradation



Targeting proteins involved in disease with small molecules is a conventional approach in drug discovery. However, about 80% of human proteins lack suitable binding sites, rendering them classically 'undruggable'. To overcome this problem, an emerging approach is to use molecular glues for targeted protein degradation, a novel strategy to destroy disease-associated proteins. Molecular glues interact with E3 ligases and redirect their binding specificity towards specific protein targets, marking them for proteasomal degradation. However, challenges associated with quantifying ternary complex formation and identifying weak E3 ligase–protein interactions that could be 'gluable' hinder the development of molecular glues. Recently, researchers from UNSW Sydney and Triana Biomedicines shed light on the effects of molecular glues on E3 ligase and protein target assembly (Huang X., Kamadurai H., Siuti P., Ahmed E., Bennett J.L., Donald W.A. *J. Am. Chem. Soc.* 2023, **145**, 14 716–26). Native mass spectrometry and mass photometry were used to provide insight into E3 ligase–protein–molecular glue interactions and weak ligase–neosubstrate interactions without molecular glues. The research unveiled a secondary mechanism, whereby molecular glues regulate E3 ligase oligomeric assemblies. These findings should accelerate the discovery of new molecular glues and E3 ligase–target pairs, paving the way for novel drug development and disease treatments.

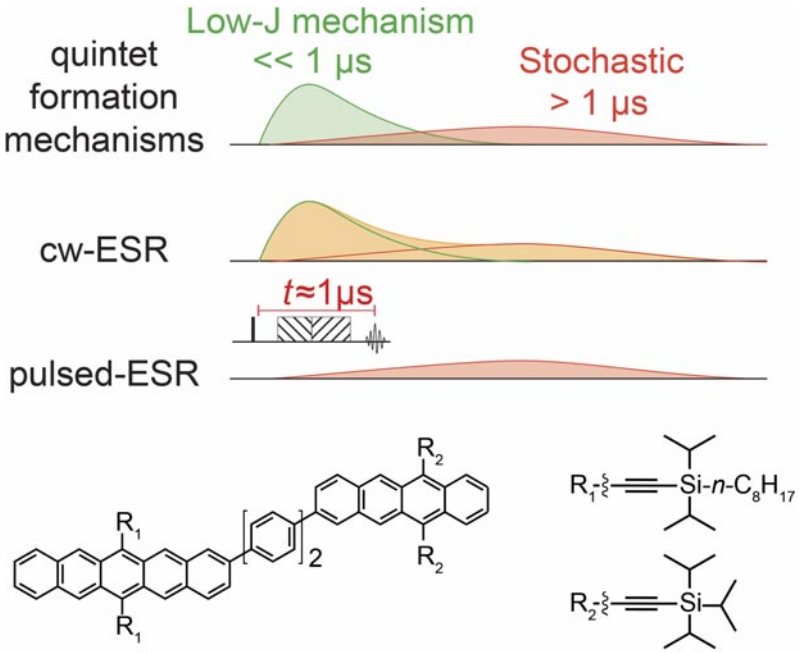
Electrifying chemistry



An interdisciplinary team at Flinders University has discovered a new way to make sulfur-rich polymers by using electrochemistry (Pople J.M.M., Nicholls T.P., Pham L.N., Bloch W.M., Lisboa L.S., Perkins M.V., Gibson C.T., Coote M.L., Jia Z., Chalker J.M. *J. Am. Chem. Soc.* 2023, **145**, 11 798–810). The key monomer is a cyclic trisulfide that, when reduced electrochemically, undergoes efficient ring-opening polymerisation. The poly(trisulfide) product can be made at room temperature, which is an advantage over alternative synthetic methods for this class of materials. The trisulfide groups in the backbone of the polymer are useful for several applications. For instance, the S–S bonds can be broken and re-formed, which allows chemical recycling of the polymer and conversion back to its monomer. Furthermore, the team showed that these polymers bind to valuable metals such as gold and copper. They also carried out quantum mechanical calculations to elucidate the mechanism of the polymerisation. The findings were surprising and fortuitous: the reversibility of the reaction provides a pathway for 'self-correction' during propagation, which ensures repeating trisulfide links across the polymer. Future applications of this class of materials include environmental remediation, gold mining and electronic waste recycling.

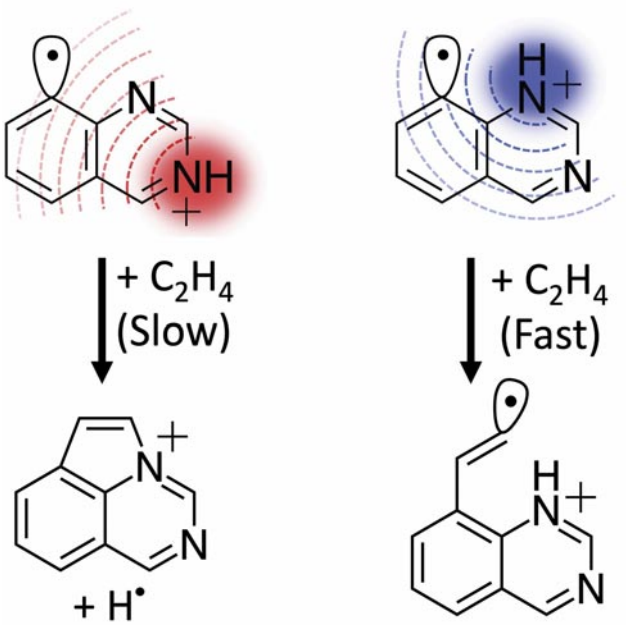
Pulsed and continuous-wave ESR probe different spin populations

Singlet fission is a process by which an excited singlet state transitions to a triplet pair state with correlated spins. The unique spin physics of singlet fission has potential applications in quantum computing and biomedical imaging. However, the spin coherence of the triplet pair state has been hotly debated since the first electron spin resonance (ESR) studies of singlet fission were published recently. Now, researchers at the University of New South Wales, Columbia University (USA) and City University of New York (USA) have demonstrated that at least two populations of triplet pair states exist: a stochastically formed coherent pair subpopulation that is selectively probed using pulsed ESR, and a majority population of incoherent triplet pairs that remain coupled and dominate continuous-wave ESR measurements (MacDonald T.S.C., Tayebjee M.J.Y., Collins M.I., Kumarasamy E., Sanders S.N., Sfeir M.Y., Campos L.M., McCamey D.R. *J. Am. Chem. Soc.* 2023, **145**, 15 275–83).



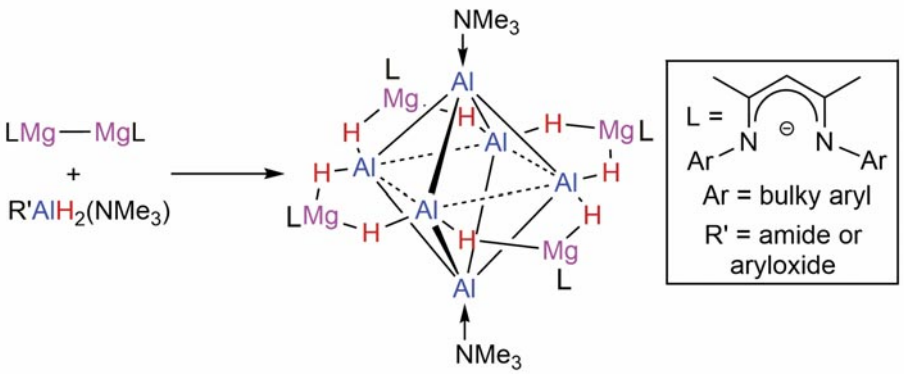
Controlling reactivity and selectivity with charge

A burst of recent studies has shown how oriented electric fields can catalyse reactions, guide product formation and tune photochemistry. However, experimental methods suited to investigate the effect of oriented electric fields on chemistry are scarce, since placing molecules in a precise orientation to an electric field is not straightforward. Charge tagging molecules provides an alternative strategy to generate an oriented field. Researchers at the University of Wollongong have exploited this strategy, measuring the radical kinetics of two gas-phase protonation isomers for the first time and demonstrating significant differences in reactivity (Shiels O.J., Marlton S.J.P., Trevitt A.J. *J. Am. Chem. Soc.* 2023, **145**, 15 024–29). The isomers were first separated and isolated via ion mobility, then probed by laser-equipped ion-trap mass spectrometry and gas-phase kinetics (see representation on p. 3). The researchers showed that the subtle variation of the protonation location in the quinazoline distonic radical cation drove a two-fold increase in radical reactivity, which was explained by through-space electrostatic interactions. Crucially, only the DSD-PBEP86 density functional theory method, a modern double-hybrid functional specifically designed to calculate long-range interactions, was sufficient to rationalise the experimental results. Routine density functional theory methods were not able to capture the underlying interactions.

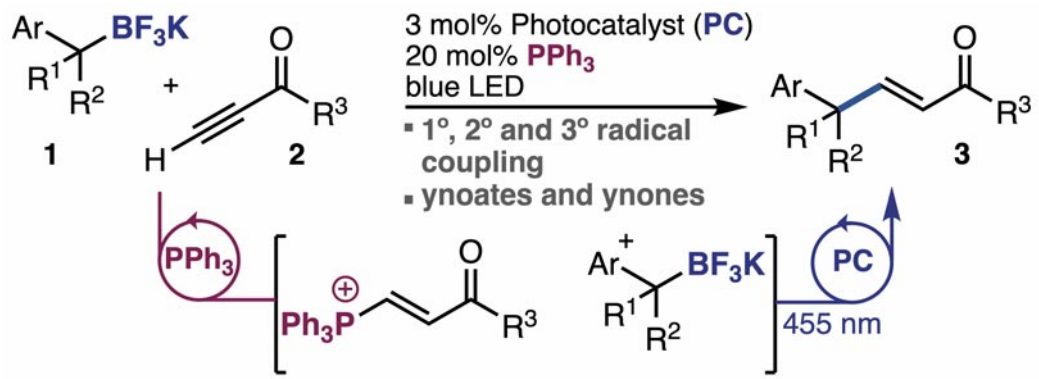


Very low oxidation-state Al hydride clusters

Binary borane compounds such as $[B_6H_6]^{2-}$ played a pivotal role in the development of main group chemistry in the 20th century. Despite this, stable aluminium hydride (alane) analogues of these species are almost unknown. This situation has been reversed over the past 5 years by the Jones group at Monash University, which has succeeded in preparing a series of stable Al–Al covalently bonded aluminium hydride compounds and clusters, with the metal in either the +1 or +2 oxidation state. Most recently, the team has shown that reductions of a range of simple amido- and aryloxy-aluminium dihydrides with Monash-developed dimagnesium(I) reagents leads to mixed-valence octahedral Al hydride clusters with an $[Al_6H_8]^{4-}$ core (Mullassery S., Yuvaraj K., Dange D., Jones D.D.L., del Rosal I., Piltz R.O., Edwards A.J., Maron L., Jones C. *Angew. Chem. Int. Ed.* 2023, **62**, e202305582). The average Al oxidation state of these clusters is an unprecedented +0.66. Computational studies by collaborator Laurent Maron of the University of Toulouse (France) revealed the clusters to have seven skeletal molecular orbitals delocalised over the cluster's octahedral core. The team is now looking to extend the ranks of polyhedral alane clusters, and to explore their applications in synthesis and materials chemistry.



Radical approach to bond formation via phosphine organocatalysis



Phosphines are one of the most important types of Lewis-base catalyst and were instrumental in pioneering reactions discoveries from the first wave of organocatalysis. As a consequence, a broad array of reactive intermediates with enhanced nucleophilicity or electrophilicity have been invoked over the last half century in a dizzying array of reaction designs. In a first for phosphine organocatalysis, the Polyzos (University of Melbourne) and Lupton (Monash University) groups have exploited single-electron reduction of one such species to make use of polarity changes normally exploited to enable polar reactions to enable radical-coupling reactions instead (Cao J., Seitz A., Forni J.A., Polyzos A., Lupton D.W. *Angew. Chem. Int. Ed.* 2023, **62**, e202303869). Specifically, it was possible to achieve a Giese-type coupling between trifluoroborates (**1**) and ynoates/ynones (**2**) to give an array of β-alkyl enoates (**3**). The reaction design showed sensitivity to the oxidation potential of the phosphine and remained viable with a number of organic photocatalysts. Mechanistic studies supported the hypothesis that the phosphine serves as a nucleophilic catalyst to give an intermediate that then undergoes photocatalysed radical coupling. Beyond its novelty, this reaction design provides important foundational information regarding the viability of combining traditional phosphine nucleophilic catalysis with radical-based bond formation.

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.*, *Chem. Sci.*) are encouraged to contribute general summaries, of no more than 200 words, and an image to David.

Gin production: art and science

(and a splash of tonic)

Daria Ustiugova/iStockphoto

BY **GRAHAM P. JONES** AND **MICHAEL R. HICKINBOTHAM**

From medicinal uses to a craft explosion, gin's history – and its list of ingredients – is long and varied.

