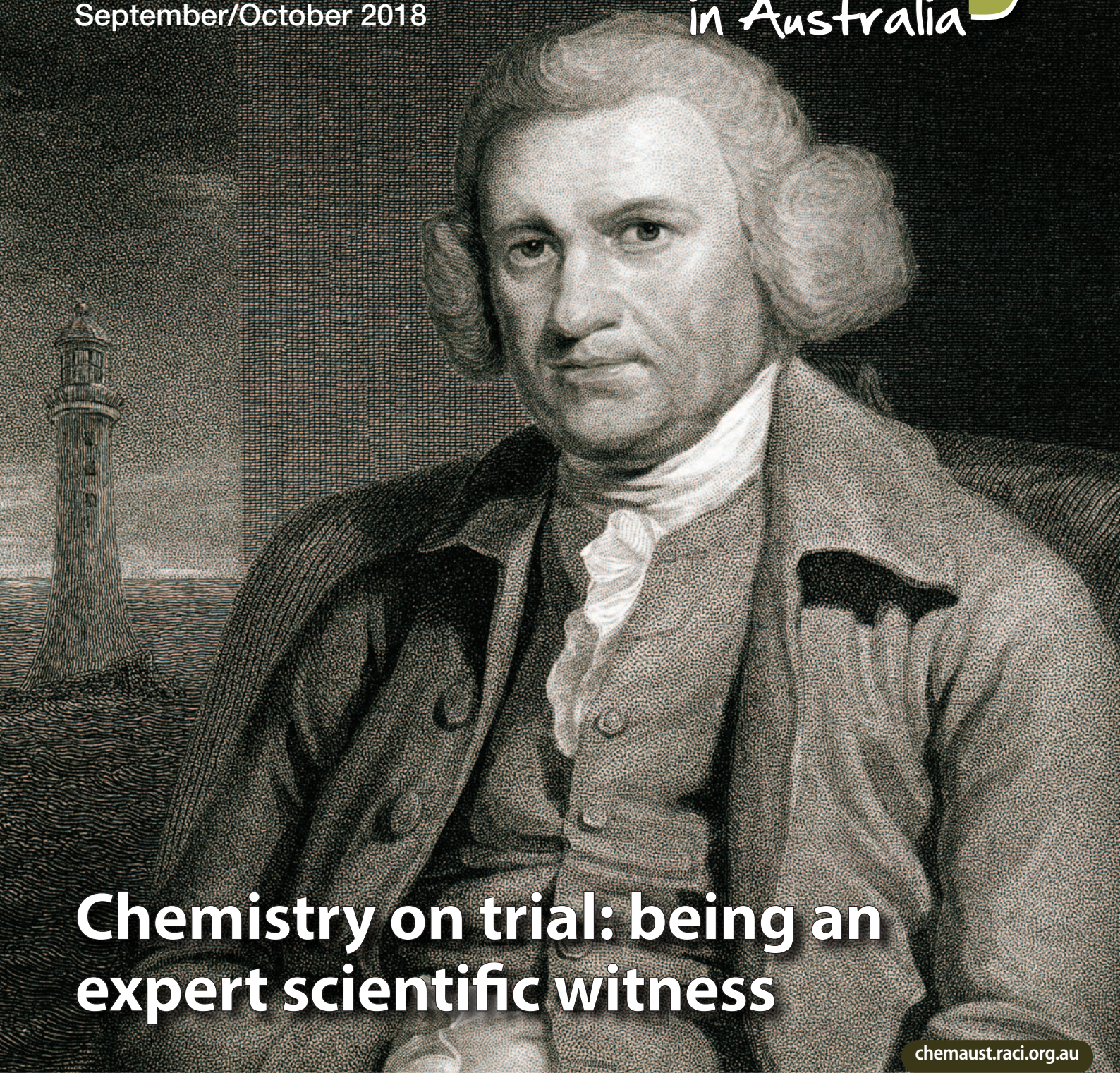


chemistry

September/October 2018

in Australia



Chemistry on trial: being an expert scientific witness

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- Ira Remsen: stories for chemical education
- Significance of soils to sustainable agriculture
- Adventures of an RSC Australasian lecturer



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cover story

Bearing witness

From 18th-century engineering to modern illicit drug profiling, the trials and tribulations of expert witnesses are fundamentally similar.

British civil engineer John Smeaton (1724–1792) was called as an expert scientific witness in *Folkes v Chadd*, in the first-ever legal instance of this practice. See cover story on p. 18.

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22 Chemistry underfoot

The significance of soils to sustainable agricultural production is enormous, explain two members of the new CRC for High Performance Soils.

26 Ira Remsen: stories for chemical education

American chemist Ira Remsen's bittersweet story holds good lessons for chemical educators, says Bill Palmer.

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The terrain of tears

'They are messengers of overwhelming grief, of deep contrition and of unspeakable love.' This evocative sentence, widely (but possibly erroneously) attributed to writer Washington Irving, alludes to the power and peculiarity of tears.

In Arnold Lobel's *Owl at home*, Owl thinks of things to make him cry so that he can drink some tear-water tea, which he describes as 'a little bit salty'. He thinks of sad things but he feels happy as he fills his cup.

Tears are clearly a source of inspiration (and tea), and their chemistry is equally fascinating. Tears of laughter are chemically different from tears of loss, and different again from tears arising from that dust that blew into your eye. Some tears are permanent residents in our eyes; others spring forth because of joy, pain, empathy – or just by chopping onions.

At a macro level, there are three main types of tears. Basal tears keep our corneas lubricated. Psychic or emotional tears happen in response to emotions. Reflex tears are the ones that try to rid our eyes of irritants. If you'd like to explain the different types to a youngster, try the TED-Ed clip about the exploits of Iris, including her eye-opening (and closing) encounter with an onion (bit.ly/2Oo8mjf). When an onion is cut, the enzyme lachrymatory-factor synthase is released, converting amino acid sulfoxides to sulfenic acid. This transforms into the tear-jerking substance syn-propanthethial-S-oxide.

All tears typically contain mucus, NaCl, KCl, hormones, antibodies and proteins (including enzymes and metabolites). We produce tears in different amounts, and the proportions of these components vary depending on the tear type. Emotional tears, for example, contain prolactin and endorphins.

Interestingly, artificial tears, used to treat dry eyes and moisten contact lenses, do not contain proteins. Typical preparations contain water, salts, polyvinyl alcohol, hydroxypropyl cellulose, carboxymethyl cellulose and hyaluronic acid. Perhaps partly reflecting the individuality of each human eye, a recent Cochrane review was unable to identify the most effective artificial tear formulation (bit.ly/2N0rXrS).

In the 17th century, anatomist Niels Steensen (later Nicolas Steno) discovered the lacrimal gland as the origin of tears, and the function of tears as a lubricant was postulated. However, the function of emotional tears is still largely a scientific



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Tears of Grief from *The topography of tears*.

mystery. Cutting the sensory nerve for tears (the trigeminal nerve) has been found to prevent reflex tears but not emotional tears. Equally mysterious is why some people do not cry at all.

We do know that a few systems jump into action to produce emotional tears. In the presence of an emotional situation, the brain's limbic system sends a signal to the autonomic nervous system, via the neurotransmitter acetylcholine. This triggers the lacrimal gland so that we 'tear up'.

The incredible diversity of natural tears was illustrated as part of US photographer Rose-Lynn Fisher's *The topography of tears* (rose-lynnfisher.com), published last year by Bellevue Literary Press. Described by Fisher as an 'ephemeral atlas', the project began a decade ago during what she has described as a 'pivotal' – and very tearful – time of her life. It was then that she asked herself if tears of grief are different from tears of joy. After mounting a digital camera onto an optical microscope and peering at some samples, she saw that the answer was 'yes'. So began the collection, preparation and photography of all sorts of tears from people of all ages. Fisher realised that even separate samples of the same types of tears are distinct, due to factors such as viscosity, evaporation rate, preparation and processing.

Steensen's studies of medicine led him to an interest in palaeontology and then geology. He is considered to be one of the founders of modern geology. If he ever pointed a microscope at the products of the lacrimal gland, his eyes would have been opened to an entirely new terrain. As Fisher says, by way of contrast with the empirical nature of her work, '... the topography of tears is a momentary landscape, transient as the fingerprint of someone in a dream'.



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p-values: use and abuse

Ole Kjaerulff's exposition of the use and abuse of *p*-values in statistical analysis (May p. 36, June p. 37) was timely and helpful. Congratulations on acquiring and printing it.

It is perhaps not surprising that when users of statistical tests of significance arrive at a calculated statistic that is associated with a low probability of chance occurrence (i.e. lower than the one they hoped for), they fall for the trap of concluding that the result is even more decisive than they hoped.

Alas, the proper use of such tests demands that the 'hoped for' probability must be determined before making a test of significance of the results examined. Then the result of the test, at the probability predetermined, either is significant or isn't. Further decisions from this yes/no result are forbidden. This is counter-intuitive, but is embedded in the underlying theory.

It is sobering to remember that having chosen a probability level, say 95%, then (on average) although 19 in 20 of such decisions will be right, one will be wrong. But of course, one cannot ask for more than this: with no risk of error there would be no need for the test of significance in the first place.

Bruce Graham FRACI CChem

Energy from waste

Readers of Duncan Seddon's article on waste management in the July–August issue (p. 34) might benefit from the following further perspective. He says a good deal about waste incineration and gasification and states correctly that municipal waste shows seasonal variations in composition and therefore in calorific value.

Way back in 1971, a major conference on waste management was held at the University of New South Wales. The proceedings (*Solid waste treatment and disposal: the international edition of the 1971 Australian Waste Disposal Conference, held at the University of New South Wales*, Ann Arbor Science Publishers Inc., 1972) were edited by N.Y. Kirov, who makes the point, which I have reiterated with some emphasis (*Thermal processing of waste*, Ventus Publishing, 2010), that the calorific value of raw municipal solid waste is around 7 MJ kg⁻¹, which is about the same as that for Victorian brown coals in their bed-moist state. In 1971, most of Victoria's electricity was produced from such coals at Yallourn and at Morwell in the Latrobe Valley. Loy Yang power station in the valley, which also used locally won brown coal, remains in operation in 2018. Kirov goes on to describe municipal solid waste as an 'energy ore'.

A common index of the value of a fuel is how many times its own weight of dry saturated steam at 1 bar it could raise starting with liquid water at 100°C. The heat of vaporisation of water under those conditions is 2256.6 kJ kg⁻¹, so a kilogram of the raw municipal waste could raise three kilograms, three times its own weight of steam. Two comparisons will be made. One is with producer gas, which can raise up to twice its own weight of steam. The other is with petroleum products, which can raise about 20 times their own weight of steam.

Clifford Jones FRACI CChem

pH probes for soil analysis

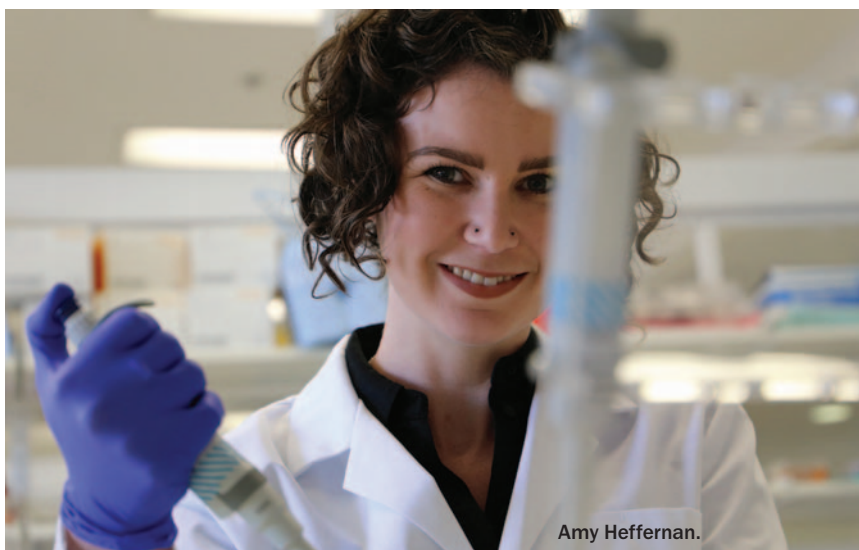
I agree with Stephen Grocott (July–August p. 5) that the 'traditional laboratory method' of air-drying soils prior to measurement of pH mentioned in the article 'Is soil more acidic than we thought?' (June p. 38) is indeed odd. In addition to the problems mentioned in Stephen's letter, I would have thought that such a sample pretreatment would be inappropriate in the case of soils sampled from anaerobic environments where reduced iron sulfides are present (such as those obtained from some Australian coastal mangrove areas). In such circumstances, I would assume subsequent oxidation and hydrolysis would lead to the production of sulfuric acid, biasing results to lower pH values.

In an effort to find out more, I contacted the principal author, who kindly supplied me with a copy of the paper on which the article was based. It turns out that the authors were primarily concerned with in situ measurements in sodden podzolic soils in Denmark with very high organic contents and where moisture contents were in the range of 70–80%. In such cases, I would assume that it would be reasonable to make in situ measurements if one were to ascertain the true pH of the soil environment. As long as the natural moisture content was high enough to allow good electrical contact between the sensing membrane and the reference electrode junction of the pH probe, this would appear a valid approach. However, it is possible to quibble about the authors' choice of a pH probe. Although from a well-known manufacturer and recommended for soil pH measurements (and with a truly eye-watering price tag), it features a porous pin reference junction that can clog easily when measuring dirty samples. Reference junction problems are an often-neglected reason for errors in pH measurement. A better choice would be an electrode with a sleeve-type reference junction, where it may be refreshed easily with new electrolyte between measurements. I have worked with the Australian-made Ionode sleeve type intermediate junction pH probes in measuring pH in all sorts of dirty samples, including soils, and obtained consistent results. These probes are available for a fraction of the price of their overseas competitors.

Thomas K. Smith FRACI CChem

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Superstars of STEM rocket through pilot year



The first 30 Superstars of STEM have graduated, following a year of training, support and opportunities to speak with the media, decision makers, mentors, students and teachers across Australia.

Superstars of STEM aims to smash society's gender assumptions about scientists and increase the public visibility of women in STEM. STA created Superstars of STEM to produce a critical mass of celebrity Australian female scientists and technologists – role models for young women and girls – and to work towards equal representation in the media of women and men working in all fields of STEM.