'A gin and tonic, please.' The bartender looks around at approximately 150 gins in the bar: 'Which one? And which tonic would you like, from our choice of around 12?'

This is a huge shift from 20 years ago, when Australian bars would perhaps have three or four gins and one or two tonic waters. The changes in Australia, and in North America and the UK, are a result of the changes in regulations that have allowed small craft distilleries to flourish – but more about these later.

So, what is gin?

In its simplest form, gin is a mixture of flavoursome botanicals, water and pure alcohol (ethanol) distilled to produce a distillate, which is then diluted with water to produce a 'distilled' gin, or simply a mixture of botanicals steeped in a mixture of pure alcohol and water, filtered and then diluted with water to bottle strength (about 40% alcohol by volume (ABV)) – so-called 'bathtub' gin. The botanicals, by law in Europe and in the US, must include juniper berries (*Juniperus communis*) and the gin must derive its main characteristic flavour from juniper berries and be bottled at not less than 40% ABV (80° proof) in the US, 37.5% ABV in Europe. Gin may be aged in oak containers. In Australia, there are no official regulations other than to be called a spirit it must have a minimum of 37% ABV.

A typical gin contains juniper berries, coriander seed, angelica root, perhaps licorice root and … and ... the possibilities are endless. In their seminal paper 'Controlling gin flavor' in *Industrial and Engineering Chemistry*, Herman Willke, C.S. Boruff and Darrell Althausen presented a standard gin formula. Despite the

statement in this paper that 'This formula is used purely for illustrative purpose and does not represent a true potable gin production formula', many gins winning local and international awards probably have a starting point based on this formulation.

STANDARD GIN FORMULA (per charge of 1000 L of 50% ABV)	
Juniper berries	4 kg
Angelica root	0.4 kg
Coriander seed	2 kg
Lemon peel	0.04 kg
Cinnamon bark	0.4 kg
Cardamom	0.04 kg

Adapted from Willkie et al. *Ind. Eng. Chem*. 1937, vol. 29, pp. 78–84

The array of possible botanicals used in producing traditional gin is impressive but this is dwarfed by the almost infinite array when considering the native and indigenous plants used in modern craft gins, not to mention exotic items such as oyster shell, wood ash and elephant dung.

Juniper berries *Juniperus communis*
Coriander seed *Coriandrum sativum*
Angelica root *Archangelica officinalis*
Sweet orange peel *Citrus sinensis*
Bitter orange peel *Citrus aurantium*
Lemon peel *Citrus limon*
Cinnamon bark *Cinnamomum zeylanicum*
Cassia bark *Cinnamomum cassia*
Cardamom seeds *Elettaria cardamomum*
Nutmeg *Myristica fragrans*
Lavender flower *Lavandula* spp.
Orris root *Iris pallida*
Liquorice root *Glycyrrhiza* spp.
Caraway seed *Carum carvi*
Aniseed *Pimpinella anisum*
Fennel seed *Foeniculum vulgare*
Calmus root *Acorus calamus*
Grains of paradise *Aframomum melegueta*
Cubeb berries *Piper cubeba*

History of gin making

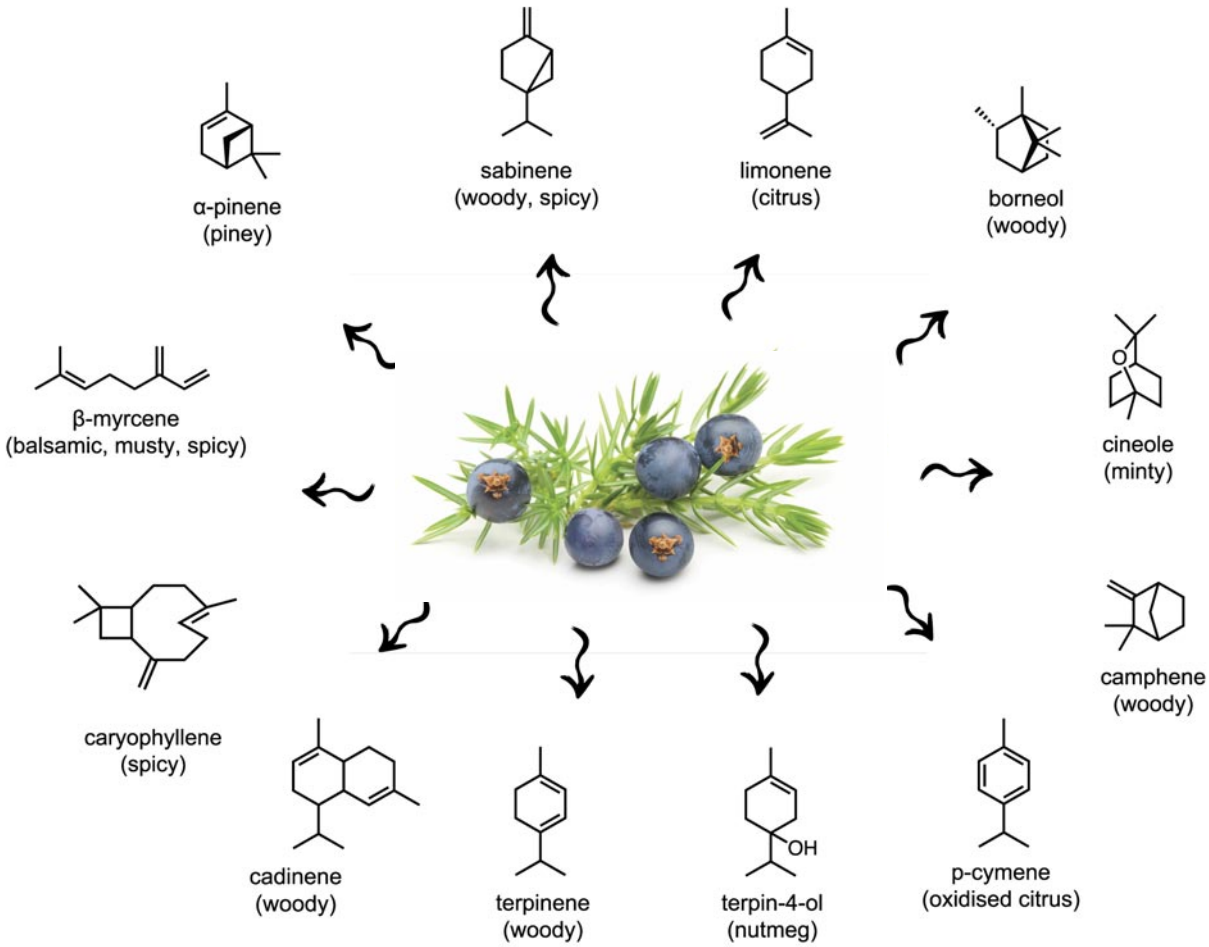
The consumption of spirits produced by the fermentation of carbohydrate feedstocks does not appear to have had a definite beginning, but for possibly as long as 2000–2500 years the distillation of alcohol was for the purpose of producing medicines. Early production of whiskies in Ireland and Scotland, and grape brandies in continental Europe, more than 1000 years ago was for the purpose of producing medicinal spirit. The earliest records of juniper berries in an alcoholic distillate date back to 1657 in John French's *The art of distillation* where the botanical list contains 63 herbs, seeds and other flavourants, in addition to juniper, including dwarf elder pith, rhubarb, lignum aloes and amber. After maceration in white spirit, sugar was added and a red-hot gold bar was plunged into the liquid prior to distillation. This resulting spirit is noted as 'being a very good cure for infections'.

Towards the end of the 17th century, there was a shift in attitude and the consumption of distilled drinks moved into the realm of social pleasure. *The distiller of London* (1698) describes a recipe including juniper in a distilled spirit that resembles a drink for pleasure rather than medicine.

Gin (or 'geneva') came to England from Holland (where it was known as *genever*/*jenever*) in the late 17th century, encouraged by William of Orange and Mary, who removed taxes to encourage the distillers of London to produce the spirit. These early gins had a spirit base of a doubled-distilled malt spirit resembling a light-bodied whisky rather than the clean, neutral spirit employed today. Early recipes are presented in Ambrose Cooper's *The complete distiller* (1757) where a recipe calls for 3 pounds (1.4 kilograms) of juniper berries, 10 gallons (37 litres) of proof spirit and 4 gallons (15 litres) of clean water, distilled to make 10 gallons of Royal Geneva. The common alehouse version was to distil 10 gallons of malt spirit (a weak spirit probably less than 30% ABV), 2 ounces of oil of turpentine and three handfuls of bay salt. This spirit was then diluted with water to drinking strength. Indeed, many of the early recipes contained oil of turpentine as well as juniper berries, which is understandable as the major constituent of oil of turpentine is α-pinene, the principal component of juniper oil.

The popularity of gin gained ground in England to the extent that, by the early 18th century, London alone had more than 7000 gin shops and gin consumption had become excessive. The heavy consumption of gin and its impacts on society were the basis of Hogarth's *Gin Lane* and *Beer Street*, depicting the evils of the consumption of gin as a contrast to the merits of drinking beer (of much lower alcohol content). The Gin Acts of 1729 and 1736 (known as the '50 Pound Act') were introduced to impose taxes on the production and consumption of gin. These acts led to public riots in 1743 and they were repealed, but in 1751 a new *Gin Act* was introduced, by again imposing heavy taxes. However,

Gin (or 'geneva') came to England from Holland ... in the late 17th century, encouraged by William of Orange and Mary, who removed taxes to encourage the distillers of London to produce the spirit.



Compounds in juniper oil. Typical proportions of major components are 40% α-pinene, 18% myrcene, 14% sabinene, 5% limonene.
Chemistry World/Royal Society of Chemistry / valentinarr/iStockphoto

by this date the government of the day had an alternative drink for the masses – tea – and tea consumption replaced that of gin.

The production of gin took a back seat, with only a few major distillers such as Booths, Gilbeys, Seagrams Beefeater and Gordons/Tanqueray starting operations in the latter part of the 19th century.

Fast forward to 1990 in Australia. In Tasmania, the law that existed in relation to the production of spirit (the *Distillation Prohibition Act 1839* had been repealed in 1847) was the *Distillation Act 1901* (legislation.gov.au/Details/C2004H01100), which, apart from requiring a substantial bond, required (wash) stills to be no smaller than 2700 litres. This was far larger than any emerging craft distiller could justify. Enter Bill Lark, a person with a passion for making premium quality whisky. He spoke to local MP Duncan Kerr about the discriminatory nature of the law, and Kerr relayed this to Barry Jones, the then federal minister for Small Business and Customs. With a stroke of the pen, the law was changed without having to go through Parliament. In 1992, Bill Lark and his wife, Lyn, set up the first legal distillery in Tasmania since 1882 with a 60-litre copper pot still, and began to produce whisky.

This legislative change was truly pioneering – various states in the US have only relatively recently changed their legislation (e.g. *California Craft Distillers Act 2015*) to allow craft distilleries to compete with larger producers, and in the UK in 2009 the *Excise Act 1823* was amended to allow stills of less than 1800 litres capacity to operate.

Modern gins and methods of production

Early in the gin distillation process, a small 'heads cut' is taken to remove the less desirable lower boiling point compounds. Following is the 'hearts' or

In 1992, Bill Lark and his wife, Lyn, set up the first legal distillery in Tasmania since 1882 with a 60-litre copper pot still, and began to produce whisky.

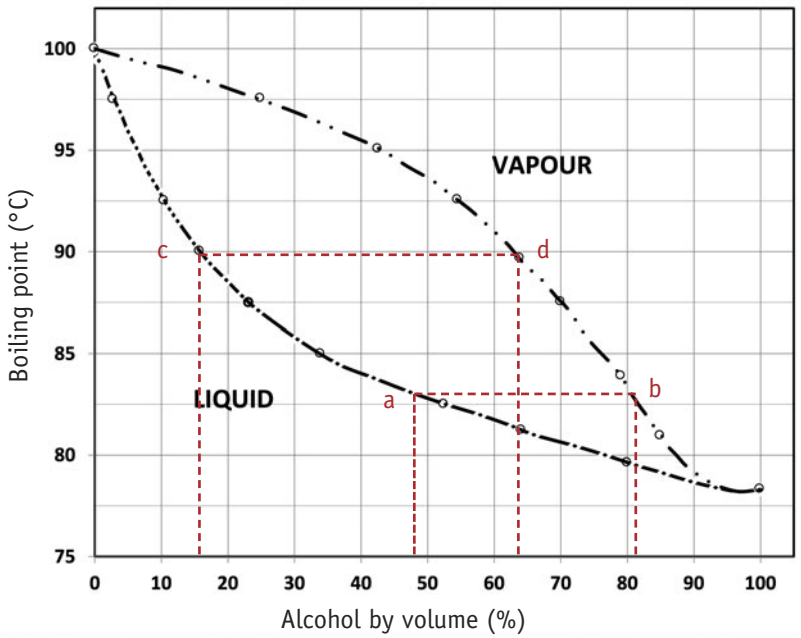
A combined image of William Hogarth's etchings and engravings *Beer Street* and *Gin Lane* (1751), contrasting the cultures of gin and beer consumption. Public domain via Wikimedia Commons

'spirits' cut, which is the gin component, and then perhaps a continuation of the distillation to recover all alcohol (the 'tails'). For the larger producers, the still size may be of the order of 3000–12 000 litres while for craft distillers the stills may be 30–2500 litres and larger.