STEM Superstar graduate and RACI member Dr Amy Heffernan is an analytical chemist and early career researcher at the Florey Institute of Neuroscience and Mental Health in Melbourne. Her research combines chemistry, bioinformatics and statistics to solve complex problems in the environment and human health.

Heffernan received her PhD in environmental chemistry from the University of Queensland in 2014. Her early research focused on environmental and health monitoring of common chemicals, including pesticides, plasticisers and flame retardants in the

Australian population, and much of this research has been used to inform national policy.

With the award of a prestigious NHMRC-ARC Dementia Research Development Fellowship in 2016, Heffernan moved to the field of neuroscience, bringing interdisciplinary expertise in quantitative mass spectrometry. Her current research investigates metal-binding proteins for therapeutic application in neurodegenerative disease.

She is a strong advocate of evidence-based policy and public engagement with science, participating regularly in science outreach, and is especially passionate about supporting and promoting women in science.

Kylie Walker, CEO of Science & Technology Australia, said the world-first program has set some impressive milestones in its first year, and is already starting to smash gender stereotypes in science, technology, engineering and mathematics (STEM).

The next round of the program will run for two years commencing January 2019, and support 60 places for female STEM professionals. Applications close 23 September 2018.

Science & Technology Australia

New research on multiple chemical sensitivities

New research reveals almost one in five Australians report chemical sensitivity, with more than one-third medically diagnosed with multiple chemical sensitivities (MCS) suffering health problems from exposure to common chemical products.

The study, conducted by Anne Steinemann, Professor of Civil Engineering and Chair of Sustainable Cities at the University of Melbourne, was published in *Preventive Medicine Reports* (<https://doi.org/10.1016/j.pmedr.2018.03.007>).

'Multiple chemical sensitivities is a serious disease that is often caused and worsened by exposure to petrochemical sources such as pesticides, solvents, new building materials and fragranced items', Steinemann said.

'Even low-level exposure can inflict a range of adverse health effects such as migraines, breathing difficulties, cognitive impairment, seizures and asthma attacks.'

The online survey found MCS is widespread in the Australian


population, affecting an estimated one million adults nationwide, with chemical sensitivity affecting a further two million.

The study also found 74.6% of people with MCS are asthmatic, and 91.5% with MCS report health problems from fragranced products, such as air fresheners and deodorisers, laundry products, candles, cleaning supplies and personal care products.

For 55.4% of people with MCS, the severity of these health problems can be disabling. In addition, 52.1% of Australians with MCS lost work days or a job in the past year due to illness from fragranced products in the workplace. The results mirror Steinemann's earlier research in the US.

Steinemann recommends choosing unfragranced products and implementing fragrance-free policies in workplaces, healthcare facilities, schools and other indoor environments.

University of Melbourne



Scientists have discovered parrots are highly unusual in how they produce their iconic red and yellow feather colours.

Jonathan Barnsley

Fascinating feather find

Ever wondered where parrots get their bright plumage? An Otago-led project may have just solved the mystery.

Lead author PhD candidate Jonathan Barnsley says parrots are highly unusual in how they produce their iconic red and yellow feather colours.

Most birds produce feather colours by two well-known methods: blue, green and purple are generated when light is reflected off microscopic layers in the feathers; most other colours, including red and yellow, are made when light is absorbed by chemically different pigments.

Parrots are unusual because their red and yellow feathers contain chemically similar pigments.

Barnsley and his team, whose findings have been published in *Royal Society Open Science* (<http://dx.doi.org/10.1098/rsos.172010>), discovered that red and yellow pigments in parrot feathers interact with light in different ways, possibly because pigment molecules in red feathers are 'communicating' with each another.

The researchers probed parrot feathers with a laser-based analysis technique that revealed a diverse group of pigment components interacting with one another.

The base colour of these components is actually orange, and they only become red when they are interacting together in the feather.

'We found that red pigments have a diversity of chromophores, but we did not find this same diversity in yellow pigments.'

A chromophore is a molecule, or part of a molecule, that absorbs visible light.

'Chromophore diversity can come about when molecules interact or communicate with their nearest neighbours to change how one another absorbs light', he said.

This observation raises the possibility that parrot plumages are 'tuned' across a range of hues, perhaps accounting for major differences in plumage coloration between closely related species. Colour-tuning is known in crustaceans, but has not previously been observed in feathers.

Most birds need to find and eat specific foods to produce their red and yellow colours but parrots are different because they can make red and yellow feather colours without eating a special diet.

Co-author Dr Daniel Thomas, of Massey University, says it is possible parrots are able to tune pigments to produce a range of colours – from the magenta of a galah to the yellow of a sulphur-crested cockatoo.

This colour-tuning could be significant in the evolution of parrots and possibly other animals.

'There is still important work to do in linking chromophore diversity to colour-tuning, but it is exciting to think that we have a new way of exploring the long-standing question of why different animals generate similar colours using wildly different pigments', he said.

University of Otago

New anticancer drugs may put cancers to sleep ... permanently



Left to right: Associate Professor Tim Thomas and Associate Professor Anne Voss from the Walter and Eliza Hall Institute with Professor Jonathan Baell from the Monash Institute of Pharmaceutical Sciences.

Melbourne scientists have discovered a new type of anticancer drug that can put cancer cells into a permanent sleep, without the harmful side-effects of conventional cancer therapies.

Published in *Nature* (<https://doi.org/10.1038/s41586-018-0387-5>), the research reveals the first class of anticancer drugs that work by putting the cancer cell to sleep – arresting tumour growth and spread without damaging the cells' DNA.

The new class of drugs could provide an exciting alternative for people with cancer, and has already shown great promise in halting cancer progression in models of blood and liver cancers, as well as in delaying cancer relapse.

The research was led by Associate Professor Tim Thomas and Associate Professor Anne Voss from the Walter and Eliza Hall Institute, Professor Jonathan Baell from the Monash Institute of Pharmaceutical Sciences and Dr Brendon Monahan from Cancers Therapeutics CRC.

Thomas said the new class of drugs was the first to target KAT6A and KAT6B proteins. Both are known to play an important role in driving cancer. KAT6A sits at number 12 on the list of genes

most commonly amplified in cancers.

'Early on, we discovered that genetically depleting KAT6A quadrupled the life expectancy in animal models of blood cancers called lymphoma. Armed with the knowledge that KAT6A is an important driver of cancer, we began to look for ways of inhibiting the protein to treat cancer', Thomas said.

The compounds had already shown great promise in preclinical testing, he said.

There is a critical difference between this new class of drugs and standard cancer therapies. Chemotherapy and radiotherapy work by causing irreversible DNA damage. Cancer cells are unable to repair this damage, and die. The downside is that the therapies cause significant damage to healthy cells as well with short-term side effects such as nausea, fatigue, hair loss and susceptibility to infection, as well as long-term effects such as infertility and increased risk of other cancers developing.

'Rather than causing potentially dangerous DNA damage, as chemotherapy and radiotherapy do, this new class of anticancer drugs simply puts cancer cells

into a permanent sleep', Voss said.

'This new class of compounds stops cancer cells dividing by switching off their ability to "trigger" the start of the cell cycle', she said. 'The technical term is cell "senescence". The cells are not dead, but they can no longer divide and proliferate. Without this ability, the cancer cells are effectively stopped in their tracks.'

Voss said the team believed the drugs might be effective in delaying cancer recurrence.

'The possibility of giving clinicians another tool that they could use to substantially delay cancer recurrence could have a big impact for patients', Voss said.

Baell said the project was particularly significant because the scientific community had coined the gene family 'undruggable'.

'There were many hurdles to overcome with this project; this compound certainly didn't fall into our laps, requiring dedicated PhD students and NHMRC-supported postdoctoral medicinal chemists to drive the chemistry forward', Baell said. 'But with perseverance and commitment, we are excited to have developed a potent, precise and clean compound that appears to be safe and effective in our preclinical models. Our teams are now working on developing this compound into a drug that is appropriate for human trials.'

Baell said the project was indebted to funding from the Australian Government and proved that public research could be an effective translational vehicle.

Dr Ian Street, chief scientist at Cancer Therapeutics CRC said it had been a great collaboration between the three organisations.

'This has been a very tough nut to crack', Street said. 'There is no doubt that the KAT6 inhibitors have played an important role in elucidating the potential of this new and exciting strategy to treat cancers.'

Walter and Eliza Hall Institute

Detailed pictures of conducting polymers

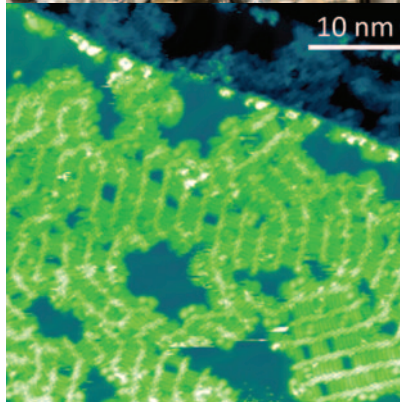
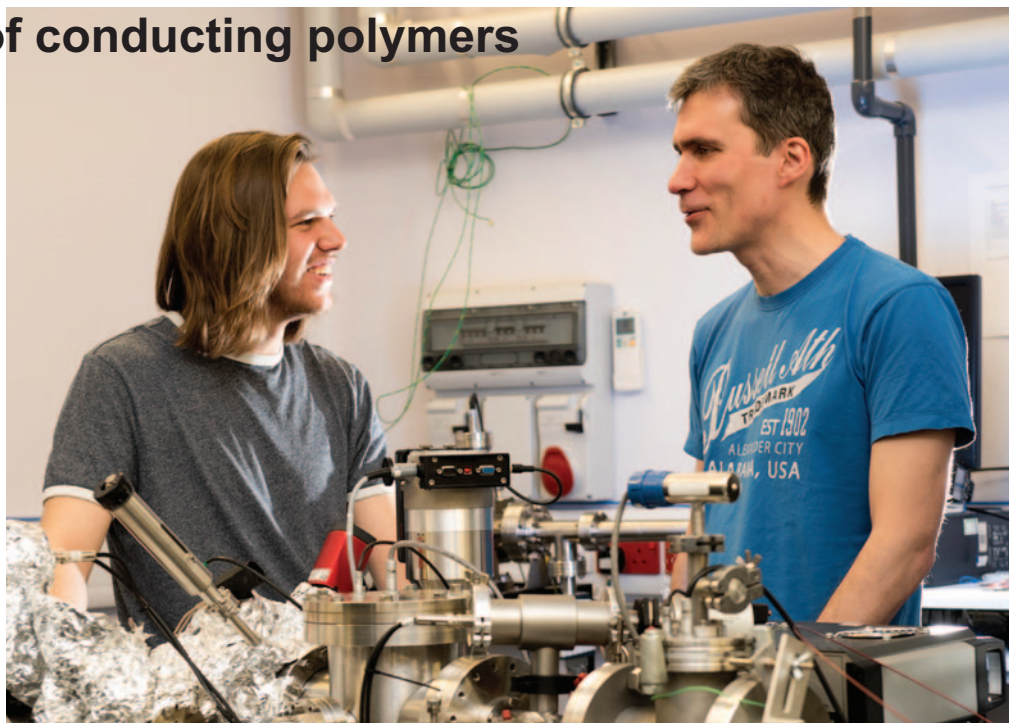
The first detailed pictures of the structure of conjugated polymers have been produced by a research team led by Professor Giovanni Costantini at the University of Warwick, UK. The research has been published in *Science Advances*.

The ability of these polymers to conduct electricity makes them highly sought after, but until now there has been no easy means to determine their structure.

Conjugated polymers are able to conduct electricity because they are a chain of conjugated molecules where electrons can move freely due to their overlapping electron p-orbitals. Effectively, they are excellent molecular wires. Moreover, they are akin to semiconductor materials (they have energy gaps), so they can be used for electronic (plastic electronics) and photovoltaic (organic solar cells) applications.

Modern functional polymers are often copolymers: they are made of different monomers. The order of these monomers is essential to their opto-electronic properties, which can be severely damaged by errors in how the monomers actually link up in a chain to form the polymer (so called polymerisation errors occurring during the synthesis of these materials). However, detecting the nature and exact position of these errors has proved problematic with current analytical methods. Mass spectrometry does not provide a solution, as shorter polymer chains are typically more likely to be ionised and thus tend to be overrepresented in the spectra.

The approach of Costantini and co-workers is to deposit the polymers onto a surface and image them by high-resolution scanning tunnelling microscopy (STM). The authors opted for a new method of spraying a cloud of the polymer through a series of tiny openings into a vacuum chamber, allowing a single unjumbled layer to be deposited onto a surface that is fully representative of the original polymer sample. STM of these layers revealed sub-monomer details of the conjugated polymers.



The high-resolution STM images of the structure of conjugated polymers are so detailed that as well as helping with quality control and fine-tuning of polymer design, they can even be used as something akin to an intellectual property (IP) passport photo for polymers. It is speculated that such precise and clear images could help synthetic researchers to demonstrate exactly the design they wish to legally protect by dramatically improving the information available to support an application for IP protection.

The researchers demonstrated the power of the new technique by examining a conjugated polymer that is currently showing some of the best performances in optoelectronic devices.

Daniel A. Warr and Luís M. A. Perdigão, co-authors of the study based at the University of Warwick.

STM image showing how the detail of the structure of C14DPPF-F can be seen. The polymer backbones appear as bright rows and the alkyl side chains are seen as darker rows perpendicular to the backbones.

This material is most effective when its polymer chains form in an alternating sequence of one large 'A' monomer and a smaller 'B' monomer. However, flaws can happen during the synthesis that break that ideal sequence, thereby also damaging its appealing conducting and light-harvesting properties. The speculations so far were that this mainly occurs when two of the larger 'A' monomers join directly together in an BAAB sequence.

When these flaws happen, gaps or voids form in the conjugated polymer's assembly corresponding to those errors in the chain. The researchers were able to use their new visualisation technique to very clearly show all of these gaps and then to zoom in further onto the polymer chains, precisely spotting each of the defective monomer sequences. On doing so, to their great surprise, they found not the expected BAAB flaws but ABBA defects.

University of Warwick

2018 Global Survey of Mathematical, Computing, and Natural Scientists

A crucial component of the Gender Gap in Mathematical, Computing, and Natural Sciences project is the compilation of self-reported data from scientists via a global, multilingual, and multidisciplinary survey. The goal is to study social dynamics in the fields of physics, chemistry, astronomy, biology, computer science and mathematics by asking a large number of scientists and practitioners about their experiences, challenges and interests, as well as focused information about women in these fields.

The analysis of the compiled data will allow comparisons across regions, countries, disciplines, level of development of the country, sector of employment, and age. The insights obtained from this survey will help inform interventions by the International Council for Science (ICSU) and member unions to increase participation in STEM fields, especially for women.

The survey is now open to respondents from all over the world. The survey is available in English, French, Chinese, Japanese, Russian, Spanish and Arabic. If you have studied or worked in mathematical, computing or natural sciences, or in the history and philosophy of science and technology, visit the link to complete the survey and to share this information with your colleagues: <https://icsugendergapinscience.org>.

Participation will be open until 31 October 2018.

IUPAC (ICSU project partner)

World's oldest colours discovered



Biogeochemistry lab manager Janet Hope from the ANU Research School of Earth Sciences holds a micro-chromatographic column showing the pink porphyrins, which have separated from bitumen (yellow-brown) on a silica gel stationary phase. Lannon Harley, ANU

Scientists from the Australian National University (ANU) and overseas have discovered the oldest colours in the geological record, 1.1 billion-year-old bright pink pigments extracted from rocks deep beneath the Sahara desert in Africa.

Dr Nur Gueneli, who discovered the molecules, said the pigments taken from marine black shales of the Taoudeni Basin in Mauritania, West Africa, were more than half a billion years older than previous pigment discoveries.

'The bright pink pigments are the molecular fossils of chlorophyll that were produced by ancient photosynthetic organisms inhabiting an ancient ocean that has long since vanished', said Gueneli.

The fossils range from blood red to deep purple in their concentrated form, and bright pink when diluted.

The researchers crushed the billion-year-old rocks to powder, before extracting and analysing molecules of ancient organisms from them. 'The precise analysis of the ancient pigments confirmed that tiny cyanobacteria dominated the base of the food chain in the oceans a billion years ago, which helps to explain why animals did not exist at the time', Gueneli said.


Senior lead researcher Associate Professor Jochen Brocks, also from ANU, said that the emergence of large, active organisms was likely to have been restrained by a limited supply of larger food particles, such as algae.

'Algae, although still microscopic, are a thousand times larger in volume than cyanobacteria, and are a much richer food source,' said Brocks.

'The cyanobacterial oceans started to vanish about 650 million years ago, when algae began to rapidly spread to provide the burst of energy needed for the evolution of complex ecosystems, where large animals, including humans, could thrive on Earth.'

The research is published in *PNAS* (<https://doi.org/10.1073/pnas.1803866115>).

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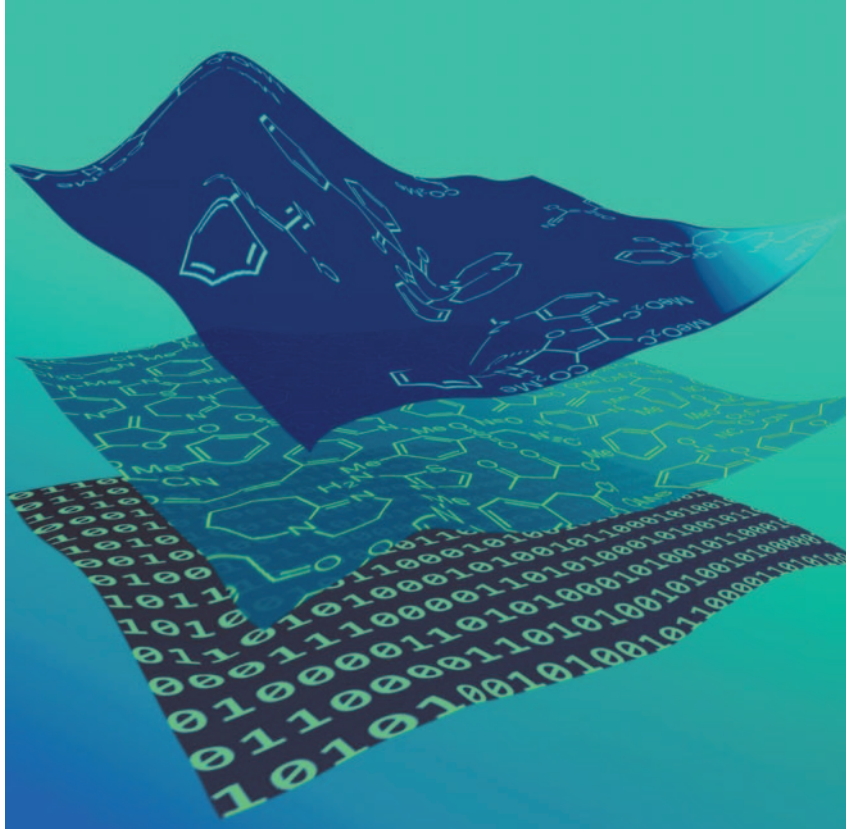
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Robot chemist discovers new molecules and reactions

A new type of artificial-intelligence-driven chemistry could revolutionise the way molecules are discovered, scientists claim.

In a new paper published in *Nature* (<https://dx.doi.org/10.1038/s41586-018-0307-8>), chemists from the University of Glasgow, UK, discuss how they have trained an artificially intelligent organic chemical synthesis robot to automatically explore a very large number of chemical reactions.

Their 'self-driving' system, underpinned by machine learning algorithms, can find new reactions and molecules, allowing a digital-chemical data-driven approach to locating new molecules of interest, rather than being confined to a known database and the normal rules of organic synthesis.

The result could be a decreased cost for discovering new molecules for drugs, new chemical products including materials, polymers, and molecules for high-tech applications such as imaging.

The team demonstrated the system's potential by searching about 1000 reactions, using combinations of 18 different starting chemicals. After exploring only about 100, or 10%, of the possible reactions, the robot was able to predict with more than 80% accuracy which combinations of starting chemicals should be explored to create new reactions and molecules. By exploring these reactions, the scientists discovered a range of previously unknown new molecules and reactions, with one of the reactions classed to within the top 1% of the most unique reactions known.

The approach was designed and developed by the team led by Professor Lee Cronin, the University of Glasgow's Regius Chair of Chemistry. Cronin and his team are convinced that this result will help pave the way for the digitisation of chemistry and developing new approaches to chemistry using a digital code that drives autonomous chemical robots.

Cronin said, 'This approach is a key step in the digitisation of chemistry, and will allow the real time searching of chemical space leading to new discoveries of drugs, interesting molecules with valuable applications, and cutting cost, time and crucially improving safety, reducing waste, and helping chemistry enter a new digital era.'

University of Glasgow

Make the change, make the GRADE!

If you're looking for a cost-effective and high-quality stomacher bag, then the UK made GRADE range may be the smart choice for your laboratory. GRADE has been manufacturing laboratory bags for over 40 years.

The full range of homogeniser/blender and separator bags come in a range of sizes from 80 to 3500 mL and are available in straight or curved bottom, with or without filters. Also available are GRADE disposable straws to pipette samples after homogenisation.

GRADE bags are suitable for all types of blender machines and are made to exacting standards. Leading laboratories world-wide use GRADE bags due to their durable composition and the extremely low likelihood of bags bursting when in use. GRADE bags are manufactured under an ISO 9001 approved quality-control system, and have a negligible failure rate.

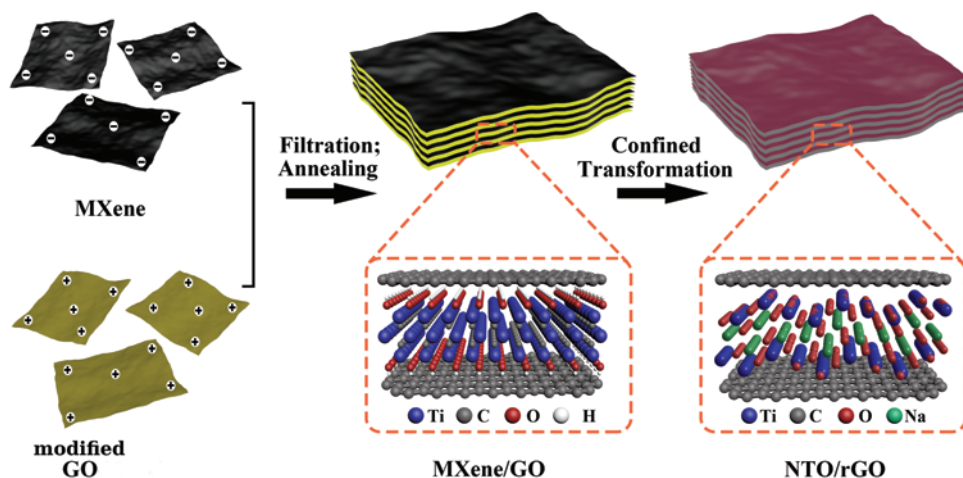
GRADE has made a robust bag by using the correct blend of polymers (high-quality, food-grade LDPE) for superior strength and elasticity. They are tested up to eight times the normal usage to ensure each individually numbered and traceable batch is up to standard.

The easy-to-open double size (4 mm) seal make any faults totally visible, giving you the added security of no leakage. GRADE bags are gamma irradiated for sample integrity and have a minimum shelf life of five years.

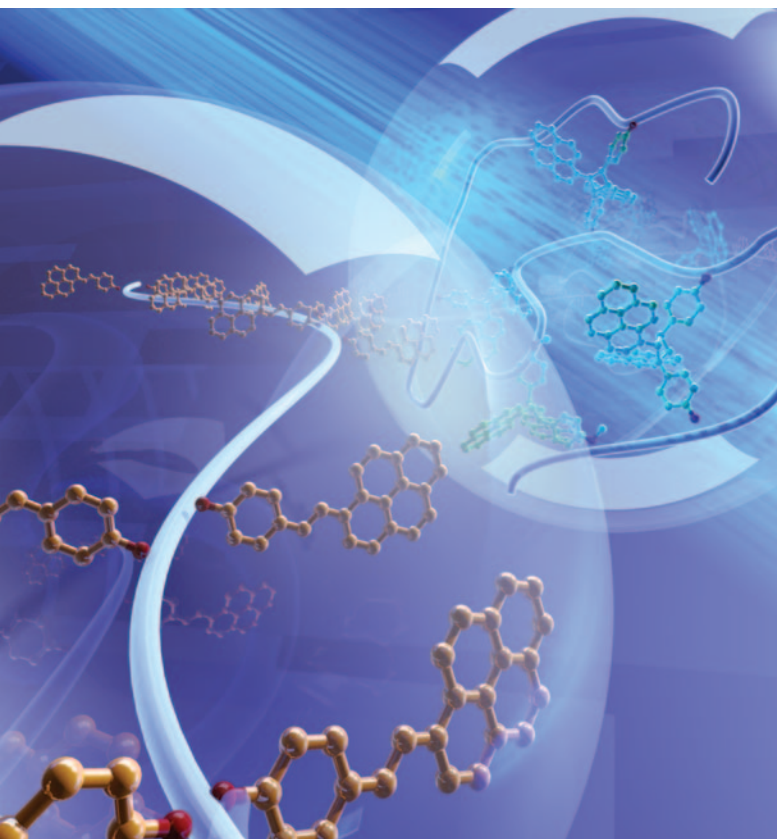
Test them for yourself; ask us for samples. Standard homogeniser/blender bags are available in three sizes 80, 400 and 3500 mL. Separator bags come in two types: 400 mL with curved or straight bottoms. For more information, visit www.rowe.com.au.

Ultrathin layered films for flexible batteries

The advent of flexible electronic devices has demanded the parallel development of flexible energy-storage systems. Mechanically flexible two-dimensional (2D) nanomaterials are promising candidates for building flexible energy storage. Ultrathin layered titanium-based materials, especially sodium titanate (NTO)/potassium titanate (KTO), have been recognised as benchmark 2D electrode materials for sodium/potassium ion batteries, owing to their low working voltage, suitable interlayer spacing for ions, and high chemical stability. Nevertheless, the synthesis of such ultrathin layered materials remains a challenge because layered nanosheets tend to restack and aggregate. Recently, a team led by Shi-Zhang Qiao at the University of Adelaide and Lei Zhang at the South China University of Technology (China) reported the synthesis of free-standing integrated films of ultrathin sodium titanate/potassium titanate nanosheets



sandwiched between graphene layers by the confined transformation of an assembled two-dimensional MXene (titanium carbide) and reduced graphene oxide (rGO) nanosheets (Zeng C., Xie F., Yang X., Jaroniec M., Zhang L., Qiao S. *Angew. Chem. Int. Ed.* 2018, **57**, 8540–4). This hybridisation produced films that were shown to act as effective binder-free anodes for sodium–potassium ion batteries with excellent durability and rate performance.