The neutral spirit at approximately 95–96% ABV is usually sourced from a third party. Traditionally, this has come from a wheat base, although in Australia neutral spirit is obtained from cereal, sugar and grape feedstocks. The neutral spirit has to meet particular specifications relating to the maximum amounts of higher alcohols, esters, aldehydes, methanol and other components. A small number of craft distillers make their own neutral spirit through fermentation of a feedstock, usually sugar or grapes, followed by distillation.

The still pot is charged with the neutral spirit and water to give a resulting ABV of 30–50% or higher. The botanicals are usually added to the pot, although a large number of craft gin producers put their botanicals in a gin basket placed in the lyne arm. Many producers place a component of

Craft distillery, Mad Monkey Distillery, Adelaide, showing the different parts of the still.



The combination of gin and tonic was made popular in India during the 19th century as a means of making the dose of antimalarial quinine (in tonic water) more palatable.

The liquid–vapour equilibrium diagram for ethanol–water at standard atmospheric pressure. (Data adapted from Altsheler et al. *Ind. Eng. Chem.* 1951, vol. 43, pp. 2559–64, with wt % to v % conversions made using *International alcoholometric tables*, IOLM, Paris, France.)

the botanicals in the pot, with some going into the gin basket. Other producers place baskets at the base of the column to hold the botanicals, or at the top of the column (known as a Carter head). Some producers steep the botanicals in the pot solution for up to 36 hours at room or slightly elevated temperature prior to distillation.

Alcohol and water are miscible in all proportions and the boiling (bubble) point of the mixture is a function of composition. The equilibrium diagram above shows what happens to the liquid and vapour compositions during a typical distillation run. Starting at a pot composition of 48.5% ABV, the liquid boils at 82.4°C (a) and a vapour composition of 82% ABV (b). As the distillation continues, the pot composition falls to 17% ABV (c) and a distillate composition of about 64% ABV (d), at which the collection of gin spirit is terminated. These numbers are important because all the volatiles in the botanicals are hydrophobic and have boiling points well in excess of the temperatures reached in a gin distillation.

Their presence and concentration in the distillate is a function of their partial vapour pressures and are determined by their volatilities, and these depend on the composition of bulk vapour, i.e. ethanol–water composition. Deterre et al. (*J. Chem. Eng. Data* 2012, vol. 57, pp. 3344–56) showed that these volatiles increase dramatically at lower ethanol concentration. This has a great impact on flavour and the flavour profile extracted from the botanicals. The use of the gin basket subjects the botanicals to high-alcohol, low-water regimes in contrast to placing the botanicals in the still pot. Some producers employ a rectifier column to increase the alcohol concentration of the vapours even further before entering the gin basket in order to produce a lighter spirit. The characteristics of the final spirit are a matter of horses for courses and personal preference.

Don't forget the tonic!

The gin scene continues to expand, with more than 330 gin distilleries in Australia in 2022 (fewer than six in 2000) and similar impressive increases in North America (75 going to 2273) and the UK. And where would gin be without tonic water? The number and types of tonics available has risen quickly over the past few years. The combination of gin and tonic was made popular in India during the 19th century as a means of making the dose of antimalarial quinine (in tonic water) more palatable. The legal limits for quinine in modern tonic are 100 ppm in Australia and 83 ppm in the US, and the therapeutic dose of quinine is between 500 and 1000 ppm, so one can only assume that the quinine levels in early tonic were considerably higher than what they are today or that taking gin and tonic in medicinal quantities was quite intoxicating.

Cheers!

Graham P. Jones MRACI CChem is at the School of Agriculture Food and Wine, University of Adelaide, Waite Campus, Urrbrae, South Australia, and **Michael R. Hickinbotham** is founder and CEO of the Australian Distilling Company Pty. Ltd., Kent Town, South Australia. The authors thank Robert Asenstorfer for helpful comments.

Accurate measurement for a healthy future

The significance of metrology in health

sergunt/iStockphoto

NMI scientists delve into the significance of measurement in the health sector, from pet food to pharmaceuticals.

In every scientific discipline, from physics to chemistry to biology and environmental science, measurement plays a pivotal role. It allows us to observe patterns, detect changes and evaluate the effects of various variables on a system. Accurate measurement acts as a foundation for developing and testing scientific theories, ultimately leading to technological advancements, and understanding of natural phenomena.

Accurate and precise measurement is an essential foundation for progress in the fields of biotechnology and health. The ability to measure and quantify various biological parameters is critical for understanding disease mechanism, developing effective therapies and evaluating the safety and efficacy of new treatments. From genetic sequencing to diagnostic tests, accurate measurements are key to scientific research, clinical practice and the development of innovative solutions that improve human health.

The National Measurement Institute is part of the Department of Industry, Science and Resources. NMI develops and maintains Australia's physical, chemical and biological measurement standards. It is responsible for developing measurement systems and delivering measurement products and client services to a wide cross-section of stakeholders, including government, industry, and science and technology partners.

Within the health sector, NMI works to give medical practitioners and consumers confidence in measurement results so they can make informed decisions.

Calibrating infectious disease measurements

Quantitative polymerase chain reaction (qPCR) is a very popular method for identifying and quantifying genetic sequences of interest. It can detect even a single copy of a specific DNA molecule, making it an invaluable tool for diagnosing infectious diseases. For instance, in the wake of the COVID-19 pandemic, qPCR has been instrumental in identifying the SARS-CoV-2 virus in patient samples,

NMI's DNA reference materials.

guiding public health measures and clinical management of patients. During the COVID-19 pandemic, the National Measurement Institute (NMI) prepared an inactivated whole-virus SARS-CoV-2 reference material, which was certified by a combination of digital PCR (dPCR), the more advanced version of qPCR, and mass spectrometry. This higher-order reference material was provided to stakeholders nationally and internationally. These materials are currently being used as calibrators, and for accuracy, precision and limits of detection verification of qPCR-based measurements.

To underpin wastewater epidemiology during the COVID-19 pandemic, NMI ran an inter-laboratory study for Australian and New Zealand laboratories performing critical wastewater surveillance; participants were provided with NMI whole-virus SARS-CoV-2 as a reference material.

DNA methylation technology

NMI has developed unique expertise in quantitative measurement of methylated DNA sequences. The measuring systems are based on a combination of dPCR, isotope dilution mass spectrometry, ultraviolet spectroscopy and liquid chromatography–mass spectrometry that enables preparation, qualitative characterisation and quantitative measurement of gene-specific methylation reference materials.

The technology was developed in response to the challenges experienced by a number of medical research institutes. It could have a significant impact on detection and management of cancer and will also help to contain pathology costs, especially if efficient measuring systems can be introduced early in the clinical validation process. Early detection of many cancer types may also be possible using methylation markers.

Future therapeutics

Gene and cell molecular therapies promise to be effective treatments for many genetic diseases and for cancer, using modified T-cells (chimeric antigen receptor modified, or CAR T-cells). Accurate, standardised quantification is needed to evaluate the therapeutic and safe dose for this new kind of biological therapeutic agent.

NMI has partnered with the Children's Medical Research Institute and their Viral Vector Manufacturing Facility to produce and validate genetic standards and to develop accurate quantification methods for clinical manufacturing of several gene therapy 'drugs'. NMI's reference materials will contribute to improved production of gene therapy 'drugs' and their approval by regulators, and facilitate bringing effective gene therapies to patients in Australia and globally.

Virus testing – hepatitis A and norovirus in foods

Development and the continued delivery of this service has been driven by repeated outbreaks of hepatitis A in berries (particularly) and other commodities. It is a challenging method (probably why few, if any other, labs in Australia offer these tests routinely) due to a complex multi-step extraction process. Detection is by reverse transcriptase PCR with virus-specific genetic sequences. The common matrices are also challenging, including those with polyphenols, pH extremes and other method-interfering components or characteristics.

Food allergen analysis

NMI food allergen capabilities currently cover at least 23 different allergens and are based on protein or DNA targets, detectable at sub ppm (mg kg^{-1}) levels. This analysis supports accurate food labelling and aids the safe consumption of packaged food by allergic individuals. The development of PCR methods also supports the new plain English allergen labelling food regulations, which include the distinction between the gluten-containing cereals (wheat, rye and barley), which is only possible by a genetic approach.

Genetic services related to food, water and the environment

Food authentication and provenance has become critical for ensuring food safety and maintaining supply chains.

NMI has developed a capability to measure the relative proportion of the species present in processed meat products and rendered pet foods.

In agricultural testing, we are developing the capacity to produce reference materials for agricultural pathogens and participating in an international study comparing capabilities across metrology institutes for measuring these organisms. We have provided DNA reference materials designed for PCR analysis of multiple environmental pathogens of interest in drinking water.

Bioassays for honey

NMI methods are based on bioassays or inhibition screens. Total activity and non-peroxide activity measurements support the labelling and marketing of high-end honeys, such as manuka, jarrah and marri. These honeys are in high demand in Australia and beyond, with the product value directly linked to the level of antimicrobial activity. Method selection in this area can be challenging as new method developments may give marketing-friendly high(er) numbers while concerns remain about comparability to historical data and other honey parameters such as methylglyoxal content.

Mask testing

The bacterial filtration efficiency test is one of three tests in Standard AS4381 for surgical face masks, the other two being physical tests. Modelling a biological system, bacterial filtration efficiency testing effectively measures the capability of a face mask to capture the small aerosol particles likely to transfer respiratory viruses such as COVID-19. Developed by NMI's Analytical Services Branch, and NATA accredited, this method was developed in response to a lack of test availability and limited stocks of face masks during the pandemic. Another complex, multidisciplinary technique, this method requires microbiological culturing, aerosol/air flow physics, a six-stage Anderson impactor (that mimics the different levels of the human lungs) and colony-counting techniques and interpretations.

In Australia, food labels must identify the presence of gluten-containing cereals such as barley, rye and wheat (oats also pictured).
emer1940/iStockphoto

Bacterial identification

In addition to a range of traditional biochemical and serological bacterial identification approaches currently performed, NMI is investigating and expanding into bacterial characterisation via mass spectrometry (MALDI-TOF) and genetic approaches. These newer developments and applications open a range of future opportunities including antimicrobial resistance information and very rapid identifications.

This article is a collaborative effort of the Analytical Services Branch and the Chemical and Biological Branch of the National Measurement Institute (customerservice@measurement.gov.au).

Other NMI health capabilities and services

NMI's technical expertise covers a wide range of services and solutions that will assist with problems both current and emerging:

- medical device compliance testing
- pharmaceutical testing
- allergens testing
- medicinal cannabis
- pathology testing
- genetic testing
- supplement testing
- translational research support
- advances in nanomedicine.

Innovation in human health, atomic clocks and industry celebrated at 2023 measurement awards

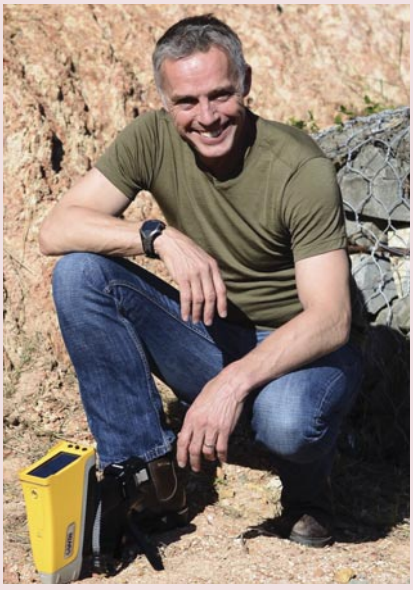
The National Measurement Institute announced the winners of the 2023 Measurement Awards at a special event as part of National Science Week in August. The seven finalists showcased their work during the ceremony, while the audience voted for their favourite to win the coveted People's Choice award.

Australia's Chief Metrologist, Dr Bruce Warrington, applauded the winners and finalists.

'Metrology is the science of measurement, and that's in everything we do. From cooking to medicine, in industry and at home, trusted measurement is key to getting the results we want every time', Warrington said.

'As technologies and industries advance, we need new ways to measure up to the changing world around us. The NMI Measurement Awards highlight the huge breadth of our field, and the incredible people in it.'

Warrington presented the prestigious Barry Inglis Medal for sustained contribution to Australian metrology to Victoria's Chief Environmental Scientist, Professor Mark Taylor.



Professor Mark Taylor, winner of NMI's Barry Inglis Medal in 2023.

Through his work with the Environment Protection Authority of Victoria, Taylor has developed new techniques to study contamination in a huge range of human environments, from blood lead levels in children, to firefighter exposure to PFAS chemicals, to soil health for residential veggie patches. His work has protected the health of thousands of Australians and inspired global research efforts on trace elements in our environment.