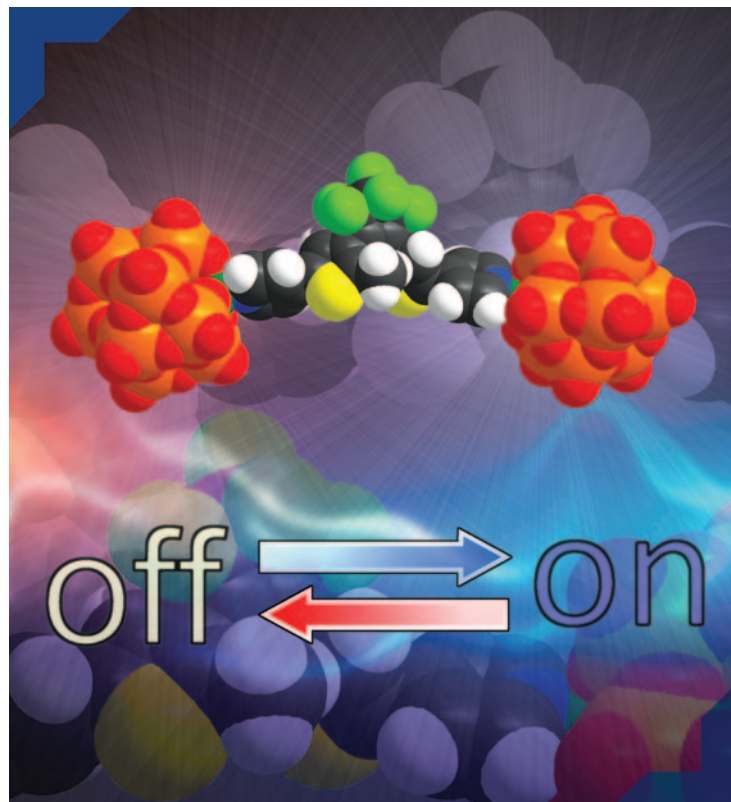


Folding polymers with ambient light

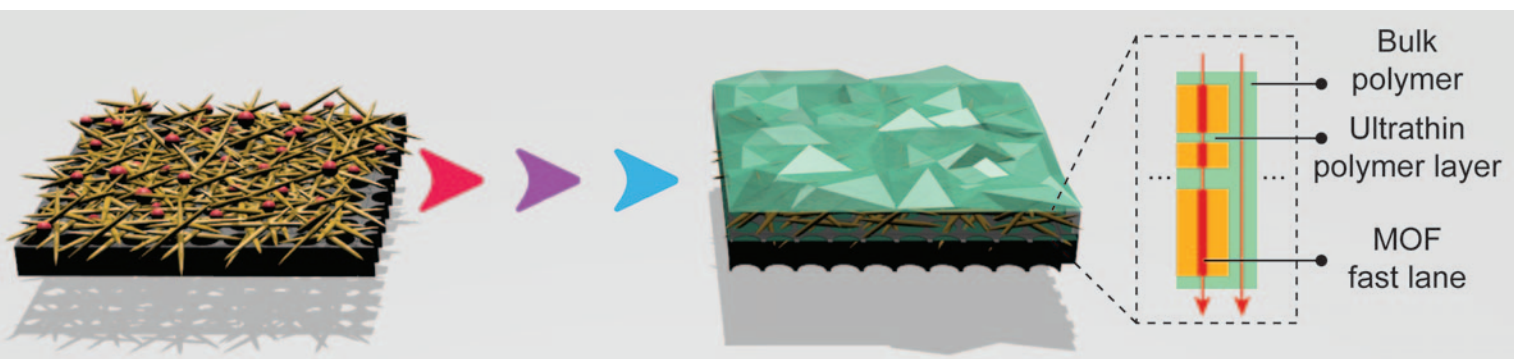
Proteins are a key class of polymeric biomolecules produced by living organisms. Their perfectly engineered macromolecular architectures allow them to perform a plethora of functions with high specificity and efficiency. The ability to mimic in synthetic polymers the folding of protein strands into precise secondary and tertiary structures would allow their function and activity to be controlled. Intramolecular cross-linking of reactive binding sites along the backbone of a synthetic polymer provides one way to emulate protein folding. But the synthesis of such synthetic single-chain nanoparticles is usually limited by ultra-low concentrations, harsh reaction conditions, and subsequent isolation procedures. Researchers in the Soft Matter Materials Laboratory at the Queensland University of Technology have overcome these limitations by developing a new method to fold polymer chains based on the photodimerisation of styrylpyrene induced by visible light (Frisch H., Menzel J.P., Bloesser F.R., Marschner D.E., Mundsinger K., Barner-Kowollik C. *J. Am. Chem. Soc.* 2018, **140**, 9551–7). The positioning of the photoreactive groups along the polymer chain generates a confined environment that increases the photocycloaddition quantum yields and in turn allows the intramolecular reaction to occur at unprecedented high concentrations. Critically, the enhanced photoreactivity enables single-chain folding driven solely by ambient light, affording synthetic polymers that fold spontaneously under ambient conditions just like their natural counterparts.

A coordination complex turned on by visible light

Addressable, self-assembled molecules with predictable compositions and structures will be important components of advanced functional materials of the future. A team of researchers at the University of Melbourne, RMIT, CSIRO and Ludwig-Maximilians-Universität (Germany) has designed, prepared and characterised the first reported example of a photo-switchable polyoxometalate diarylethene coordination complex (Xu J., Volfova H., Mulder R.J., Goerigk L., Bryant G., Riedle E., Ritchie C. *J. Am. Chem. Soc.* 2018, <https://doi.org/10.1021/jacs.8b04900>). As anticipated, the reaction components self-organise to yield a molecular 'dumb-bell' that is constrained by steric and electrostatic factors, effectively 'locking' the photo-responsive ligand in its photoactive conformation. Unlike the non-coordinated ligand, the electrocyclisation reaction of the resulting assembly can be triggered by visible light, converting the substance from pale green to an intense blue colour via a polyoxometalate-based excitation pathway. This work unveils the potential of such molecules as components in next-generation photochromic materials.



MOF membrane for fast gas separations



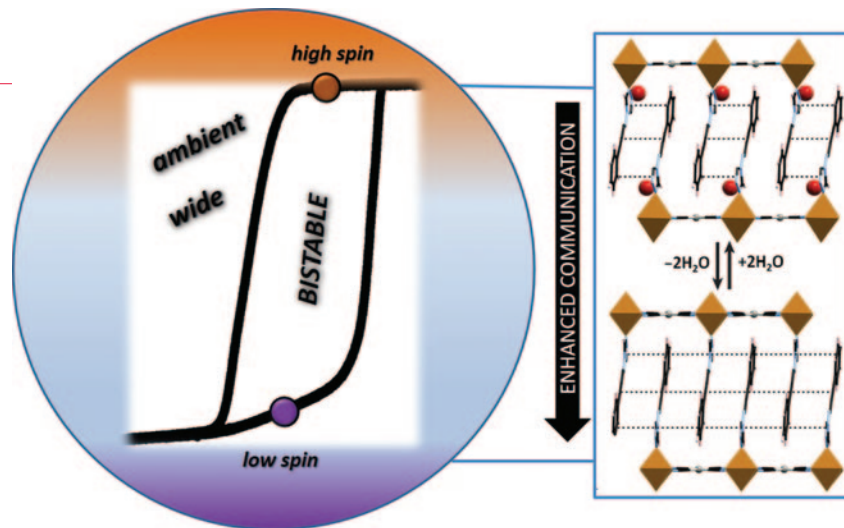
Researchers at the University of Melbourne have developed a novel separation membrane consisting of a cross-linked polymer matrix and a metal-organic framework (MOF) with a 'scaffold-like' topology that displays exceptional CO₂ separation performance (Xie K., Fu Q., Webley P.A., Qiao G.G. *Angew. Chem. Int. Ed.* 2018, **57**, 8597–602). The membrane was fabricated by synthesising an interconnected MOF fibre

'scaffold' on a porous support, followed by growing a cross-linked polymer layer in situ on the MOF fibre surface. Of particular note, the polymer (e.g. polyethylene glycol) fills up all the voids formed by the MOF scaffold. The interconnected MOF scaffold in the membrane facilitates fast gas transport through the membrane. Because of its unique design, the membrane exhibits an 18-fold enhancement in gas permeability

compared with conventional membrane systems, without compromising separation efficiency (e.g. selectivity). This performance is above all existing industrial membrane materials and exceeds predictions by existing theory. This work opens a new avenue for the development of composite membranes for efficient CO₂ capture.

Molecular switching at its best

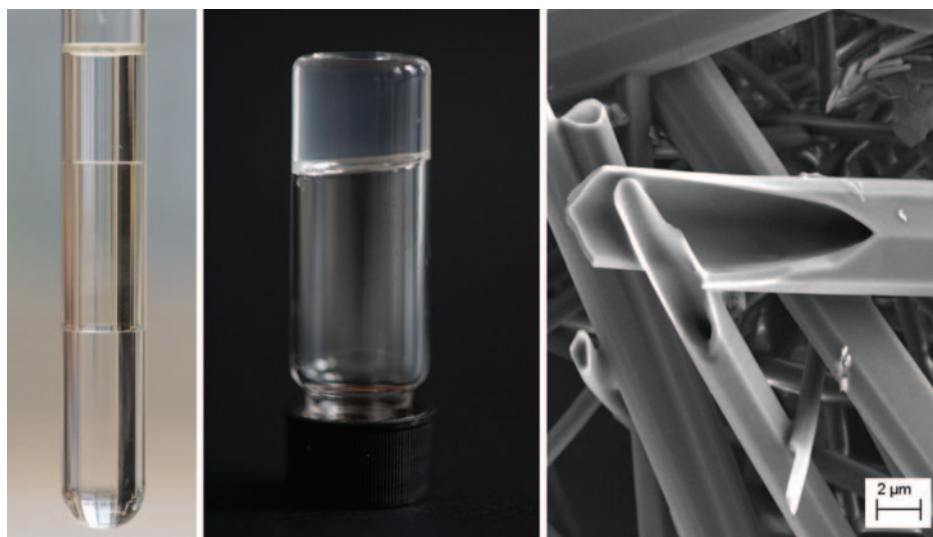
Interest in molecular switching materials is ever growing because of their applicability in modern technologies such as active data expansion, storage and communication elements, and optics. Molecular switches can be reversibly shifted between at least two different states with distinct properties by the application of external stimuli (e.g. mechanical, magnetic, electrical or optical). Spin-crossover materials are classic examples of molecular switches, in which pronounced chemical and physical changes accompany the switching transition. However, to date, few examples exist with behaviours optimal for application, namely access to high- and low-spin states at ambient temperature with accompanying wide thermal hysteresis (>40 K). Now,



researchers at the University of New South Wales, the University of Sydney, the University of Rennes (France) and Nagasaki University (Japan) have discovered the first two-dimensional (2D) framework material to display both room temperature and wide thermal hysteretic properties (Zenere K.A., Duyker S.G., Trzop E., Collet E., Chan B., Doheny P.W., Kepert C.J., Neville S.M. *Chem. Sci.*, 2018, **9**, 5623–9). This feat is achieved, in part,

through the flexibility of the interdigitated 2D framework lattices to optimise long-range communication pathways. These enhanced pathways can be strategically disrupted and regenerated with repetitive inclusion and exclusion of molecular water from the pore network. Overall, this study establishes flexible 2D networks as a new class of application-appropriate molecular-switching materials with further uses as molecular sensors.

A highly capable small molecule

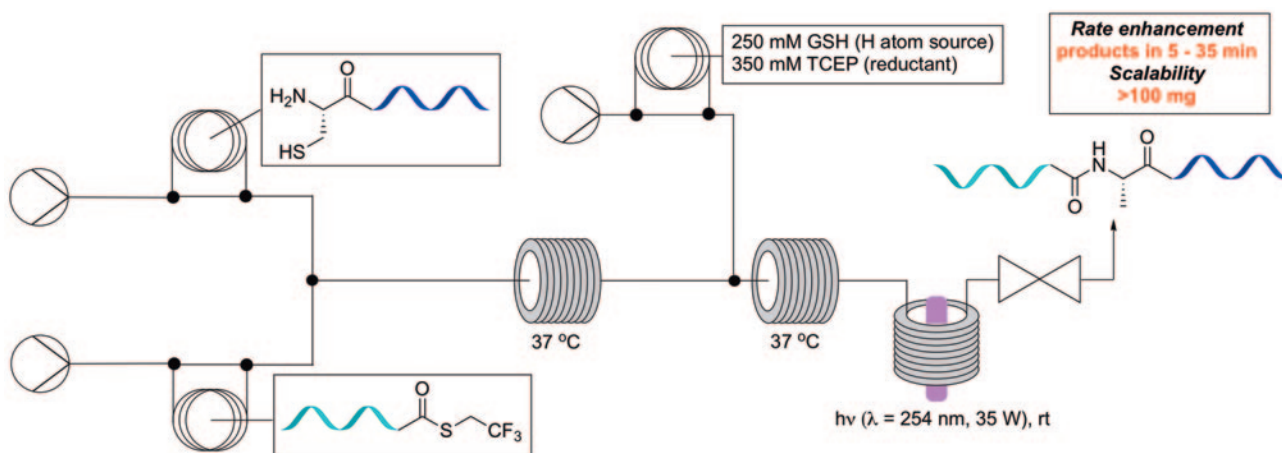


The development of potent low molecular-mass organogelators (LMOGs) is of considerable interest in a variety of research areas such as sensing, cosmetics and drug delivery. Researchers at Deakin University, the University of Melbourne, and Trinity College Dublin (Ireland) have characterised some remarkable gelation properties of salts of a simple phenylalanine functionalised norbornene (Engstrom J.R., Savyasachi A.J.,

Parhizkar M., Sutti A., Hawes C.S., White J.M., Gunnlaugsson T., Pfeffer F.M. *Chem. Sci.* 2018, **9**, 5233–41). Synthesis of the gelator requires only readily available starting materials and is amenable to gram-scale production. The sodium salt at 0.5 wt% elicits rapid formation of a clear gel in a range of organic solvents such as tetrahydrofuran, isopropanol, *n*-butanol and 1,4-dioxane. In addition to forming gels, the

chaotropic salt can initiate aqueous biphasic and triphasic systems. Scanning electron microscope images of the isopropanol xerogel show the formation of remarkable hollow helical hexagons. The process leading to gel formation is believed to be caused by cation-mediated assembly. Crystals reliably obtained from the gel reveal cation-templated chiral triple helicates.

Protein synthesis goes with the flow

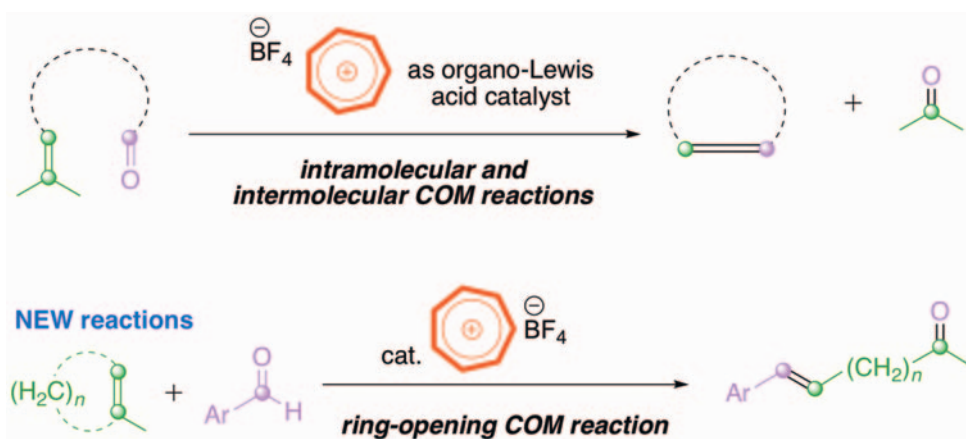


Native chemical ligation at cysteine- and thiol-derived amino acids has underpinned the way in which large polypeptides and proteins are generated by chemical synthesis. But this methodology is hampered by long reaction times, inefficient reactions at sterically hindered amino acids, and difficulties with scale up. Researchers at the University of Sydney have recently outlined the use of flow chemistry and photochemistry to address many of these limitations (Chisholm T.S., Clayton D., Dowman L.J., Sayers J., Payne R.J. *J. Am. Chem. Soc.* 2018, **140**, 9020–4). By performing native chemical ligation in flow, a substantial acceleration in the rate of the reaction was

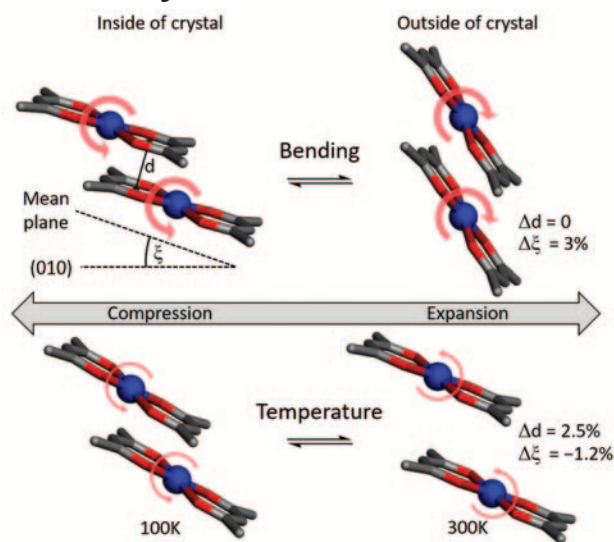
achieved. When combined with a novel photochemical desulfurisation reaction, the method enabled cysteine and thiol amino acids at the ligation junction to be cleanly converted to alanine and other native amino acids within minutes, further expanding the scope of the technology. The flow ligation–photodesulfurisation platform enabled access to polypeptides two orders of magnitude faster than traditional methods. The researchers also highlighted the utility of the technology through the synthesis of the FDA-approved HIV drug Fuzeon and the diagnostic agent somatostatin on a >100 mg scale and in excellent yields.