The University of Adelaide's Atomic Clock Team, represented by Dr Rachel Offer, proudly took home both the NMI Measurement Impact Award and the People's Choice Award for their world-first portable, autonomous atomic clocks.

Keeping accurate time to navigate has been a problem for centuries, including at sea. Most modern timing systems rely on satellite-based solutions, but these are vulnerable if that connection is lost. Tested on a naval vessel off Pearl Harbor in military exercises earlier this year, the team's portable optical clocks proved to be vastly superior to current defence technologies – and are the first of their kind to operate outside a laboratory.

Dr Zhiwei Sun of the University of Adelaide was presented with the Measurement Achievement Encouragement Award for his development of a micro-focusing shadowgraph technique for microparticle sizing.

Imagine taking a photo of a few people who are moving through a crowd. You might get them, but the image would also capture the blur of people moving in front and behind them during the shot. The same problem applies to Australia's iron ore industry, where current techniques take an overlapping snapshot of the ore samples. Sun's technique uses new focusing methods to filter out interfering samples in front and behind, allowing fast measurement of particle properties that can't be achieved with current systems.

For more information on the National Measurement Institute, go to www.measurement.gov.au.

NMI

The University of Adelaide's Atomic Clock Team, winner of both the NMI Measurement Impact Award and the People's Choice Award in 2023.

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THE TIMES HIGHER EDUCATION

Young University Rankings 2023: **Top 50**
Impact Rankings 2023
(UN Sustainable Development Goals): **Top 100**

Early career researchers at the Second Commonwealth Chemistry Congress

May 2023 saw the international chemistry community descend on Trinidad and Tobago to take part in the first in-person meeting of Commonwealth Chemistry – the Federation of Commonwealth Chemistry Societies. Established in 2020, the organisation is led by representatives from across the Commonwealth nations. Its mission is to inspire, celebrate and elevate the role and practice of the chemical sciences for the benefit of Commonwealth nations and their people.

The Congress took place at the University of the West Indies (UWI), St Augustine Campus, just a short bus ride from the capital Port of Spain, and it involved about 200 delegates nominated by chemical societies across the Commonwealth. RACI ran its own selection process in late 2022, choosing two early career researchers (this article's authors) to attend the Congress – Dr Neil Robinson from the University of Western Australia and Dr Isobella Stone from the University of Adelaide – who were joined by RACI Past-President Professor Steven Bottle from the Queensland University of Technology. The Australian delegation was completed by plenary speaker Professor Norelle Daly (James Cook University), together with keynote speaker Professor Karen Wilson (Griffith University), who also represented Australia on the Scientific Organising Committee. Dr Vicki Gardiner, former RACI President, chaired Commonwealth Chemistry from 2020 to 2023, including the Congress.

The opening ceremony was well attended by an array of senior UWI leaders and local representatives, including Dr the Honourable Nyan Gadsby-Dolly, Minister for Education for the Republic of Trinidad and Tobago, who later took part in a panel discussion. For many of the delegates attending from low- or middle-income countries, the Congress provided a unique opportunity to showcase their research on the international stage, and to benefit from face-to-face discussions with leading figures from their respective fields in the chemical sciences. Funding for the meeting was generously provided through the Chemists' Community Fund, the benevolent fund of the Royal Society of Chemistry.

Following the Congress theme 'Partnership for the Goals', the meeting aimed to stimulate and showcase chemical research and community building of direct relevance to the United Nations Sustainable Development Goals (SDGs). The scientific program focused on six SDGs grouped across three themes: Zero hunger (SDG 2) and Good health and well-being (SDG 3), Affordable and clean energy (SDG 7) and Responsible consumption and production (SDG 12), and Clean water and sanitation (SDG 6) and Climate action (SDG 13). An array of invited plenary and keynote presenters from across the Commonwealth provided expert talks on research associated with each theme; highlights included new developments in catalytic processes for biofuel production and circular economy establishment, realising microplastic toxicity, the synthesis of magnetic bio-char composites for water remediation, and the development of ensilication methods for thermally stable vaccines.

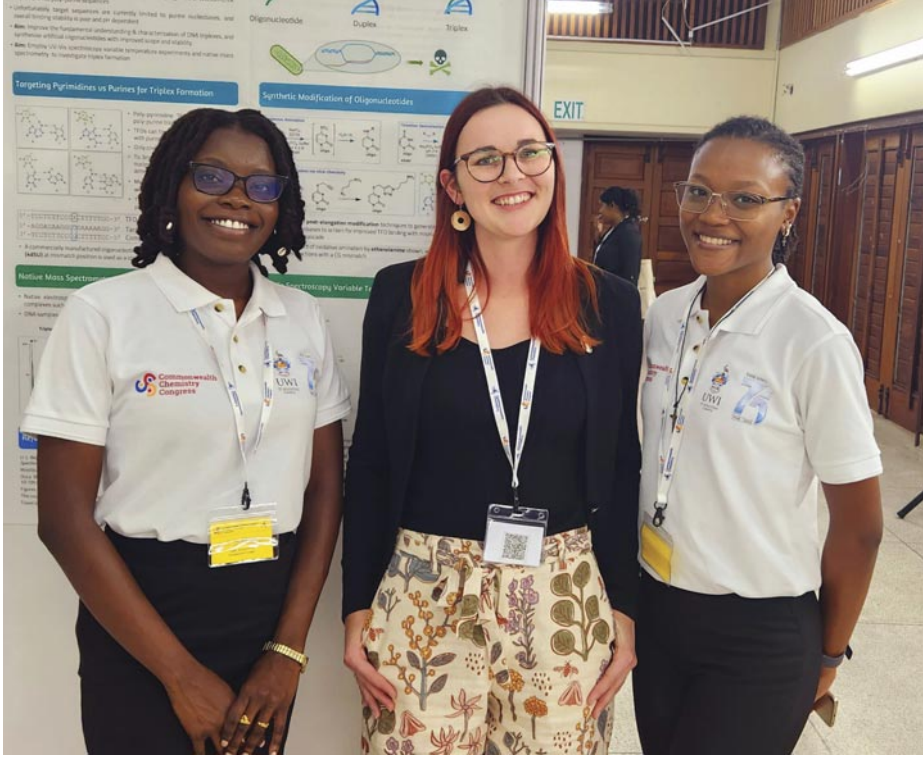
An extensive poster session showcased research underway by the early career delegates, with selected researchers within each theme taking part in a flash talk competition. Both Australian early career delegates were selected to give flash talks, with Neil presenting his work 'Characterising interfacial

The Australian delegation at the Second Commonwealth Chemistry Congress cocktail reception. From left to right: Professor Karen Wilson, Dr Isobella Stone, Dr Neil Robinson, Dr Vicki Gardiner, Professor Steve Bottle, Professor Norelle Daly.

phenomena in porous materials with low-field magnetic resonance' under the Affordable and clean energy (SDG 7) and Responsible consumption and production (SDG 12) theme, and Isobella sharing her work 'Triplex-forming oligonucleotides as an anti-gene antibiotic strategy' within the Zero hunger (SDG 2), Good health and well-being (SDG 3) session. The session further provided an opportunity to showcase research topics underway at UWI, with a wide variety of poster contributions ranging from controlling nanoparticle luminescence to investigating the antimicrobial properties of frog skin secretions.

While chemistry provides a central science for research of relevance to the SDGs, it remains critical to reflect on how this research community is strengthened through implementation of some of the goals not mentioned above. The Congress tackled this through the provision of panel discussions, each involving 4–6 international experts. Each panel member provided a short introductory presentation or speech to share their perspectives on the topic, followed by a spirited discussion among the panel, which was fuelled by questions and reflections from the audience. The Congress opened with a discussion on 'Chemistry, the Commonwealth, and the SDGs' – in particular what Partnerships for the goals (SDG 17) looks like from a chemical community perspective. It began with an acknowledgement that 'a chemist is a chemist everywhere', but that there is great disparity when it comes to accessing resources and opportunities. There was a reflection that there is an interesting discourse on 'interest versus usefulness' in chemistry, and that 'applied' should not be a dirty word. Significantly, there was an acknowledgement that this particular group of nations has been brought together through a history of colonialism that left an inequitable landscape, and that funding and collaboration is critical for future endeavours towards equality.

The second panel discussion focused on Gender equality (SDG 5) and Reduced inequalities (SDG 10), with key insights from panellists such as Professor Akua Britwum (University of Cape Coast, Ghana), who explained how current global education systems reproduce existing inequalities, and the pitfalls of so-called merit-based selection principles. Dr Ale Palermo (Royal Society of Chemistry) discussed how privilege affects a sense of belonging in the chemical sciences, and how mentoring is great, but sponsorship can change lives. Kevin Coutinho (Windsor Fellowship) impressed on us the importance of positive action to respond to these challenges, focusing on systemic over 'trophy' change, because inclusion is integral to good science, even if it is hard work. Dr Cynthia Ibeto (University of Nigeria) concluded the remarks with numerous examples of inspirational scientists from historically disadvantaged and excluded groups that have done invaluable work, highlighting how these contributions would have been missed without the actions taken to break down barriers globally, and asking us to reflect on the amazing people we continue to lose out on in the current system.



Student volunteers were excited to hear about Dr Isobella Stone's (centre) research on potential anti-gene antibiotic therapies during the poster presentation session.

The final panel was on Quality and effective education (SDG 4), with special guest Dr Nyan Gadsby-Dolly, the Minister for Education for Trinidad and Tobago, who coincidentally holds a PhD in organic chemistry from the host university. She spoke about their national plan to train the next generation of professionals to run their young, post-colonial country – equipped with the knowledge and the skills to keep pace with other countries on the global stage, using local talent. For this, it is important for education to reflect on the humanity in science and understanding the broader issues facing society rather than solely emphasising theoretical principles. The other panellists contributed interesting ideas about the importance of systems thinking, and not shying away from curriculum renewal where needed. A key take-away once again touched on inclusivity and equitable quality of education – with the point being made that access without a reasonable possibility of success is not true equality of opportunity.

There was also a fantastic social program, including a cocktail networking evening complete with local cuisine and tables bearing the flags of the more than 30 countries in attendance, a gala dinner with a spectacular cultural showcase featuring the National Steel Symphony Orchestra, dancers and carnival performers, and a tour of the Trinidad Bird Sanctuary to catch a glimpse of the emblematic scarlet ibis. Overall, the Congress proceeded with an incredible spirit of welcome, the opportunity to connect with researchers from an unparalleled diversity of backgrounds and perspectives, and an optimism that we can work collaboratively to further sustainable development around the globe.

Neil Robinson MRACI CChem is at the University of Western Australia and **Isobella Stone** MRACI is at the University of Adelaide.

Vale Professor Dennis Estcourt Mulcahy

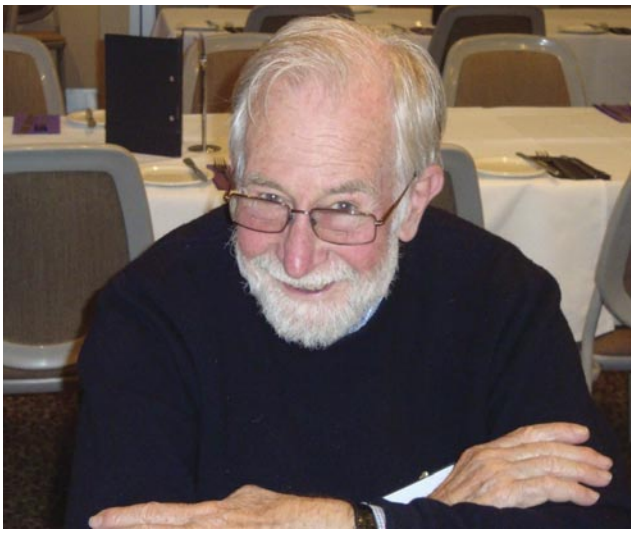
Generous teacher and mentor

Popular academic and revered friend and associate, Dennis Mulcahy passed away peacefully on 7 May 2023. One time president of the RACI South Australian Branch, Dennis was much liked and admired by all who knew him and by those whose paths he crossed. A tireless teacher and mentor of students, as former student Ray Bubner recalls:

> *Dennis made a lasting impression with his dynamic and enthusiastic style. He wrote his notes on the chalkboard so quickly that I couldn't keep up before he wiped off the last section and began the next section. I recall being amazed, particularly in a Physical Chemistry lecture on the non-ideal gas law, at his ability, while continuing to write on the board, to turn towards the students at the same time and give further explanation on the topic. I will certainly continue to remember Dennis's enthusiasm for chemistry.*

If anyone wanted to know how a former colleague or student was faring, they only had to ask Dennis. He managed to keep in touch with many former students and staff. As one of his former graduate students, research fellow Baden Myers commented: 'When clearing up his desk, recently, there were many emails found that he had printed from students both local and overseas, just keeping in touch with Dennis, including photos of people with family or of some interesting place or other, providing an update and keeping in contact'. Dennis was always generous with his time, mentoring students, keeping up with their progress and addressing issues they may have. He kept an 'open door' policy and was approachable at any time.