New metathesis catalyst

The carbonyl–olefin metathesis (COM) reaction is a highly valuable chemical transformation with a broad range of potential applications. But its scope has been far less explored than that of the analogous olefin–olefin metathesis reaction, which has been extensively studied in the past decades and led to the award of the 2005 Nobel Prize in Chemistry to Yves Chauvin, Robert Grubbs and Richard Schrock. In a joint experimental–theoretical study, Vinh Nguyen and Junming Ho of the University of New South Wales have discovered that the tropylium ion, a special non-benzenoid aromatic cation, can be used as a new versatile organic Lewis acid catalyst for intramolecular, intermolecular and ring-opening metathesis COM reactions (Tran U.P.N., Oss G., Pace D.P., Ho J., Nguyen T.V. *Chem. Sci.* 2018, **9**, 5145–51). This metal-free COM reaction represents a significant improvement in substrate scope over recently reported developments in the field.

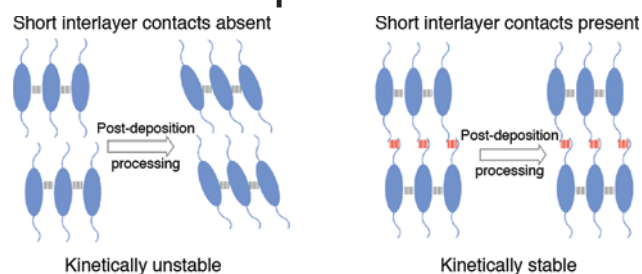


Understanding molecular motion in flexible crystals



Controlling the mechanical properties of elastically flexible single crystals may lead to applications in a range of fields, including flexible electronics. Researchers at the University of Queensland, Queensland University of Technology, University of Western Australia and University of Edinburgh (UK) have determined the mechanism of thermal expansion in flexible crystals of bis(acetylacetonato)copper(II), compared it with the mechanism of molecular motion induced by bending, and shown that the two mechanisms are distinct (Brock A.J., Whittaker J.J., Powell J.A., Pfrunder M.C., Grosjean A., Parsons S., McMurtrie J.C., Clegg J.K. *Angew. Chem. Int. Ed.* 2018, <https://doi.org/10.1002/anie.201806431>). Upon bending, individual molecules within the crystal structure reversibly rotate, while thermal expansion results predominantly in an increase in intermolecular separations with only minor changes to molecular orientation through rotation. These findings overturn the literature assumption that thermal expansion can be used as a general model for molecular motion induced in single crystals by bending and instead show that the mechanisms of each must be directly measured by carefully planned experiments.

How molecules pack in solids



Polymorphism is pervasive in molecular solids. Although computational predictions of the molecular polymorphic landscape have improved significantly, identifying which polymorphs are preferentially accessed and experimentally stable remains a challenge. The solid-state packing arrangement of organic molecules critically affects their material properties, from those as general as solubility and thermal stability to ones as specific as bioavailability and charge transport. Gavin Collis and Ying Shu of CSIRO Manufacturing, as part of an international multidisciplinary team led by Lin Loo from Princeton University (USA), have developed a conceptual framework that correlates short intermolecular contacts with polymorphic stability (Purdum G.E., Telesz N.G., Jarolimek K., Ryno S.M., Gessner T., Davy N.C., Petty II A.J., Zhen Y., Shu Y., Facchetti A., Collis G.E., Hu W., Wu C., Anthony J.E., Weitz R.T., Risko C., Loo Y.-L. *J. Am. Chem. Soc.* 2018, **140**, 7519–25). The presence of short contacts between neighbouring molecules prevents structural rearrangement and stabilises the packing arrangement, even when the stabilised polymorph is not enthalpically favoured. In the absence of such intermolecular short contacts, the molecules have added degrees of freedom for structural rearrangement, and solid–solid polymorphic transformations occur readily. The team established this framework with the packing polymorphs of more than 20 compounds, ranging from molecular semiconductors to pharmaceuticals and biological building blocks. These findings highlight an important factor in understanding the performance and long-term material stability in biological and non-biological applications.

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

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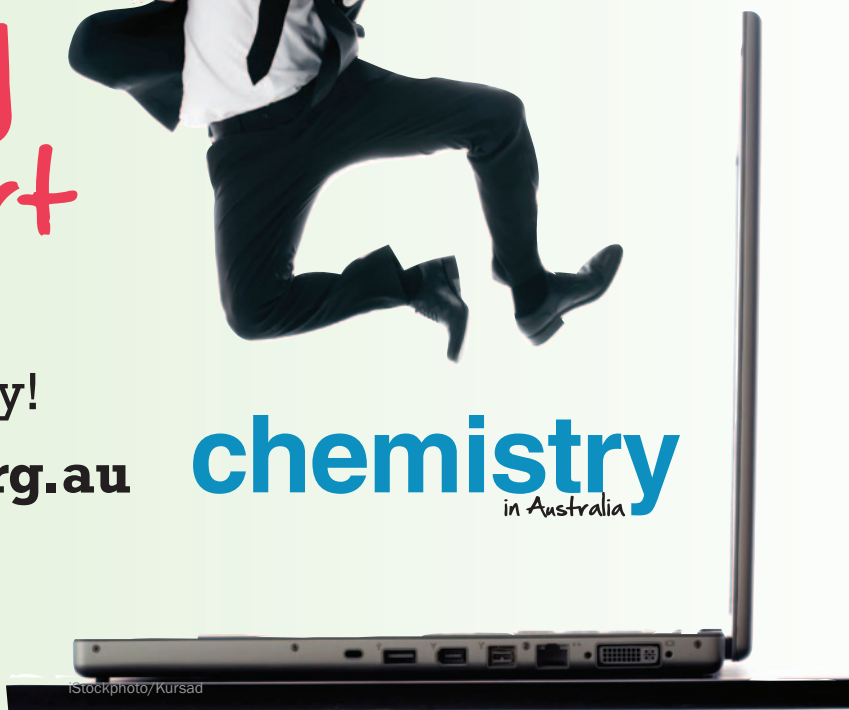


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Bearing witness

BY **DAVE SAMMUT**
AND **CHANTELLE CRAIG**

From 18th-century engineering to modern illicit drug profiling, the trials and tribulations of expert witnesses are fundamentally similar.

In 1780, the traders and seamen in the port of Wells Harbour, England, were fed up. For at least two decades, they had faced the growing challenge of harbour silting obstructing access for lucrative Norfolk grain exports. The docks were no longer accessible by ship, and in the traders' minds the blame was clear. Through massive land embankments and reclamations on the harbour channel, rich local landholders had choked off the vigorous tidal bore that used to scour the harbour clean. The ensuing legal battles, *Folkes v Chadd*, would set two historic legal precedents.

Over a two-day trial in August 1781, plaintiffs seeking removal of the embankments brought forward a series of local witnesses – pilots, mariners and seamen, men who had known the harbour intimately over lifetimes of experience. Again and

again, they testified to the degradation of the harbour after the construction of the embankments, based on their own long years of observations.

On the second day, lawyers for the defendant, Sir Martin Browne Folkes, presented just one witness: Mr Robert Mylne, Fellow of the Royal Society and owner of a reputed engineering and architectural practice in London. In authoritative tones, he dismissed the embankments as not being causal to the problem, in favour of the effects of wind and tides carrying estuarine sediments along the Norfolk coast and into Wells Harbour.

Awed by the gravitas of the esteemed man of science, the jury was convinced. Locals were outraged. How was it possible that the single opinion of a London expert, after only the shortest examination, could carry the day over lifetimes of experience of local observers?

Lawyers for the Harbour commissioners sought leave to appeal. After consideration, the royal judges of the King's Bench agreed – setting the first key precedent. After Mylne's testimony, the plaintiffs had not been granted the opportunity to seek their own expert witnesses. 'In matters of science', the Bench ruled, 'the reasonings of men of science can only be answered by men of science.' A new era of litigation was born: the era of the expert scientific witness.

The story doesn't end there. Coming into round two, both sides upped the ante. The plaintiffs sought the advice of a cadre of 'big guns' – expert engineers, all senior, well-reputed and experienced with river navigation, canals and drainage. They were guided by the legal assistance of George Hardinge, Barrister of the Middle Temple and solicitor-general to Queen Charlotte. The defendant

added just one name: John Smeaton, another Fellow of the Royal Society, and considered England's highest authority on harbours.

The case came back to trial in July 1782. The outcome hinged on a complicated legal argument about the admissibility of Smeaton's testimony. Being based on principles of natural philosophy that Smeaton could not have directly observed, but had deduced, was his testimony fact or opinion?

Smeaton's testimony was ruled inadmissible. Round two went to the plaintiffs. Sir Martin Browne Folkes was quick to appeal, and the case was ultimately adjudicated by one of the 18th century's most influential judiciary figures: Lord Mansfield, Chief Justice of the King's Bench. His seminal decision has been widely argued to have established the practice of partisan expert testimony. Notwithstanding that Smeaton's testimony was opinion '... the whole case is a question of opinion from the facts agreed upon. Nobody can swear that it was the cause; ... It is a matter of judgment, what has hurt the harbour.'

Role of the expert witness

More than two centuries later, the same questions are fundamental to the standing of the expert witness. Is the witness testifying to fact or opinion? Does the witness have training and experience to form a qualified opinion? What assumptions has the witness made in forming that opinion?

Dr Philip Maynard at the Centre for Forensic Science at University of Technology Sydney teaches a course in 'Expert Evidence Presentation'. A forensic scientist and RACI member, he has expertise in the areas of trace evidence and chemical/arson analysis. Speaking to *Chemistry in Australia*, he expanded the point to ask 'Is this topic [for the expert opinion] a peer-reviewed, accepted science? Is the topic capable of producing a hypothesis, and is the hypothesis capable of being falsified? Does the expert provide some analysis which

In most jurisdictions, the rules and guidance dictate that the first responsibility of the expert witness is to the court itself, and ultimately to the truth.

the judge and jury could not do for themselves?'

These questions were fundamental to the 2011–12 case of Gordon Wood's successful appeal to the NSW Supreme Court against his conviction for the murder of Caroline Byrne. The original trial testimony of key Crown expert witness Associate Professor Rod Cross was called into question. Were Cross's experimental designs – with strong men literally throwing women into pools, versus women jumping or diving – suitably robust and relevant for him to draw the conclusion that Byrne had been thrown in a 'spear-like' fashion from the cliffs at Sydney's famous suicide spot The Gap? Was the assumption that the women in his experiments were not struggling relevant to Cross's conclusion that Byrne could not have jumped and still reached her point of impact?

The judgement by Justice Mclellan in the Wood case is also particularly interesting. Mclellan notes that Cross identified problems with his own testimony that he elected not to raise with the court. 'Given the significance of the assumed landing spot to Associate Professor Cross's calculations this is, to say the least, surprising. I would have expected that if he knew that the landing place had been misidentified he would have raised the issue when he first knew of the error' Ultimately, Mclellan ruled that 'The verdict is unreasonable and cannot be supported by the evidence'.

Over the past two centuries, the use of expert witnesses has become substantially adversarial. The common perception that experts are just 'guns for hire' is exacerbated by the lucrative industry that has grown up around expert witness services, often at rates of hundreds of dollars per hour. So what happens when experts twist, misuse or ignore relevant information to help their client's case?

In most jurisdictions, the rules and guidance dictate that the first responsibility of the expert witness is to the court itself, and ultimately to the truth.

RACI Fellow Emeritus Professor Brynn Hibbert, recently appointed as a Member of the Order of Australia (AM) for 'significant service to science in the discipline of chemistry, to professional societies, and to sport through illicit drug profiling', has a great deal of experience as an expert witness, and is an engaging and delightfully entertaining speaker on the topic.

Speaking at the 2018 RACI Fellow's Lunch in New South Wales, Hibbert recounted his role acting for the defence in a Customs prosecution for the alleged illegal import of 9.2 million cigarettes. 'The customs had cut corners and instead of using the NMI or state forensic labs had asked Philip Morris to analyse around 10 of the putative cigarettes. The certificate had come back "nicotine detected"', said Hibbert in his speech.

'Apart from the lack of a sampling strategy, or the possibility of contamination in a lab in which an awful lot of nicotine is routinely analysed not under forensic conditions, merely detecting nicotine might not have been enough to uniquely establish the presence of tobacco. What plants have nicotine? Tobacco, potato peelings, tomatoes, in fact any member of the very large nightshade family, in which nicotine is a natural insecticide. Of course to establish that we are dealing with tobacco was straightforward – just quantify the nicotine (there is heaps more in

Traps to avoid include getting offended, being perceived as evading a question ... and falling for verbal tricks, double negatives or complicated questions.

tobacco) or establish the pattern of the other alkaloids which can fingerprint the plant, but all the court had was "nicotine detected" and that was, in my opinion coming from a drug background, not enough.'

'Under cross-examination I had to admit that observation was an important part of analysis [with] the prosecution homing in on the bleeding obvious – namely the 9.2 million white tubes. They were duly found guilty, but I think everyone was grateful for the light chemical relief.'

Says Hibbert: 'The reason I can sleep at night is the Expert Witness Code of Conduct contained within Schedule 7 of the Uniform Civil Procedure Rules 2005. ... I am required to fess up to anything I know that I believe is relevant whether it helps 'my' client or not. Indeed the nicest thing a barrister has said to me is "Well Professor Hibbert – you are very fair" (and he wasn't smiling)'.

Immunity and the expert witness

In Australia, expert witnesses have limited immunity from civil suit relating to their role in judicial proceedings, extending to actions outside the court that are 'intimately connected' with the giving of evidence in court (such as preparatory steps). The aim is to both limit an endless cycle of re-litigation, and support witnesses to give evidence freely for the higher interest of justice.

That immunity obviously does not extend to intentional untruth, the fabrication of evidence or giving false evidence to the court. However, the principle itself has been mostly removed in the UK in the 2011 *Jones v Kaney* case. This hinged on the fact that a plaintiff's own expert witness signed a document that they did not believe to be true, and in doing so harmed the settlement received by the plaintiff in a personal damages case. Jones was permitted to sue Dr Kaney for the financial effect of her compromised advice. Over the years that have followed, this decision has apparently not opened the floodgates to re-litigation, and other countries, including Australia, are considering following suit in limiting or eliminating expert immunity.

That leaves plenty of scientists still willing to stand as experts in their particular field. Maynard offers a range of very useful tips for the novice expert witness in the courtroom. Most particularly, he emphasises that you must remain within your area of expertise when being asked, and be strict – don't be led by a chain of questioning.

Traps to avoid include getting offended, being perceived as evading a question ('You will be in for a long afternoon', says Maynard), and falling for verbal tricks, double negatives or complicated questions. Just ask for the question to be rephrased.

'Answering questions within your area of expertise, an expert witness has privileges which are not granted to eye-witnesses', says Maynard, 'You may state an opinion, and you may refer to published scientific literature produced by other scientists, which strictly counts as hearsay evidence. These privileges are tightly limited by legislation and by past judgements, and you should not presume to offer unsupported opinions'.

As a more recent innovation, courts in some jurisdictions practise 'concurrent evidence' (known as 'hot tubbing') to limit the adversarial

aspects of 'duelling experts'. With lawyers being excluded from the room, the expert witnesses for both sides are asked to meet and discuss key evidence. They prepare a joint report stating matters agreed, not agreed and the associated reasons for disagreement, which is tendered to the court. In many cases, this can help the parties find a settlement outside the court. Says Hibbert 'I think I might have done one of the first [in Australia] with Graham Johnston on an analogue drug case. I lost – the court preferred Graham's view, but we were commended for our cooperation'.

Ultimately, the criminal courts rely heavily on scientific witnesses – there could easily be another article about forensic science in the courtroom, its limitations and 'the CSI effect'. In civil cases, the use of experts tracks the money – large-value cases pay for a lot more advice.

After Lord Mansfield ruled to admit Smeaton's expert opinion on the *Folkes v Chadd* case, who won? According to the *Norwich Mercury* at the time (10 April 1784), following the third trial, the injunction against Wells Harbour Commissioners was lifted and the Commissioners were free to 'throw down the bank'. The bells of Wells Church were rung and after a 'most excellent' dinner provided by the Royal Standard Inn, the Commissioners and a great body of the public proceeded to the embankment where a very large breach was made and the tide returned to the ancient parts of the harbour. The whole affair was accompanied by music, flags and discharge of cannon to celebrate the public nuisance being removed and the trade of Wells once again being allowed to flourish upon the ruins of the bank, for a time.

Dave Sammut FRACI CChem, MRSN, and **Chantelle Craig** are the principals of DCS Technical, a boutique scientific consultancy, providing services to the Australian and international minerals, waste recycling and general scientific industries.

Beyond reasonable doubt

Pharmacist Bernard Leddy specialises in drug information, and he knows so much about the subject that his colleagues call him the encyclopaedia. His knowledge and attention to detail are what makes him so good at his second role – as an expert witness in court cases.

As a child Bernard had no inkling of what he would end up doing with his life. 'For years I wanted to be a pilot. But when I was in sixth year at school I read a 19th-century textbook on pharmacy and chemistry, which fascinated me.' Bernard applied for pharmacy courses at university and got into the London School of Pharmacy, now University College London, before going on to do an MSc and a PhD in heterocyclic chemistry at the University of East Anglia.

He then went on to work as a pharmacist, and it was while doing this that a chance encounter led him into the world of criminal law.

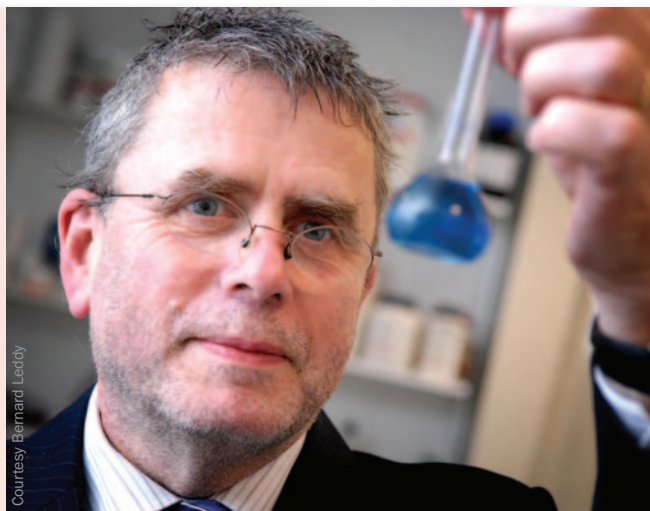
'One day, a local solicitor contacted me to write a report in for a client that he was defending on a driving under the influence (of a drug) charge', says Bernard. The case involved an older lady who had driven to the local shops for bread after taking her sleeping tablet, 'before it kicked in'. The tablet contained the drug Zolpidem – a fast-acting hypnotic, and she was arrested by police who spotted her driving erratically. 'She was completely oblivious to the flashing lights and sirens', says Bernard, 'and only stopped when she harmlessly struck a wall'.

Witness for the defence

Bernard explains how he used his knowledge of pharmaceuticals in his report. 'My report focused on the evidence of drug use', he said. 'The forensic test that exposed the opiate use was simply qualitative. There was no measurement or attempt at measurement of the actual amount of opiate in the sample. The same result would have been obtained if she had taken one Solpadeine tablet – which can be bought without prescription – or a bag of heroin. The Zolpidem was not detected at all. Without her voluntary statement a prosecution would have been quite difficult.'

The matter went before a district court in a nearby town and Bernard was called as a witness for the defence.

'I went on the stand and gave my evidence as clearly as I could, explaining that the test for opiates was qualitative only and the prosecution hadn't found any Zolpidem in the urine sample. In my preparation I had learned that Zolpidem is very fast acting and takes effect within 15–30 minutes of being taken, which is why this unfortunate lady didn't have a chance of safely getting to the shop and back before it 'kicked in'. I also explained that Solpadol contains two drugs – codeine and paracetamol – and that paracetamol would have no effect on her ability to drive.'



Courtesy Bernard Leddy

The pursuit of justice

The woman was initially convicted on both charges, but appealed the conviction and the case went to court again. 'This time I was much better prepared', says Bernard, and the drugs charge was dropped.

'I realised after this case that I had really enjoyed the experience of putting my scientific knowledge in the pursuit of justice', says Bernard. He now gets commissions from solicitors – normally for the defence – to prepare expert reports for court cases, tribunals, and other types of quasi-judicial processes. He has to attend hearings to present his evidence and prepare to be cross-examined.

'I love the challenge that each case brings. I enjoy reading and analysing the written evidence and putting it into logical order before starting to write my report.'

Do something you love

'It is important to only comment on matters within my area of expertise, and to openly state when something is outside my area. The expert witness must not act as an advocate for either side, but must be a servant of the court and justice at all times.'

'The hardest thing for me is cross-examination in open court. If you are not careful, you can undo a lot of good work with one wrong answer.'

Bernard spends around four to five days a month on the role, alongside his job as a pharmacist.

His advice for those starting out in chemistry is to study as many different branches of chemistry as you can at the beginning. 'See what you like doing most and concentrate on developing a career around that', he says. 'You should always work at something you love to do because it will always encourage you to keep going.'

Bernard is looking to share his experience with early career chemists who want to train as drug information scientists and expert witness.

Bernard is a longstanding member of the Royal Society of Chemistry and is a chartered scientist and chartered chemist. This article was originally published by the Royal Society of Chemistry (www.rsc.org/news-events/profiles/2018/jul/beyond-reasonable-doubt).

Chemistry *underfoot*



BY **NANTHI BOLAN** AND
MICHAEL CRAWFORD

Soil is an important natural and economic resource. The Australian fresh food sector is a key driver of public health, the economy and employment. The gross value of production from Australia's 135 000 farmers is about \$60 billion a year, with exports accounting for approximately \$48 billion a year. Most of this agricultural production is derived from land-based broadacre farming. About 1.6 million people (one in seven Australian jobs) are in the farm-dependent economy, and food and beverage processing employs around one-third of all Australian manufacturing workers. Australian farmers own and manage 48% of Australia's land area.

Soil and food security

Australia's diverse soils and climate provide a wide variety of fresh food year round, and the country produces enough food to feed more than 80 million people. Historically, we produce far more than we consume, and we sell about 65% of farm production overseas, making Australia a leading food-exporting nation. We contribute to the food security not just of Australia, but also of many other nations, including our neighbours.

Sustainable soil management practices are integral to food security and thus human health.

The significance of soils to sustainable agricultural production is enormous, explain two members of the new CRC for High Performance Soils.

Soil chemistry underpins sustainable agricultural production

Chemical reactions in soil control the cycling and bioavailability of nutrients. Many of the chemical elements essential to humans come from the soil through either plant or animal products. In several countries, including Australia, large proportions of the arable soils are deficient in essential elements such as zinc, iodine and selenium. Some components of soil, such as arsenic, can be taken up by plants and passed on (sometimes at toxic levels) to those who consume them.

Soil chemical reactions play an important role in the purification processes of water. Rainwater and wastewater (e.g. storm water) sources that enter the soil recharge the groundwater reserves, which are then used as a source of drinking water or for irrigation. Some of these water sources are contaminated with pollutants such as heavy metal(loid)s, pesticide residues and organic contaminants (e.g. petroleum hydrocarbons). Fortunately, soils are great water purifiers, and they represent the largest natural filter on the planet. These filtration benefits are an important part of the ecosystem services provided by soil.

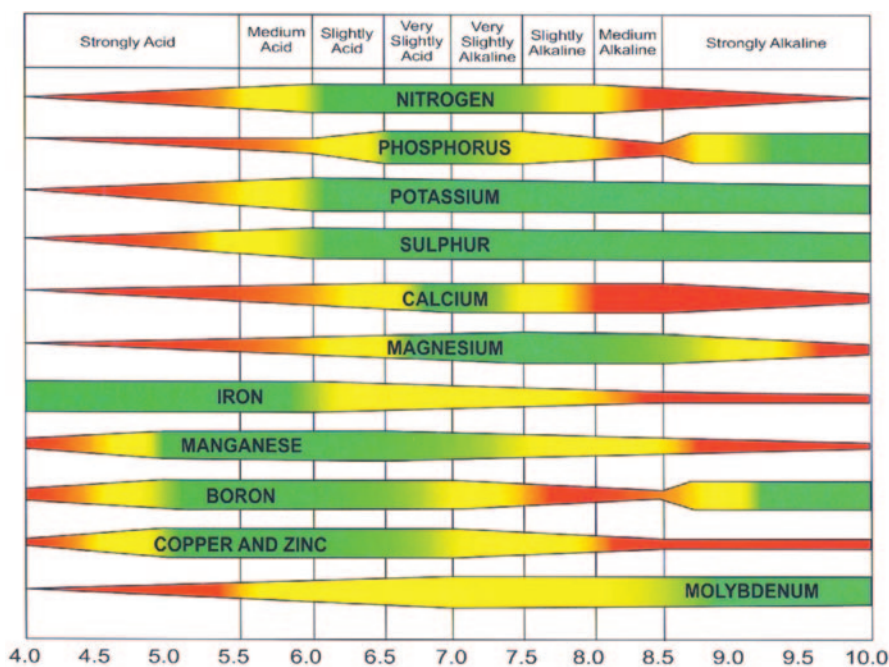
Soil particles such as clay, silt and sand carry positive and negative charges. A number of physical and chemical properties of soil are controlled by the nature and the amount of surface charge and the variation of surface charge with soil solution characteristics and pH. These properties include dispersion and flocculation, electrophoretic mobility, solubility and the adsorption and movement of solutes.

Surface charge is an important determinant of the physical and chemical properties of soils, including cation exchange capacity. Surface charge can be manipulated to take advantage of solid phase interactions relating to the movement of nutrient and pollutant ions in soils, the

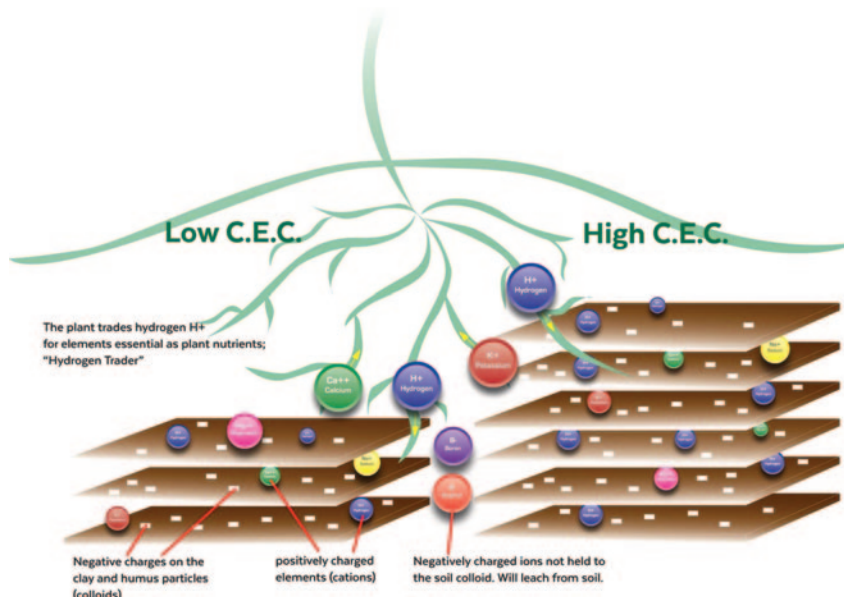
degradation of pesticides and the decontamination of soils.