Born in 1941, he graduated from the University of Adelaide with a BSc(Hons) in 1963 and a PhD in 1968, the year after he joined the then South Australian Institute of Technology as lecturer in Physical Chemistry. He subsequently became senior lecturer and Deputy Head of the School of Chemical Technology. In 1993, as associate professor, he became head of school in the now University of South Australia. He retired in 2001 and as leader of the Cooperative Research Centre (CRC) for Water Quality and Treatment was appointed adjunct professor and later emeritus professor in recognition of his continued commitment to the Centres of Excellence, namely the International Centre of Excellence for Water Resources Management and the CRC for Water Quality and Treatment. He was interim Director, Microelectronics Centre; Deputy Director, Urban Water Resources Centre; Education and Training Programme Coordinator of the CRC for Water Quality and Treatment; and convenor of the South Australian Stormwater Quality/Quality Monitoring Group – an impressive list of leadership roles.



Dennis Mulcahy, with his customary smile, at a meeting of the RACI South Australian Retired Chemists Group. John Mason

Dennis was always generous with his time, mentoring students, keeping up with their progress and addressing issues they may have.

As noted by Professor Don Bursill: 'Dennis's significant achievements are evident from the range of awards he received during his career, including the Chemex Award in Chemical Education in 1979 (by RACI South Australian Branch, of which he was a Fellow). He was awarded the South Australian Branch of the Australian Water Association's Premier's Water Medal in 2011, presented to him by the then South Australian Premier Jay Wetherill. This was awarded to Dennis on the basis of his significant contribution to research and to the training of water professionals through the University of South Australia.

In 2014, Dennis was unanimously endorsed by the University of South Australia Council for the honorary award of University Fellow, in recognition of his distinguished service to the university. In making this award, the University Council noted that throughout Dennis's career he had, with passion, undertaken the education and training of students for their future careers in the water industry.

Gordon Wilkinson FRACI CChem, with thanks to several colleagues and associates, including Baden Myers, Don Bursill, John van Leeuwen and John Mason.

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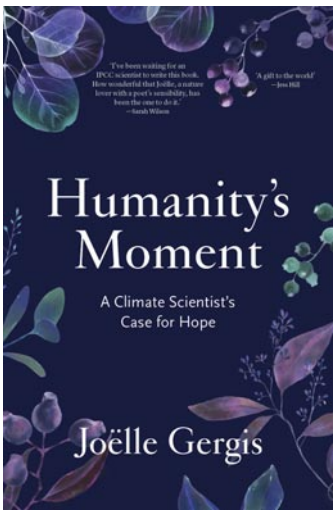


Humanity's moment: a climate scientist's case for hope

Gergis J., Black Inc. (a division of Schwartz Books), 2022, paperback
ISBN 9781760643232, ebook
ISBN 9781743822531, 320 pp., $34.99

Humanity's moment is a passionate book by Australian (ANU) climatologist Joëlle Gergis. It is well written in clear, 'user-friendly', jargon-free prose and should appeal equally to those with a passing interest in climate science (and if you do not have that, then you are about to get an almighty shock!) and other more experienced climate watchers.

Dr Gergis takes her reader patiently through the issues of climate change, both drawing on the literature and adding frequent anecdotes and commentary based on her own experiences. Overall, the book exudes a note of confidence: yes, we can do something, but we had better get a move on. Personally, I feel she is a tad over-optimistic, but as a colleague said to me many years ago, 'If you can't think of something brilliant, then for heaven's sake, just think of something!' Who knows? It just might work.

Over the past few years, Gergis has been a lead author of the United Nations Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report. This mammoth task is performed by volunteer scientists as an activity on top of their day jobs. Certainly, this is a way to get your views heard, but more important, it provides a very wide knowledge base about world climate change, how it is manifesting and what strategies might be useful to ameliorate its impacts.

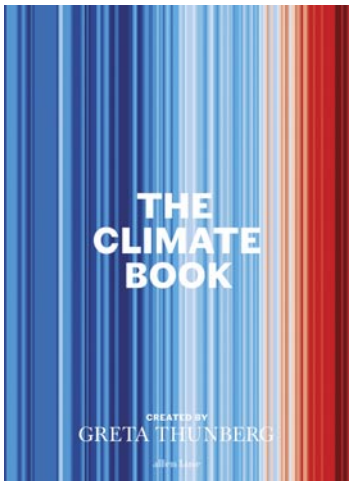
Gergis's book generously shares her damascene awakenings and their profound and overwhelming impact on her life. There are also instances cited in her book where very subtle nuances of language enter the Report in order to achieve consensus. You will certainly derive valuable knowledge from peeping at the inner workings of the IPCC.

There are three parts to *Humanity's moment*: The Head (which outlines the climate science), The Heart (where ecological and cultural aspects are considered) and The Whole (where Gergis speculates on a future where the arts and literature and paying greater heed to indigenous cultures might lead us in the right directions).

Overall, there is something for everybody in this modestly priced book.

R.J. Casey FRACI CChem HLM

The climate book



Thunberg G. (the book is described as 'created by'), Allen Lane (an imprint of Penguin Random House), 2022, hardback, ISBN 9780241547472, 464 pp., $55

The climate book is a very strange tome. By my count, it has 105 authors (who each retain individual copyright) spread across about 110 chapters, which are organised into five main subgroups. Each author's contribution is therefore limited to about 3–4 pages. The table of contents includes the affiliations of the authors with their names and the titles of their contributions. Each section – How climate works, How our planet is changing, How it affects us, What we've done about it, and What we must do now – is introduced with a page or two by Thunberg. There is no explanation of the raison d'etre for the book, nor for how the authors were selected, nor what remit was presented to them, nor, indeed, the suggested target readership. For me, these are significant omissions and shortcomings.

None of the chapters are referenced, but I discovered these can be accessed online. The premise seems to be if you take over 100 authors, who all look to have reasonable 'pedigrees', and toss their brief contributions before readers, then at least some will appeal or stick! The book is a giant assemblage of bits-and-bobs, a sort of omnibus with something for everybody. An alternative view is if some readers find awakening to climate amelioration in this agglomeration, then, good. Personally, it did not appeal. If you are looking for something to dip into, you are bound to find something that appeals. However, if you are seeking deeper knowledge about the climate, then I would not start here. The book is not particularly expensive. You can buy the hardback for under $40 or an ebook for about $20.

Creator Greta Thunberg, born in 2003, achieved a level of fame (some might call notoriety) in 2018 as the figurehead of a massed school strike for climate action outside the Swedish Parliament. This action galvanised similar movements in other countries and has led to Thunberg's prominence at international environmental forums (and possibly also at events where political figures use her presence to enhance their own environmental credentials). Personally, I have no idea whether her fame has its origins in a young woman's radical challenge to the status quo and/or whether she has a deep and mature knowledge of issues of climate change. Either way, it seems a question worth asking. On a love–hate spectrum, people seem largely clustered at both ends.

Overall, there is really nothing particularly good or bad about *The climate book*. I simply did not like it, at all sorts of levels. You may like the omnibus approach: I do not. You pay your money and accept your choice.

R.J. Casey FRACI CChem HLM

‘Soft’ skills: taking chemistry to diverse industries

In our experience, people making career changes often have difficulty describing their skills in an imaginative way. Chemists, who are highly technically trained, often overlook the importance of soft skills. These portable, or transferable, skills are learnt on the job and through life experience.

As well as being important for job transitions, transferable skills are seen as more critical to jobs of the future. They encompass a range of personal attributes and interpersonal abilities, and are relevant across a broad range of fields.

The skills developed through the study and practice of chemistry extend far beyond the boundaries of the laboratory, and can open doors to new and exciting career opportunities.

1. Analytical thinking and problem solving

Chemistry nurtures a strong foundation in analytical thinking and problem-solving skills. Chemists are trained to break down complex problems into manageable components, identify patterns, and apply logical reasoning to find solutions. This skill set is highly transferable to various industries, including finance, data analysis, engineering, and research and development. The ability to analyse data, think critically, and devise innovative solutions is invaluable, regardless of the field.

2. Attention to detail and precision

Chemistry demands meticulous attention to detail and precision in experimental procedures and data analysis. The significance of accuracy is ingrained in chemists, as even minor variations can significantly affect results. This keen eye for detail is beneficial in sectors such as quality control, manufacturing and project management. It ensures that tasks are executed with precision, minimising errors and optimising outcomes.

3. Communication and collaboration

Effective communication and collaboration skills are vital in chemistry, where teamwork and information sharing are essential for successful research and development. Chemists often work in multidisciplinary teams, collaborating with other researchers, and technical and business staff. Clear and concise communication is crucial when conveying experimental findings, proposing hypotheses, or presenting research outcomes. These communication and collaboration skills can transfer to industries such as project management, sales and consulting, where the ability to articulate ideas and work collaboratively with diverse teams is highly valued.

4. Adaptability and flexibility

Chemistry is a dynamic field that is constantly evolving with new discoveries and technological advancements. Chemists learn to adapt to changing circumstances, modify experimental approaches, and think creatively to overcome challenges. This adaptability translates well to industries that undergo rapid transformations, such as technology, health care and entrepreneurship. Chemists are well equipped to embrace change, identify emerging trends, and find innovative solutions to complex problems.

5. Time management and organisation

Chemistry experiments often require meticulous planning, scheduling and adherence to strict deadlines. Chemists develop strong time management and organisational skills to ensure experiments run smoothly and efficiently. These skills can be applied in industries where project management, resource allocation and meeting deadlines are crucial, such as event planning, logistics and operations management.

6. Ethical responsibility and safety awareness

Ethics and safety are paramount in the field of chemistry. Chemists are trained to prioritise safety protocols, handle hazardous materials responsibly, and adhere to ethical guidelines. These values are transferable to industries where safety, compliance and ethical practices are fundamental, such as occupational health and safety, environmental protection, pharmaceuticals and public service.

7. Cultural awareness

Chemistry is a global enterprise and often requires collaboration across different countries. The experience gained through working with people from different cultural backgrounds gives chemists insights into the value of different perspectives and different ways of thinking. Increasingly, this skill is highly valued across all sectors, particularly in companies operating globally or working with clients from multicultural backgrounds such as education or community services.

8. Innovation

Drawing on innovation and other transferable skills, chemistry professionals looking to make a cross-sector career transition are well suited to boundary-spanning roles. These roles are increasingly in demand for professionals who can foster collaborations, especially between professionals from different fields who have not collaborated before, link seemingly disparate ideas and bring different approaches to problem solving.

When job seeking, help employers ‘open the aperture’ and consider a broader set of skills from what they might normally seek. Emphasise your unique combination of skills, remembering that ‘hard skills get interviews, soft skills get jobs’.

In future columns we will profile chemists who have moved into new and unexpected fields, and how they are using their transferable skills differently to how they envisaged.

Dr Barbara Cosson and **Dr Janine Pickering** are co-founders of War on Wasted Talent (www.waronwastedtalent.com.au), a social enterprise providing career transition services for mature age professionals.

Like most scorpions, *Hottentotta jayakari* has a body that fluoresces under ultraviolet light. Philipp Weigell

Treating epilepsy with scorpion venom

Disorders of the central nervous system (CNS), such as pain, epilepsy and stroke, remain some of the world's most serious and debilitating health problems. Chronic pain is the largest unresolved medical condition in the world – symptoms can be treated but there is currently no cure. Globally, stroke is the second leading cause of death and the leading cause of morbidity. Epilepsy cannot be effectively treated in more than one-third of all cases.

Pain, stroke and epilepsy have three things in common. First, they are all influenced by mutated protein channels in the body. Second, there are currently few treatments to address them. Third, they all have the potential to be successfully treated with the venoms of spiders, centipedes and scorpions. Research groups, such as the Peptide Kings group at my university, the University of Queensland, are undertaking research for potential cures for these diseases.

Epilepsy and Dravet syndrome

Epilepsy, a disorder characterised by recurrent seizures, occurs because of uncontrolled electrical impulses from neurons in the brain's cerebrum, or outer shell. There are many different types of epileptic seizures, and the underlying cause of most attacks is unknown. However, it has been shown that 30–40% have a genetic origin. The seizures that characterise Dravet syndrome are one such example, presenting largely in childhood and frequently having catastrophic outcomes.

Individuals with Dravet syndrome experience polymorphic seizures. Each seizure is characterised by alternation of two or more different types of epileptic attacks. Clinically, Dravet syndrome presents as one of the most pharmaco-resistant types of epilepsy. As such, patients with Dravet syndrome commonly develop multiple neuropsychiatric comorbidities and have an increased risk of premature death.

Loss-of-function mutations in one version of the gene *SCN1A* causes Dravet syndrome. *SCN1A* encodes for a specific variant of voltage-gated sodium (Na_V) channel, $Na_V1.1$.

Na_V channels are cell-membrane proteins responsible for moving sodium ions from one side of the membrane to the other. This movement is of particular importance in neurological function because sodium ion influxes lead to initiation and propagation of neuronal impulses. In the brain, $Na_V1.1$ plays a key role in sending inhibitory impulses from inhibitory neurons

Pain, stroke and epilepsy ... all have the potential to be successfully treated with the venoms of spiders, centipedes and scorpions.

to excitatory neurons. Inactivation of these channels through mutation can therefore cause uncontrolled hyperexcitation, leading to epileptic seizures.

Why scorpion venom?

Many animal venoms have evolved to target the important Na_v channels, often as prey capture or defence mechanisms. This means venoms are key targets in potential drug therapies.

It has previously been demonstrated that inhibition of $Na_V1.1$ inactivation by a peptide isolated from spider venom eliminated seizures and premature death in a mouse model of Dravet syndrome. However, whether venoms from other animals also contain compounds that target $Na_V1.1$ was unknown – until recently. Recent work by the Peptide Kings group, led by Professor Glenn King at the University of Queensland's Institute for Molecular Bioscience, identified two scorpion-venom peptides that have agonistic actions on $Na_V1.1$: Hj1a and Hj2a (*ACS Pharmacol. Transl. Sci.* 2020, vol. 3, pp. 119–34). In fact, these peptides were shown to be some of the most potent activators of this channel ever discovered.

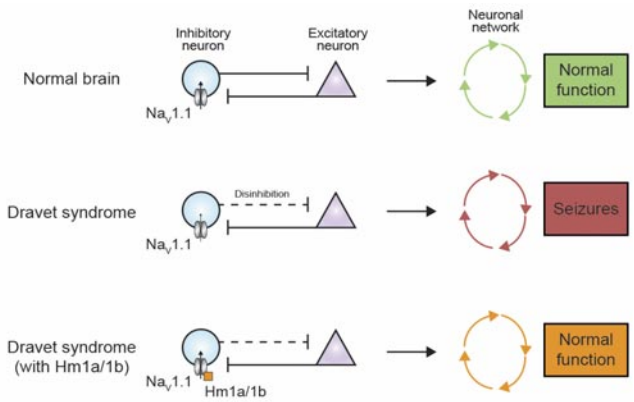
Isolating Hj1a and Hj2a

In order to isolate peptides of interest, venom was first extracted from a species of previously unstudied scorpion, *Hottentotta jayakari*, by electrical stimulation, and then separated by reverse-phase HPLC.

This technique resulted in large groups of toxins with similar hydrophobicities. These groups were then put through electrophysiological screening, a method used to determine Na_V channel activation. Groups that elicited high $Na_V1.1$ activation were sent back through the same isolation steps. Eventually, two 'hit' peptides were isolated: Hj1a and Hj2a.

Hj1a and Hj2a as Dravet syndrome therapeutics

When developing pharmaceutical drugs from Na_V channel activators, two characteristics are of particular importance: potency (strength of molecule function) and selectivity (accuracy of function). These characteristics are extremely important because pharmaco-modulation of any CNS-dominant Na_V channels, such as those in heart and muscle cells, can cause life-threatening side-effects such as seizure, cardiac arrest and respiratory failure.



The neuronal networks (depicted as green/red/orange circuits) located in different brain regions consist of distinct cell types. In normal conditions, the activity of excitatory neurons is regulated by inhibitory neurons (top row). The $Na_V1.1$ channel is found in inhibitory interneurons in the brain, where it is essential for regulating brain excitability. In Dravet syndrome, loss-of-function mutations in the *SCN1A* gene that encodes $Na_V1.1$ lead to reduced excitability of inhibitory neurons (middle row). A drug that enhances the function of the unaffected population of $Na_V1.1$ channels should restore the balance of excitation and inhibition in Dravet syndrome and be a useful treatment strategy (bottom row).

Despite their high potency towards $Na_V1.1$, Hj1a and Hj2a lack the subtype selectivity needed for an antiepileptic drug. However, the researchers believe it is possible that this could be resolved through route of administration and dosage. As they say in their research paper:

> *For example, Hj1a and Hj2a have agonistic activity on $Na_V1.4$, which is found in smooth and skeletal muscle, and $Na_V1.5$, which is localised to the heart ... Since these subtypes are restricted to the peripheral nervous system, activity at these channels may not be a serious concern for a CNS-restricted antiepileptic drug.*

The Peptide Kings paper concluded that additional research is needed, and that exploring these peptides further may very well lead to a cure for Dravet syndrome. The group noted that modelling:

> *structures of Hj1a and/or Hj2a in complex with a human Na_V1 channel would provide important insights into the molecular mechanism by which these peptides impede channel activation, and they would facilitate rational design of analogues with enhanced selectivity for $Na_V1.1$.*

More recently, King said:

> *We have developed a more selective and stable activator of $Na_V1.1$ that we plan to test in rodent models of DS [Dravet syndrome] while simultaneously examining methods for specifically targeting the peptide to the brain.*

Daniel McCarthy is an undergraduate student studying a Bachelor of Biomedical Science at the University of Queensland. This article is based on a chemical biology assignment he and assignment partner John Brouwers completed in 2021.

Tribute to the late John B. Goodenough, Nobel laureate in Chemistry

John Goodenough in 2019.
US Embassy Sweden, Public domain via Wikimedia Commons

The criteria for the award of Nobel Prizes include the phrase 'those who have conferred the greatest benefit to mankind'. If in 2023 one had to choose a topic of molecular science that is currently benefitting the global community, the development of the lithium-ion battery stands out. The importance of this invention is evident in the evolution, during the information age of the past 30 years, of a wide range of communication devices, including personal computers, handheld devices and mobile phones. The lithium-ion battery is also playing a critical role in the emergence of robotic devices. But its single most important role will be in enabling the electric transportation revolution and the development of electric vehicles that recently are reducing the rate of growth of global greenhouse carbon emissions from fossil fuel combustion vehicles.

A lithium-ion battery is a rechargeable battery that uses the reversible reduction of lithium ions to store energy. The anode (negative terminal) is lithium–graphite and the cathode (positive terminal) is lithium metal oxide. The electrodes are separated by a porous separator. The liquid electrolyte is $LiPF_6$ in ethylene carbonate or a closely related solvent. The graphite is used because of its lithium intercalation capacity. The advantage of lithium-ion batteries is their unusually high current densities generated by the high reactivity of metallic lithium. New forms of these batteries are expected to be solid state, which will be safer than existing liquid versions.

The award of the Nobel Prize for Chemistry in 2019 to John Goodenough, M. Stanley Whittingham and Akira Yoshino recognised their contribution to the development of the lithium-ion battery. The scientific career of John Goodenough reflected a broad interdisciplinary intellect with exceptional creativity. He served as a professor of engineering (mechanical, materials and electrical engineering) at the University of Texas at Austin. His life and career are remarkable in other ways as well. He was the oldest Nobel awardee at age 97 and until his very recent death (25 June 2023) was the oldest surviving Nobel laureate.

His scientific career from start to finish involved meteorology, physics, mathematics, chemistry and engineering. It is one more example of how the major problems facing humanity (climate impacts, pandemics and vaccines, circular economy/waste management, and others) invariably require a deep interdisciplinary collaborative strategy to lead to genuine and practical solutions. He is credited internationally with the identification and development of the lithium-ion battery, for developing rules for determining the sign of the superexchange in materials (indirect exchange coupling between neighbouring magnetic moments) and for seminal developments in computer random access memory.

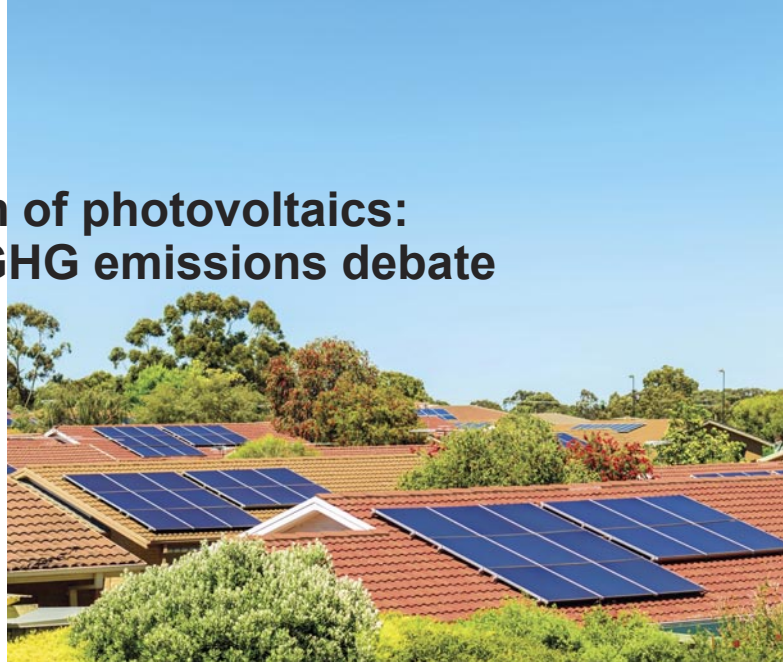
Goodenough was born in Germany in 1922 to US parents, but his career was spent mainly in the US (the University of Chicago, MIT Lincoln Laboratory and University of Texas). He also spent a period starting in the late 1970s, as Head of the Inorganic Chemistry Laboratory at the University of Oxford. He received numerous awards prior to the Nobel Prize, including the 2013 National Medal of Science awarded by President Obama. The Royal Society of Chemistry established a John B. Goodenough Award to recognise his contributions. During his long career, he authored more than 550 articles, 85 book chapters and reviews, and five books. He had at least one controversial publication (2017), which reported a glass battery that was non-combustible and had a long life with high current densities. However, viewed from the perspective of 2023, the pursuit of solid-state batteries is now accepted globally as a high priority for the next major step in safer global electric transportation and for higher current densities and hence longer-range travel.

As previously mentioned, the current rapid growth in numbers of electric vehicles internationally provides the first major practical step towards reducing climate changing carbon emissions. The world in 2021 had the opportunity to observe images showing the extraordinary improvement in urban atmospheres and the almost complete removal of carbon emissions caused by the hiatus of traffic during the 2021 COVID-19 lockdown. This was a glimpse of a future cleaner, healthier urban environment in a post internal combustion world. A 2023 report in *Lancet Planetary Health* from Monash University reports that extreme temperatures caused by increased levels of greenhouse gases in the coming years will lead to 5 million deaths per year, or pro rata about three times the mortality rate of the COVID-19 pandemic.

The development of the lithium-ion battery for transportation must be acknowledged in this climate context as an exceptional contribution to humanity.

Ralph Cooney ONZM, FRSNZ, FRACI CChem has had a science and innovation career bridging New Zealand and Australia. He was former University of Auckland Pro Vice Chancellor of the Tamaki Innovation Campus, Dean of Science, Head of Chemistry and Science Leader of several major national research programs.

The sustainability conundrum of photovoltaics: unravelling the energy and GHG emissions debate



Andrey Moisseyev/iStockphoto

'What's the point of photovoltaics?' a former colleague challenged me recently. He argued that the energy consumption and greenhouse gas (GHG) emissions during solar panel production outweigh the lifetime benefits of zero-emissions energy. Similar arguments are made against electric cars and other carbon-friendly technologies. Intrigued, I embarked on research that yielded unexpected outcomes.

A 2016 *Nature Communications* paper (vol. 7, article 13728) shed light on a potential break-even point between the disadvantages and benefits of photovoltaics, projecting it to fall somewhere between 1997 and 2018 – a rather long period. Yet definitive evidence of this elusive point and whether we now enjoy net positive benefits for energy or net GHG emissions remains unproven.

One crucial unstated assumption in the paper is the sole use of fossil fuel energy for making solar panels. Presently, in China, the major producer of solar panels, 12% of the energy consumed from the grid is renewable energy, insufficient to tip the balance towards a 'net positive' status. Additionally, energy-intensive processes in the silicon supply chain in China still rely solely on cheap coal energy and diesel fuel.

What we can say, with certainty, is that where fossil fuels are used in the production of solar panels, there will be a side product of local pollution. China wears all this pollution and we, the importers of their solar panels, get all the clean energy without the pollution. By importing solar panels from China, we are effectively exporting our emissions from the offset energy production, at least until China is using 100% clean energy to make solar panels (which won't be any day soon).

A good way to look at a solar panel is that all the energy and GHG emissions are invested up front. Thereafter, it's all upside. There are two main measurables that affect the net energy and GHG position: solar efficiency and solar panel longevity. The higher the solar efficiency and the longer the solar panel life, the more energy that is generated relative to the original investment in energy and GHG emissions during production. Weather matters too, of course.

Higher solar efficiencies have continuously been sought by the manufacturers of solar panels for decades, and at ever low costs of production. Longevity of solar panels has also improved over time, with solar panel product warranties now typically being for 25–30 years. However, just because solar panels are warrantied for such long periods doesn't mean that they are used accordingly. In fact, in a recent market survey some colleagues found that the typical installed life of a solar panel in Australia may be as low as eight years. This, ironically, is because of the continued improvement in solar efficiencies and costs. Effectively, after eight years one might find that solar panels have doubled in output power, and that they are such relatively low cost that is it worthwhile to discard old panels and install new ones. This is viable because much of the cost of installing solar systems is not the solar panels but other upfront costs such as site costs, grid access and power system connectivity.