The electrical charge properties of soil colloids cover a spectrum of behaviour. At one end of the spectrum, the charge on the surface is fixed or permanent and remains independent of the solution composition, but the electric potential is sensitive to concentration of indifferent electrolyte (one that has little effect on electric

... soils are great water purifiers, and they represent the largest natural filter on the planet.



Soil productivity is heavily dependent on soil pH. Superior New Zealand



Cation exchange capacity (CEC) indicates how much fertiliser a soil can hold. Superior New Zealand



This well-aggregated soil has adequate cation exchange capacity.

potential). This is usually termed the constant charge surface or permanent surface charge. At the other end of the spectrum of the constant potential surface, it is the charge that varies with changing concentration of indifferent electrolyte. This charge is known as variable surface charge. Permanent charges are developed by isomorphous substitution of ions in the lattice structures of silicate clay minerals, whereas variable charges are developed through the dissociation of functional groups. Organic surfaces, such as humified organic matter, acquire their charge through the ionisation of carboxylic (COOH), phenolic (OH) and possibly other functional groups.

An understanding of soil in relation to plants, water and surface charge properties is critical for management systems to maintain soil chemical fertility and biophysical health for productivity, and minimise environmental degradation.

CRC for High Performance Soils

We know more about the movement of celestial bodies than about the soil underfoot.

(Leonardo Da Vinci, 1452–1519)

Despite recent major advances in understanding, the spatial and temporal heterogeneous characteristics of soil remain a mystery. The University of Newcastle is hosting the newly established Cooperative Research Centre for High Performance Soils (Soil CRC, www.soilcrc.com.au). The Soil CRC brings together 39 partners spanning the industry, government, research, not-for-profit and business sectors to help bridge the gap between soil science and farm management. The investment of \$40 million from the Australian Government is being supported by more than \$120 million of cash and in-kind contributions from industry and other partners over ten years. The Soil CRC will address critical barriers to high-performance

soils by developing real solutions, with a focus on how these solutions could be adopted throughout the farming community. Aimed at overcoming the most complex soil management issues, the Soil CRC will integrate research across diverse fields, including soil science (including soil

Recent research approaches have focused on nutrient 'recovery' from waste streams through a variety of pathways based on biological, chemical or physical processes.

Soil chemistry in relation to agricultural production and environmental protection

Function	Chemical reaction examples
Supplying nutrients	<p>Urea hydrolysis: $\text{NH}_2\text{CONH}_2 + 3\text{H}_2\text{O} \rightarrow 2\text{NH}_4^+ + 2\text{OH}^- + \text{CO}_2$</p> <p>Phosphate solubilisation: $\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2 + 12\text{H}^+ \rightarrow 10\text{Ca}^{2+} + 6\text{H}_2\text{PO}_4^- + 2\text{F}^-$</p>
Filtering contaminants	<p>Cadmium removal: $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 + x\text{Cd}^{2+} \rightarrow (\text{Cd}_x\text{Ca}_{10-x})(\text{PO}_4)_6(\text{OH})_2 + x\text{Ca}^{2+}$</p> <p>Phosphate removal: $\text{Fe}^{3+} + \text{PO}_4^{3-} + 2\text{H}_2\text{O} \rightarrow \text{FePO}_4 \cdot 2\text{H}_2\text{O}$</p>
Immobilising contaminants	<p>Lead precipitation: $10\text{Pb}^{2+} + 6\text{H}_2\text{PO}_4^- + 2\text{H}_2\text{O} \rightarrow \text{Pb}_{10}(\text{PO}_4)_6(\text{OH})_2$</p> <p>Chromate reduction: $3\text{CH}_2\text{O (organic matter)} + 2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ \rightarrow 4\text{Cr}^{3+} + 3\text{CO}_2 + 11\text{H}_2\text{O}$</p>
Regulating soil pH	<p>Nitrification (ammonium oxidation): $\text{NH}_4^+ + 2\text{O}_2 \rightarrow \text{NO}_3^- + 2\text{H}^+ + \text{H}_2\text{O}$</p> <p>Elemental sulfur oxidation: $2\text{S} + 2\text{H}_2\text{O} + 3\text{O}_2 \rightarrow 2\text{SO}_4^{2-} + 4\text{H}^+$</p>
Emitting greenhouse gases	<p>Nitrous oxide emission: $2\text{NO}_3^- + 12\text{H}^+ + 10\text{e}^- \rightarrow \text{N}_2 + 6\text{H}_2\text{O}$</p> <p>Methane oxidation: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$</p> <p>Ammonia volatilisation: $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$</p>

chemistry), big data, sensor technology, nanotechnology, environmental science, social sciences and agricultural and farm management.

In relation to chemistry, the Soil CRC aims to develop novel technologies to recover nutrients from waste and natural resources, polymer-based novel products to mitigate soil constraints, including soil acidity and sodicity, and real-time chemical sensors to monitor soil health (e.g. nutrient status). One of the major research areas for the new Soil CRC in relation to soil chemistry is nutrient recovery and synthesis of new fertiliser products. Recent research approaches have focused on nutrient 'recovery' from waste streams through a variety of pathways based on biological, chemical or physical

processes. The primary objective of these nutrient-stripping approaches is to achieve a safe disposal of waste stream, and limited work has been carried out on the technological development for 'recovery' and subsequent reuse of these valuable nutrients. In order to achieve the recovery of nutrients, these options need to exhibit a unique balance between economic feasibility (effort required to make the value-added product), societal benefit (product utilisation by end-users) and ecosystem service (plant uptake, biodiversity, soil and water quality).

A number of challenges are involved in the cost-effective recovery and reuse of nutrients from waste streams. These include: (i) variability in the quantity and characteristics of various nutrients present in a range of

waste streams; (ii) the low concentration of nutrients and the presence of co-contaminants – serving as technical and economic barriers for the recovery of nutrients; and (iii) uncoupling of waste generation from agricultural production, resulting in limited access at the farmgate level. The aim is to develop innovative pathways and technologies for the recovery of nutrients from waste streams and propagate the adaptive capacity required for a resource-efficient future aimed at farm profitability and food security.

Nanthi Bolan MRACI is Professor of Environmental Chemistry at the Global Centre for Environmental Remediation (GCER), Faculty of Science and Information Technology, University of Newcastle.

Michael Crawford is Chief Executive Office of the CRC for High Performance Soils, Newcastle.



Ira Remsen

Stories for chemical education

**American chemist
Ira Remsen's
bittersweet story
holds good
lessons for
chemical
educators,
says **Bill Palmer**.**

I suspect that few Australian chemistry teachers have heard of American chemist Ira Remsen. Last year, after presenting a paper on Remsen at the RACI National Centenary Conference and reading Ian Rae's piece in the October issue of this magazine (p. 41), I wondered what information concerning Remsen would be useful to Australian chemistry teachers and their students. This year's February cover of *Chem 13 News* (<https://uwaterloo.ca/chem13news>), featuring 'Beautiful copper solutions: products of a Remsen demonstration', prompted me to write. Remsen's story may also be found in US chemistry textbooks, so many North American chemistry students will become familiar with Remsen's name. Perhaps he and his chemical achievements should become more familiar in Australia. Ira Remsen was born on 10 February 1846. Due to the death of

his mother when he was eight, Remsen lived with his maternal great-grandparents. When he was 12, Remsen's father, who lived in New York, brought him back from the country and Remsen entered the Free Academy of New York at the early age of 14. He was not happy there and he left after a year, so his father apprenticed him under a homeopathic physician to learn medicine. He enjoyed chemistry but accepted his father's ruling that he should become a doctor. He obtained his MD degree in 1867 at the age of 21, but never really felt settled in medicine. He left the US in the summer of 1869 to study under Justus von Liebig in Munich, but Liebig was about to retire, so he spent a year at Munich studying under Jacob Volhard. He then moved to study organic chemistry at Göttingen under Rudolf Fittig. He was awarded a PhD in 1870.

Fittig moved to Tübingen and Remsen then worked as Fittig's assistant for two years, gaining further laboratory experience. He returned to the US in spring 1872, where he obtained a position as Professor of Physics and Chemistry at Williams College, Massachusetts, which was poorly equipped for practical chemistry. During his tenure at Williams College, he set up a laboratory for himself and continued his research work in organic chemistry. He became well known as an active chemist for his research and practical ability.

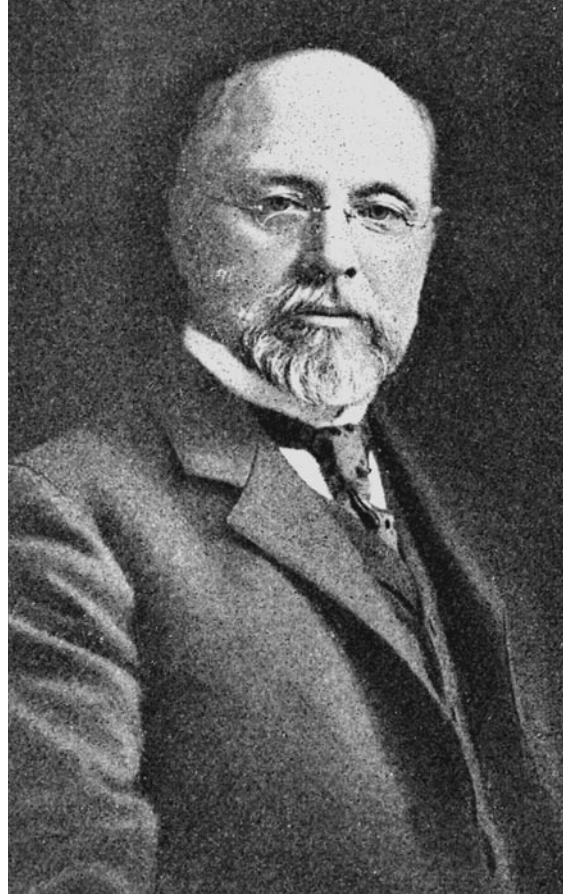
In 1876, Ira Remsen was appointed as Professor of Chemistry at Johns Hopkins University in Baltimore, where he set up a department based on the German model. In 1901, he became President of Johns Hopkins University but continued his chemical research and teaching as far as time allowed, until his retirement. Remsen was an enthusiast for student practical work, so he wrote two student practical manuals to accompany two of his texts. He started the *American Chemical Journal*, in 1879 which under his editorship became the leading journal for chemical research.

Remsen's influence on emphasising laboratory-based university research in the US based on his German experience became translated into the emphasis for practical work in US secondary schools. This was due to his influence on the Committee [of Ten] on Secondary School Studies (1892), headed by Charles W. Eliot.

Remsen received many honours. He served as President of the American Chemical Society (1902), the Society of Chemical Industry (1910), the National Academy of Sciences (1907–13) and the American Association for the Advancement of Science (1903).

He resigned as President of Johns Hopkins University in April 1912 due to ill health. During his presidency, he expanded Johns Hopkins University both physically and in reputation. He ensured that women were admitted to

the Johns Hopkins courses. He also gave time to public life, serving on the Baltimore Sewage Board for many years as he considered public health issues important. He always regretted leaving research in chemistry for administration. The story of his visit to the antipodes can be found in *Chemistry in Australia* (October 2017, p. 41). Prior to his retirement, Remsen had refused to work for private industry, but after retirement, he was retained as a private consultant for Standard Oil until his death. Remsen did not retire completely until his 80th birthday in 1926. He died in Carmel, California, on 4 March 1927. After his death, the newly completed chemistry building was named after him and his ashes were interred behind a plaque in the building.



Ira Remsen, c. 1901.

Popular Science Monthly volume 59/CC BY-SA 3.0



Gilman and Remsen Halls (c. 1935), Homewood House, at Johns Hopkins University, of which Ira Remsen was the second president. Ferdinand Hamburger Archives, Sheridan Libraries, Johns Hopkins University

Action of concentrated nitric acid on copper

The story about Remsen and the action of concentrated nitric acid on copper is a favourite experiment for US educators, which happened during his introduction to chemistry at the homeopathic physician's office. This seems to be where Remsen's love for chemistry was born.

As Remsen related in one of his many addresses in later years: 'While reading a textbook of chemistry, I came upon the statement "nitric acid acts on copper". I was getting tired of reading such absurd stuff and I determined to see what this meant ... The spirit of adventure was upon me. Having nitric acid and copper, I had only to learn what the words "acts upon" meant ... In the interest of knowledge, I was even willing to sacrifice one of the few copper cents then in my possession. I put one of them on the table; opened the bottle marked "nitric acid"; poured some of the liquid on the copper; and prepared to take an observation. But what was this wonderful thing I beheld? The cent was already changed, and it was no small change either. A greenish blue foamed and fumed over the cent and over the table. The air in the neighbourhood was disagreeable and suffocating. How should I stop this? I tried to get rid of the objectionable mess by picking it up and throwing it out of the window, which I had meanwhile opened. I learnt another fact – nitric acid not only acts on copper but it acts upon fingers. The pain led to another unpremeditated experiment. I drew my fingers across my trousers and another fact was discovered. Nitric acid acts upon trousers. Taking everything into consideration that was the most impressive experiment I ever performed. ... It resulted in a desire on my part to learn more about that remarkable kind of action. Plainly, the only way to learn about it was to see its results, to experiment, to work in a laboratory.

(Getman F.H. (1940). 'The life of Ira Remsen', Easton, Pennsylvania: *Journal of Chemical Education*, pp. 9–10)

This experiment described by Remsen has become very popular in the US, though now very much modified from the description that

A greenish blue foamed and fumed over the cent and over the table. The air in the neighbourhood was disagreeable and suffocating.



Remsen gives, perhaps with the intention of making students as interested in chemistry as Remsen was. More complex experimental variations on Remsen's simple experiment continue to the present time (Sytsma T.M., Li A., Ganske J.A., *Chemical Educator*, 2018, vol. 23, pp. 58–63) with the authors acknowledging that the original experiment had 'visually inspired generations of chemists'.