Addressing the present state of solar panel R&D, efforts concentrate on combating the impending efficiency limit for single-junction silicon devices. This situation compels researchers to consider two options for improvement: either change the substrate materials (impractical due to the established silicon infrastructure) or develop dual-junction devices that capture a broader solar spectrum.

It is possible, of course, that improving efficiencies simply exacerbates the solar panel lifetime problem by continually making it economically viable to replace working solar panels well before their practical end of life. This problem could be overcome by addressing the recyclability of solar panels. The silicon in solar panels represents a very high energy cost when first produced; if the silicon could more easily be recycled, then much of the upfront energy cost for making solar panels could be avoided.

However, the current solar panel design makes the recycling of silicon very difficult; the weathertight encapsulant essentially glues all the components together, making it difficult (expensive and energy intensive) to extract the silicon, free from the other components. If solar panels were only warrantied for 8–10 years, it is feasible to imagine solar panel designs that would not need encapsulant, and that would allow easy recycling of the silicon.

Of course, if most of the energy used to make solar panels were renewable, then the net energy and GHG emissions problem would solve itself. However, this is only likely to happen if the solar supply chain is replicated outside of China (to create diversity in approaches to manufacturing) and solar panels were taxed on their carbon footprint, inclusive of end-of-life considerations.

Ian A. Maxwell is a visiting professor in the Faculty of Engineering and IT at University of Technology Sydney, who started his career as a physical polymer chemist. Ian is also the chair of a number of high-tech start-ups.

The IUPAC Orange Book: 14 years in the making

It's November 2008, and the Officers of the Analytical Chemistry Division of the International Union of Pure and Applied Chemistry (IUPAC) are convening in Beijing. After discussing the lack of consistency of the third edition of the Orange Book – based on a report of mine, as division secretary – the group concluded that the Division should go for a complete update. 'This demanding task will involve all the Division members … each [Titular Member] taking the responsibility for a sub-project.' This was confirmed at the General Assembly in Glasgow in 2009. As Secretary, and about to become Vice President, then President and Past President, I would have plenty of time (six years of senior office) to complete the project. (Ha!)

What's in the Orange Book?

The tome that is the Orange Book *(Compendium of terminology in analytical chemistry)* comprises 13 chapters, 666 pages, 4007 entries (3187 unique entries), 479 symbols, 636 abbreviations and acronyms.

The first definition is **1.1 analytical chemistry**. The strangest (and most humorous) acronym is **HOHAHA** (homonuclear Hartmann–Hahn spectroscopy).

Decisions, decisions

Having decided to more or less start from scratch with the fourth edition, two further decisions had to be made. First, what was to be included and – more contentiously – excluded.

Officers of IUPAC's Analytical Chemistry Division and hosts in Beijing 2008: left, Past President Ryszard Lobinski; sixth from right, host Professor Zhifang Chai; fifth from right, Secretary Brynn Hibbert; fourth from right, President Ales Fajgelj; third from right, Vice President Walter Lund. First published in 2009 Teamwork (bit.ly/3OIU7HB) and reproduced with permission of IUPAC.

Very quickly it was decided to stick to the terminology of principles and methods, and not have applications (as was found in the third edition). So, in came a first chapter on fundamental metrology and a last chapter on modern quality assurance. This added to a new chapter on chemometrics.

Second, the preparation of an entire book from scratch that would contain definitive terminology would have been a review nightmare. We therefore decided that each of the 13 chapters would be prepared as a IUPAC Recommendation published in *Pure and Applied Chemistry*, and the accepted and fully reviewed terms could be easily moved into the Orange Book. This was a good idea and eventually saved the project from falling in a heap, but the execution of the transfer turned out to be a bit more complicated than we hoped.

IUPAC and the 'Colour Book' series

IUPAC was formed after World War 1 (in 1919) to be the authority on matters chemical – chemical nomenclature and terminology, including the naming of new elements in the periodic table; on standardised methods for measurement; and on atomic weights, and many other critically evaluated data. Its work on nomenclature (Red, Blue, Purple, White) and terminology (Green, Orange, Silver) has appeared in the 'Colour Book' series since 1958. In 1987, terms were brought together into the Gold Book, which has recently (2019) been updated as an online interactive version.

The first edition of the *Compendium of nomenclature of analytical chemistry* or Orange Book was in 1977, and the third edition in 1997. An online version, downloadable as a hyperlinked pdf, was published in 2009, the year the decision to embark on the fourth edition was confirmed. (Note: For some time, 'nomenclature' was in relation to both chemical names and terms used in chemistry. This word is now reserved for chemical names, and 'terminology' is used to describe the language of chemistry.)

Editors … and editors

It might be thought that the job of an editor is to collect the chapters, make sure they are sensible and bring them together in a nice order for publication. This turns out not to be the case for a Colour Book. Even with a published Recommendation, the order of terms might need amending, duplications (surprisingly many) must be resolved, introductions to chapters harmonised and finally an index of terms and symbols created. Learning a lot about writing terminologies, I found myself a co-author on eight Recommendations in addition to writing the Recommendation for Chapter 2, so here the title 'editor' covers a bit more than usual.

Why did it take so long?

The 14 years went by with arguments within disciplines (notably radioanalytical with a first draft in 2011 and publication of the Recommendation in 2021), three deaths of people leading chapter projects, including Paul De Bièvre, to whom the Orange Book is dedicated; one member of the Division committee (I shall not name him) totally withdrawing after several years of coming to meetings saying his chapter was nearly finished – any day soon; and a couple of chapters that lingered in the editorial system perhaps a tad longer than necessary. The book was completed by 2021, then, after internal IUPAC reviews, submitted to the publisher (RSC Publishing) in 2022, and it appeared on 23 January 2023.

So, what took so long? Nothing in particular – this is how long these kinds of projects take.

D. Brynn Hibbert FRACI CChem is Secretary of the IUPAC Interdivisional Committee on Terminology, Nomenclature and Symbols, and editor of the *Compendium of terminology in analytical chemistry* (4th edn, Royal Society of Chemistry, 2023); Emeritus Professor of Analytical Chemistry at the University of New South Wales, Sydney and Emeritus Fellow of IUPAC Analytical Division.

This report is based on Brynn's article 'The IUPAC Orange Book – it's all about the journey' (*Chemistry International* April–June 2023). Extracts are used with permission of IUPAC.

Beautiful flowers, lovely perfume, and deadly!

Most Australians and visitors from overseas fear an encounter with one of this country's venomous snakes or spiders. Fortunately, bite victims treated promptly with anti-venenes usually recover completely. Little do many people realise that, in certain parts of the country, there are plants that are poisonous by ingestion and sometimes simply by touch, for which there are no lifesaving remedies.

In the September–November 2021 issue (p. 35), I wrote about indospicine found in plants of the genus *Indigofera*, which caused the death of more than 40 dogs in Victoria after they were fed raw meat from horses that had grazed *Indigofera linnaei* in the Northern Territory. This year, east coast newspapers informed readers in May (*Sydney Morning Herald*, 9 May; *The Age*, 10 May) of the death of two previously healthy, well-maintained horses, in Lismore, New South Wales, which allegedly had ingested a common weed, *Cestrum nocturnum*, belonging to the family Solanaceae (which includes potatoes, tomatoes and eggplants). A third (larger) horse survived.

C. nocturnum has numerous common names – lady of the night, night-blooming jasmine, night-blooming jessamine, night-scented jessamine, night-scented cestrum and poisonberry – derived from observations that the plant flowers open at night, have a particularly alluring perfume and are poisonous. The plant originated in the West Indies but has spread widely in subtropical areas. It is very intrusive and, following floods in New South Wales, has dominated native plants in some parts.

C. nocturnum grows as an evergreen shrub to about four metres. Several related species are also known in Australia: *C. parqui* (green centrum), *C. elegans* (red cestrum) and *C. auriculatum* (orange centrum). All originated in or around South America and were brought to Australia as garden ornamentals. Each has different coloured flowers and berries. Generally, they are described as toxic to mammals.

In Lismore, a local veterinarian inspected the property where the horses were kept and found it was infested with *C. nocturnum*, with obvious signs that parts of the plants had recently been eaten. He commented that this was the second case he has seen in horses, but other cases have been seen in sheep, goats and cattle. He speculated that *C. nocturnum* may also be causing the death of native animals, including wallabies.

C. nocturnum and *C. parqui* can be differentiated by the size, shape and colour of their berries. *C. nocturnum* has large white berries, whereas mature berries of *C. parqui* are small and black. Because of the disease risk of carrying out an autopsy on a horse, a blood sample was taken from a third horse that had survived and the liver enzymes were examined. They showed a toxicity profile matching both *Cestrum* species. Thus,

... the composition of *Cestrum* species, and in particular the toxic principles, have not been investigated systematically and reported. Often the plants are simply described as toxic.

The greenish-white flowers of *Cestrum nocturnum*.
Asit K. Ghosh, Public domain via Wikimedia Commons

The yellow flowers and leaves of *Cestrum parqui*.
Macleay Grass Man, Public domain via Wikimedia Commons

identification of the *Cestrum* species relied on visual examination of the remaining uneaten parts of the plants; because the liver enzyme profile of the surviving horse was consistent with both *C. nocturnum* and *C. parqui* ingestion, the species identification was not definitive.

A search of the literature found that the composition of *Cestrum* species, and in particular the toxic principles, have not been investigated systematically and reported. Often the plants are simply described as toxic. The New South Wales Department of Primary Industries (NSW DPI WeedWise) has issued information on several *Cestrum* species, including identification and poisoning. It can be browsed by common name or scientific name.

> *C. nocturnum – all parts of the plant are poisonous to human beings and livestock. The strong fragrance released from the flowers at night can cause breathing difficulties and irritation of the nose and throat. It can also cause intense headaches, nausea and dizziness.*

> *C. parqui – highly poisonous to cattle and can kill animals and human beings. The plant contains carboxyparquin, a kaurene glycoside that causes severe liver and brain damage. Avoid touching the plant with bare skin.*

Since all *Cestrum* species belong to the family Solanaceae, they would contain solanine, a glycoalkaloid, but seemingly not in sufficient quantities to be toxic. It has been reported that some *Cestrum* species contain chlorogenic acid, which is abundant in coffee and is therefore unlikely to be the toxic principle.

It seems to me there is an opportunity here for natural products chemists to investigate and clarify the chemistry of these attractive but poisonous plants, now becoming widespread in New South Wales.

Peter G. Lehman FRACI CChem joined RACI as a student member in 1963, subsequently pursuing a career in academia and industry, the latter in Australia and the US. In his retirement, he has been writing occasionally for *Chemistry in Australia*.

Tasting terroir – influence of barley malt flavour on beer

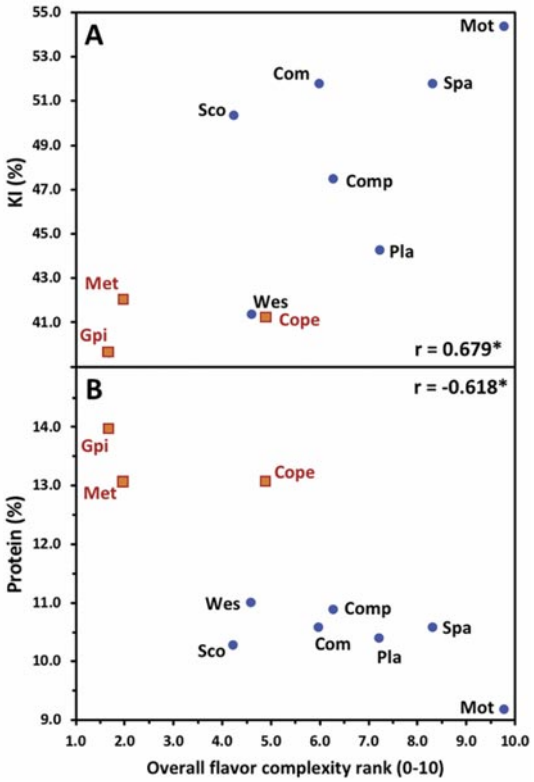
There is no disputing that 'a beer drinker drinks as much with his or her eyes as with their mouth'. The serving of beer in a well-selected glass also heightens the anticipation of beer quality attributes such as flavour, colour, clarity, foam and degree of carbonation, which the brewer crafts to meet or exceed that promise. The dispensed beer must also consistently meet or exceed the drinker's expectations for style and brand.*

Beer flavour must then fulfil the expectations arising from visual cues, as described above, which forms the opening lines of a recent paper (Stewart et al., *J. Am. Soc. Brew. Chem*. 2023, vol. 81, p. 282–98). This anticipated beer flavour is primarily influenced by malt kilning and the choice of yeast/hops in the beer recipe. Although barley malt is the material backbone of most beers, variety has until recently been largely overlooked with respect to flavour differences. Stewart and colleagues studied 11 malt variety samples from Australian and international (UK, Canada, China) growing regions, that were infusion mashed (65°C) at laboratory scale to produce unboiled wort, to investigate differences in flavour profiles determined by sensory assessment and headspace-solid phase microextraction gas chromatography–mass spectrometry.

Sensory evaluation identified wort flavour differences, with the control heritage samples, Maris Otter/Schooner, having the highest overall flavour complexity and acceptability (see graph). The Chinese-malted Chinese/Canadian samples ranked lowest for overall flavour complexity. Overall, 107 compounds (aldehydes, alcohols, esters, organic acids, terpenes, ketones) were found to vary among the varietal worts. The sensory assessment was supported by principal component analysis plots, with Maris Otter and the Australian samples clustering in different quadrants from the Chinese-malted Canadian/Chinese samples. Overall flavour complexity was correlated with Kohlbach index (protein modification), malt protein (negative) and β-glucosidase (negative), while sweetness was correlated with limit dextrinase and pH.

In the last decade, several groups have sought to delineate the molecular basis for putative malt flavour differences in wort, whisk(e)y and beer. Although most malt flavour studies concentrate on differences between varieties, four investigations have considered the influence of the barley growing environment on beer flavour (Bettenhausen et al., *J. Am. Soc. Brew. Chem*. 2018, vol. 78, p. 136; Herb et al., *J. Am Soc. Brew. Chem*. 2017, vol. 75, pp. 345, 354; Li et al., *Mast. Brew. Ass. Am. Tech. Quart*. 2022, vol. 59, p. 74). In an extended study over two growing seasons in Canada, using four commercial varieties, Li et al. (2022) observed that despite significant differences for malt quality parameters (e.g. grain protein content, Kohlbach index), limited differences were observed for aroma and non-volatile beer compounds by sensory analysis or by mass and NMR spectrometry.

Terroir is a sparsely studied aspect of malt quality, despite it being an important component of wine marketing: the 'sense of place' imbued by terroir is an expression of the growing of a variety in a specific region with respect to local climate, soil, grape microbiome, vineyard elevation/aspect, and viticultural and winemaking methods. Similar corollaries to wine terroir can be drawn for the quality of malting barley.



Scatterplots between wort overall flavour complexity/intensity ranking and (A) malt protein, and (B) malt Kohlbach index. Malting barley varieties AC Metcalfe (Met) and CDC Copeland (Cop) were grown in Canada and malted in China, while Gan Pi was grown and malted in China. Compass (Comp), Commander (Com), Planet (Pla), Scope (Sco), Sparticus (Spa) and Westminster (Wes) were grown and malted in Australia, while Maris Otter (Mot) was grown and malted in the UK. Figure extracted from Stewart et al., *J. Am. Soc. Brew. Chem.* 2023, vol. 81, p. 282–98.

Direct evidence for terroir in malting barley literature is more elusive and is mainly confined to recent malt flavour studies. The evidence in turn appears to be at least somewhat linked to grain protein content and Kohlbach index. Recently, Evans et al. (*J. Inst. Brew.* 2023, vol. 129, in press) observed that the primary terroir-influenced malt component is grain protein content, which in turn appears in part to be controlled by day length during grain maturation. In general, increasing day length typical of grain maturation in Australia tends to be associated with lower grain protein content, while decreasing day length during grain maturation tends to be associated with the higher protein contents typical of Canada. These insights link directly into the flavour relationships outlined in the graph above.

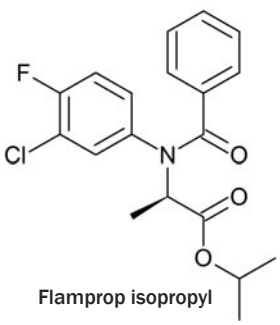
* Bamforth C.W. *Euro. Brew. Conv. Monograph XXVII (Amsterdam)* 1999, pp. 10–23.

Evan Evans is a malting and brewing research consultant as the Tassie Beer Dr in Tasmania.

The Jackman era

Although Lloyd Jackman was professor of organic chemistry at the University of Melbourne for a relatively short time (1962–7), he had a profound impact on the department and especially on the students who were pursuing research degrees in organic chemistry. Jackman completed his PhD at the University of Adelaide in 1951 and undertook postdoctoral work in England that led to his appointment as reader at Imperial College London in 1953. At the time of his appointment to the Melbourne chair, he was on leave as a visiting professor at the University of Iowa.

In support of Jackman, author of a well-known book on applications of nuclear magnetic resonance in organic chemistry, the Melbourne department acquired its first NMR spectrometer and a mass spectrometer, icons of the new methods being adopted by chemists. The research topics tackled by his students were also from a new era, and he collaborated with staff in biology departments on problems of biosynthesis and drug development. Problem-solving sessions introduced by Jackman brought all the organic chemists together, challenging students to work out the structures of natural products for which spectroscopic and other data was provided. The outcomes were the broadening of their chemical knowledge and a strong sense of camaraderie that has survived over the years. Students seeking overseas postdoctoral appointments often asked for Jackman's advice, and found places in America rather than going to Britain as their predecessors had done. Some returned, but unlike their British-oriented predecessors, a few of them stayed in the Land of the Free and the Home of the Brave.



Flamprop isopropyl

When Jackman moved to Pennsylvania State University in 1967, some of his students remained in Melbourne to complete their degrees; some nearing completion went to Penn State to write the theses that earned them a Melbourne PhD; while others who were partway through their degrees were able to transfer their enrolment to Penn State and so earned their PhD degrees there.

From time to time the Jackmans, Lloyd and Marie, travelled to Australia to visit relatives, and it was on such a visit in 1998 that Dan Whelan spotted them dining in a restaurant and introduced himself as a student of what we now think of as 'the Jackman era' (although Dan's PhD work was supervised by another member of staff). The idea for a reunion meal was born there, and a few days later a dozen or so couples met for dinner with the Jackmans at a local pub, to reminisce about their time at the University of Melbourne in the glorious sixties.

From its beginning, the group grew to include other Melbourne students – mostly organikers – and some members of staff, so over the next two decades some 30–40 chemists along with partners sat down to lunch or dinner every year. Lloyd was present at several of these functions and from time to time so were other overseas-based members for whom the time of a family visit coincided with the reunion date. Others who are unable to attend because of distance often write to greet the others and to reflect on the way their careers developed as they became part of the post-Jackman diaspora.

Mark Scott, for example, who has made his career in England, wrote this year:

> *From Penn State I went to a postdoctoral position at the Massachusetts Institute of Technology (MIT) in Boston, and then to Shell's Woodstock Research Centre in Sittingbourne, Kent, England. In crop protection I had been working on a rodenticide project when I had an incredible stroke of luck. I was asked by one of the directors to improve the performance of a wild oat herbicide called Flamprop isopropyl (see structure below). Wild oats are taller than wheat and barley and they suppress crop yields. They drop their seeds early, resulting in increasing contamination in future yields, and much poorer bread, malting barley for beer, and so on. It was pure luck that I was able to use a single chiral form of the herbicide to kill the wild oats. The synthesis started with naturally occurring S-(+)-lactic acid, but the herbicide that I made from it required the opposite chiral form, and had to be folded inside out. If the same chiral form had been needed, it would never have been possible to achieve adequate purity. The improved wild oat herbicide was actually cheaper to make than the original racemic one and made billions of dollars for Shell, at least five times that for farmers, and then there's the supply chain of wholesalers, advertisers who also profited. Those of you in 'the lucky country' (Australia, of course) won't know of the products because they are relatively ineffective in thinner, lower-yielding crops as are the norm in the expansive areas of Australia. But in any case they're now a thing of the past, Shell having changed its view from considering crop protection as being good, to it being bad, for its image. And today soil conserving, low-tillage, low-treatment techniques have become common, and probably will become the norm soon. At the time, though, my luck continued and I was able to participate in every stage apart from marketing – R&D, synthesis of field samples and, for four years, process development and manufacturing in Holland.*

After a recess in the COVID years, the group, now depleted by the loss of several members, convened again earlier this year with Peter Gordon succeeding Dan Whelan in the coordinator role. Its existence is a remarkable outcome of Lloyd Jackman's time at the University of Melbourne and the spirit it engendered in students, not only those who worked directly with him but for all of those in the vicinity of the young professor.

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 is an editor of *Historical Records of Australian Science*.

events

Find out more at raci.org.au/events

Early Career Chemists Murder Mystery Night
15 September, West End, Qld

Structural Bias and Inequality in Science: Ageism
21 September, webinar

Physical Chemistry Student Conference
25–28 September, Katoomba, Blue Mountains, NSW

Chemraderie National Networking Event
28 September, webinar

Structural Bias and Inequality in Science: Living with a Disability
3 October, webinar

Top Tips When Starting a New Job
12 October, webinar

Careers in Forensic Science: The CSI Effect
19 October, webinar

CHEM 2023 / Melbourne Protein Group Symposium
24–26 October, RMIT University, Melbourne, Vic

Medicinal Chemistry Workshop
24–26 October, webinar

Chemraderie National Networking Event
26 October, webinar

Careers Outside the Lab
31 October, webinar

Science and Working Flexibly
9 November, webinar

Mentoring Program 2024 Information Session
23 November, webinar

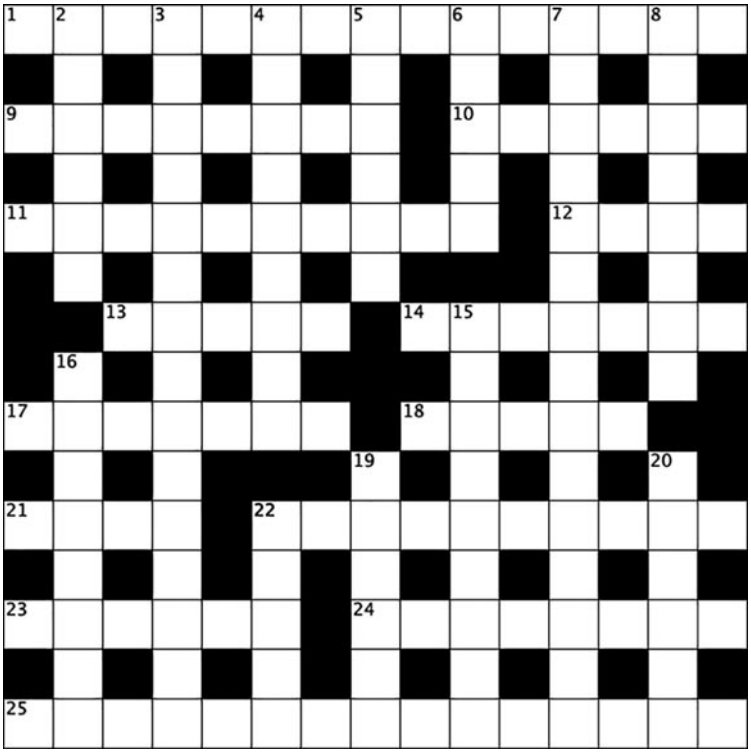
Queensland Annual Chemistry Symposium
24 November, QUT, Garden Point, Brisbane, Qld

Australian Materials Chemistry Conference
30 November – 2 December, Esplanade Hotel by Rydges, Fremantle, WA

RACI R&D Topics Conference 2023
3–6 December, University of NSW, Kensington, NSW

14th Australasian Organometallic Chemistry Meeting
4–7 December, Australian National University, Canberra, ACT

cryptic chemistry



Across

1 & 16 Down Choose or return attractive new crumpets to make waves. (15,8)
9 As precedes dancing emu lines. (8)
10 Devil Do crash. (6)
11 Transmitters of sound manage detector of radiant energy. (10)
12 Sit on papers in 75. (4)
13 Gamma cross-section bottles up something big. (5)
14 A sub-culture dig follows 9 Across. (7)
17 Leading environmental performance index's second order differential equation is happening. (7)
18 Orbital in electron backbone. (5)
21 Bus which has been used since the 80s (!) has at least two elements. (1.1.1.1.)
22 Mystic east to be organised. (10)
23 Third alloy. (5)
24 Sluts die as fighters. (8)
25 Describe unfinished actions for mix if cement presets. (9,6)

Down

2 Room to move the Bruce?! (6)
3 Ace clinic scheme changes what we do. (8,7)
4 Relieved risk controls rude outburst. (9)
5 Wealth shot in manganese. (6)
6 Periphery bound by germanium dust. (5)
7 I nominate expert for what is critical to 3 Down. (15)
8 Indium investigators specialisation is happening. (8)
15 Show about here. (9)
16 See 1 Across.
19 Code is changed when conveying impressions from the surface of the body to the spinal cord. (6)
20 Pinch shrimp. (6)
22 First simple harmonic electromagnetic Lorentz force counter?! (5)

Graham Mulroney FRACI CChem is Emeritus Professor of Industry Education at RMIT University.
Solution available online at chemaust.raci.org.au, Other resources.

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