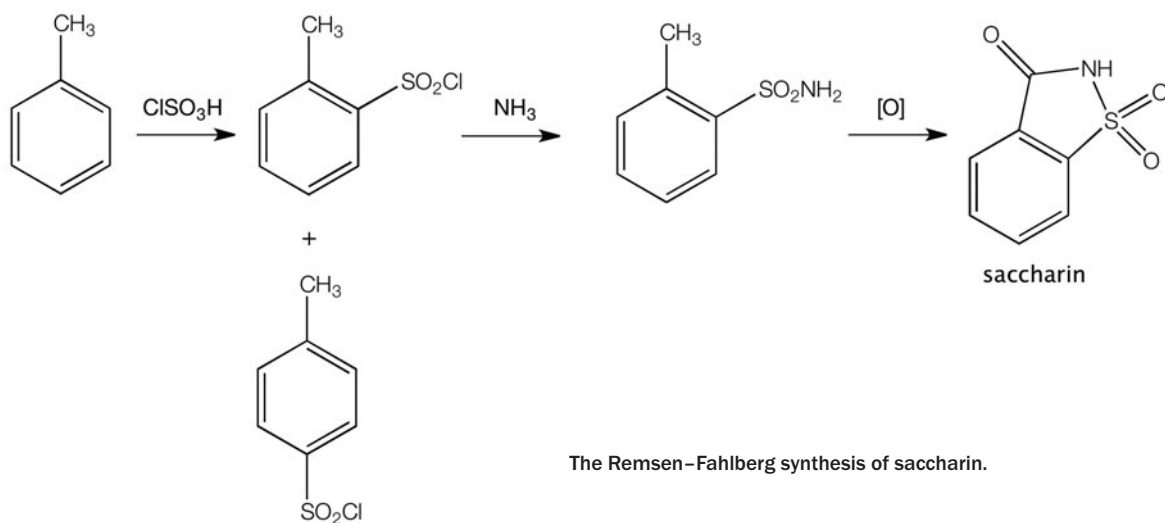
Discovery of saccharin – serendipity in science

One remarkable incident early in Remsen's research career concerned the discovery of the sweetener saccharin (o-sulfobenzoic imide, o-benzosulfimide) by his research assistant Constantin Fahlberg. There is controversy about Fahlberg's conduct in failing to credit Remsen as joint discoverer and for patenting the discovery in his own name. A version of events favouring Fahlberg follows:

Fahlberg was asked to study the oxidation of certain coal-tar derivatives known as toluene sulphonamides, purely because this had not been done before. It seems Fahlberg was a pretty sloppy chemist, usually not even bothering to wash his hands after leaving the laboratory. And that turned out to be his stroke of luck! One day, at dinner, Fahlberg noted that a slice of bread he had picked up tasted unusually sweet. He traced the sweetness to a substance he had been handling in the laboratory and immediately brought this chance discovery to the attention of Remsen.

(Schwarcz J. (2002). 'Saccharin, and the sweet smell of chemistry: [Final Edition]' *The Gazette* [Montreal, Quebec] 23 March)

In this version of the story, much of the credit lies with Constantin Fahlberg, but Fahlberg patented the discovery claiming that it was entirely his own work and as a result he made a fortune! Remsen was annoyed that Fahlberg gave him no credit for the discovery. Remsen considered that saccharin was discovered during an investigation



undertaken by Fahlberg at his suggestion and under his direction; the synthesis was first described in a joint paper by Remsen and Fahlberg. In one outburst showing his annoyance at Fahlberg's actions, Remsen referred to Fahlberg as a 'scoundrel'.

There are numerous alternative versions of the same story and alternative views about Fahlberg's conduct. In this version of the story, Fahlberg appears less unreasonable. Fahlberg was an experienced qualified Russian chemist, who had been hired by a Baltimore business, H.W. Perot Import Firm, to analyse a shipment of sugar, testing it for impurities because it had been seized by the US Government Customs service. H.W. Perot also hired Remsen's laboratory to allow Fahlberg to carry out his experiments. After completing his analysis, there was a waiting period before the trial and Fahlberg obtained Remsen's permission to carry out his own research in the laboratory. As he got on well with other researchers, he took part in Remsen's research agenda.

One night that June, after a day of laboratory work, Fahlberg sat down to dinner. He picked up a roll with his hand and bit into a remarkably sweet crust. Fahlberg had literally brought his work home with him, having spilled an experimental compound over his hands earlier that day. He ran back to Remsen's

laboratory, where he tasted everything on his worktable – all the vials, beakers, and dishes he used for his experiments. Finally, he found the source: an overboiled beaker in which o-sulfobenzoic acid had reacted with phosphorus(V) chloride and ammonia, producing benzoic sulfinate. Though Fahlberg had previously synthesised the compound by another method, he had not had any reason to taste the result. Serendipity had provided him with the first commercially viable alternative to cane sugar. Fahlberg and Remsen published a joint paper on their discovery in February 1879. Remsen had a personal disdain for commercial ventures. However, Fahlberg aggressively pursued the commercial potential of the new compound. He named it 'Fahlberg's saccharin' and patented it without informing Remsen, infuriating him.

(Khan M.M., Islam R. (2017). *Zero waste engineering: a new era of sustainable technology development*. Hoboken, New Jersey: John Wiley & Sons, Inc.: Scrivener Publishing LLC, p. 369)

Fahlberg put in time, effort and ingenuity in adapting the laboratory preparation of saccharin into a successful industrial process. It is very unlikely that Remsen would have spared the time to do this. Nonetheless, Remsen remained bitter about the discovery of saccharin. It is ironic that a substance that provided intense sweetness could be the cause of such bitterness. The rights and wrongs of Remsen's and Fahlberg's actions in the case of the

It is ironic that a substance that provided intense sweetness could be the cause of such bitterness.

discovery of saccharin would make a good topic for student discussion and debate. The debate could expand into the health issues concerning sugar, which are currently a significant health issue, and the role of saccharin in replacing sugar.

Captivating chemistry

The reaction between copper and nitric acid is a vigorous chemical change. Remsen as an adult remembers his excitement as a young man at experiencing this reaction. This illustrates how chemistry can captivate students for life. The saccharin story illustrates the problems of crediting individuals with scientific discoveries. Searches of the literature reveal that some authors credit Ira Remsen with the discovery of saccharin while others credit Constantin Fahlberg. Most commentators credit both men with the joint discovery of saccharin.

William P. Palmer FRACI CChem is Adjunct Research Associate, Curtin University of Technology.

Centenary fellows

RACI's centenary ended on 30 June, and as part of this special year the RACI Board, Branches and Divisions suggested names for consideration for fellowship status. Congratulations to the following people on becoming Centenary fellows during the centenary year.

Previous groups of Centenary fellows were announced in the April (pp. 26–28) and May (p. 30) issues.



Professor Damien Arrigan
Curtin University



Professor Michael Breadmore
University of Tasmania



Professor Frank Caruso
University of Melbourne



Associate Professor Jack Clegg
University of Queensland



Mr Anthony 'Jak' Denny
Retired



Dr Paul Fraser
CSIRO



Dr Margaret Hartley
Australian Academy of
Technology and Engineering



Mrs Mary Hodge
Retired, formerly Team Leader,
Organics, Queensland Health
Forensic and Scientific Services



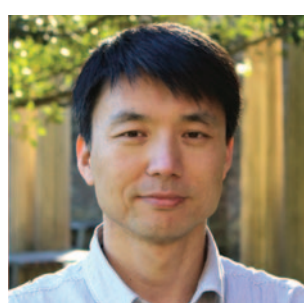
Professor Sandra Kentish
University of Melbourne



**Associate Professor Michelle
Spencer**
RMIT University



Mrs Heather Warren
Queensland Alumina Limited



Professor Chuan Zhao
University of New South Wales

Gerry Bottomley

A passion for high-precision measurements of liquids and gases

Gerry Bottomley was a scientist of enormous curiosity, exceptional experimental ability and impeccable integrity.

Gerald Andrew Bottomley was a very proud Yorkshireman, born in Keighley, Yorkshire, England, on 9 October 1924. He died in Perth on 6 June 2018.

Gerry was awarded a scholarship to go to university and chose Leeds University. He gained first class honours in analytical chemistry and proceeded to a PhD in chemistry, which took him only 30 months. His PhD had two parts: first, the physical properties of silicon tetrafluoride; and second, the compressibility of certain gases. His supervisor, Robert Whytlaw-Gray, was involved in very accurate measurements of the relationship between pressure, temperature and the volume of gases. It was at this time that Gerry developed his lifetime passion for high-precision measurements of the properties of liquids and gases.

His first academic appointment was as an assistant lecturer at the University of Liverpool. He stayed there for three years. He then spent five years as a lecturer in physical chemistry at the University of Otago, New Zealand. Funding was not enough in Otago for him to do high-precision gas property research, so there he continued with his analytical chemistry interest. Whytlaw-Gray must have been impressed with him because after five years he returned to England as a research assistant to Whytlaw-Gray, who had moved to the research laboratories of ICI in Welwyn, Hertfordshire, just north of London. In the two years that Gerry was there, the ICI laboratory made great advances in the precision measurements of gas properties. Whytlaw-Gray died in 1958 and that probably prompted Gerry to apply in 1958 for a position at the University of Western Australia.

Once at the University of WA, he immediately commenced his research on the properties of gases by reproducing his ICI Welwyn apparatus. He continued his very accurate, demanding work on gases. As an example, he asked his research assistant John Evans to make an oven to have a temperature that would not vary by more than one-tenth of a degree. When it was finished, he said, 'That is fine, now make it to maintain temperature to within one-hundredth of a degree'. Having finished that, John was asked to fix it to maintain temperature to within one-thousandth of a degree. A PhD student Laurie Glossop had to build a temperature bath to maintain temperatures to within a ten-thousandth of a degree.

He married while on study leave and there is a letter in his staff file dated 30 June 1965 notifying the University of WA that he married Miss Judith Browne on 26 January 1965 in West Los Angeles.

Gerry trained a small group of very successful postgraduate students. His first student, Ian Coopes, was a Master's student who went on to have a successful research career with Kodak



Australia. Of his PhD students, Tom Spurling became Chief of a CSIRO Division, Laurie Besley the Chief Executive of the National Measurement Institute, David Nairn a research manager with the Australian Mineral Industry Research Association, John Farrow a senior research manager in CSIRO, Laurie Glossop director of an industrial hygiene consultancy and Mike Bremers Senior Examiner of Patents at the Australian Patents Office.

Besides his teaching and research, Gerry made many important contributions to the University of WA. Except for interruption by study leave, Gerry was Head of the Department of Physical and Inorganic Chemistry from 1979 until 1982.

He was a member of the University Senate, and in this role he demonstrated his unshakeable integrity. When he came to morning tea after senate meetings he would be questioned by other staff about what had happened about various matters. He would reply that senate matters were confidential, and he could not speak about it.

Relating chemistry to matters of community importance was always an important activity for Gerry. He was a member of the Clean Air Authority of WA and did some important work on nitrogen oxide levels in the suburbs of Perth, contributed to the Kwinana Air Modelling study using SF_6 to track the emissions from smoke stacks in Kwinana, and studied lead levels in soils and on plants near major roads.

Gerry joined the RACI soon after his arrival in Australia in 1959 and was elected Fellow in 1989.

G.S. Chandler FRACI CChem and T.H. Spurling FRACI CChem

Build your own lava lamp

Although this isn't quite the same as a lava lamp that you buy, it is a very exciting and visually spectacular experiment. It is very safe, using only things you would usually find in your kitchen.

There are a number of ways that you can do this experiment. This one is my favourite because it is very easy to control how fast it goes. If you start slowly, this experiment can last for hours. Alternatively, you can speed it up, which will make it finish sooner, but looks very cool.



What you need

- Citric acid powder
- Bicarb soda (sodium bicarbonate)
- Cooking oil (the lighter in colour, the better)
- Food colouring (multiple colours for the best effect)
- Tall see-through container (I usually use a 250 mL measuring cylinder, but a tall narrow glass or vase works as well.)

What to do

- 1 Mix together approximately equal amounts of the citric acid and bicarb soda. You need enough to have the mixture about 1 cm deep in the bottom of the container.
- 2 Very gently, slightly tilt the container and pour cooking oil down the side of the glass so that it sits on top of the citric acid-bicarb soda mixture. You can use as much as you like, depending on how big the container is.
- 3 Sit the container upright on a flat surface.
- 4 Add a few drops of food colouring to the top of the oil layer. Use only one or two colours. They will eventually mix, and if you use all colours you'll end up with a boring black colour.
- 5 Watch and enjoy!

The food colouring drops sink, allowing the citric acid and bicarb soda to mix together and form bubbles. The bubbles attach to the outside of the food colouring drop, which is then carried back to the surface of the oil layer. The bubbles should then pop, and the food colouring drop sinks back down to the bottom. The cycle continues until either the citric acid or the bicarb soda runs out.

If you want to speed it up, just add more food colouring drops. Alternatively, you could add water drops, which will lighten the colour of the food colouring drops. For another fun effect, you can shine a desk lamp through the lava lamp in a dark room against a light-coloured wall.

What's happening?

There is so much science going on here!

- 1 **Acid-base reactions:** The citric acid and the bicarb soda are an acid and a base, which can react with each other. However, as solid powders they do not react with each other – they must be dissolved in water and do not dissolve in the oil. The base in this reaction is a carbonate, so when it reacts with an acid it forms carbon dioxide bubbles.
- 2 **Density:** The food colouring drops are mostly water. Water is denser than cooking oil and also does not mix with it, which means that when dropped on the top it sinks to the bottom of the container. However, when the carbon dioxide bubbles are attached, the combined food colouring drop and bubble is less dense than water, so it floats back up to the top. When the bubbles pop and the gas is released, the food colouring drop becomes denser than the oil again, and sinks back down.
- 3 **Colour:** When the food colouring drops mix together, the colours blend together too. The colour for the food dyes is determined by what colours of light they absorb, and what colours they reflect. When they mix together, the combination of different colours makes the drop appear to be one colour; for example, red and yellow mixed together make orange. If you were able to look *really* closely (you can't), you would be able to see that the food dyes are still yellow and red.

I hope you enjoy this experiment! If you have any questions or feedback, I can always be contacted by email so feel free to get in touch anytime!

Until next time, happy sciencing!



Dr Jeremy Just MRACI CChem (Jeremy.Just@utas.edu.au) is a Hobart-based lecturer in food safety and a passionate science communicator, specialising in chemistry shows and demonstrations. Jeremy writes these columns for members to share with or demonstrate to friends and family without formal chemistry knowledge.

It's all about patent searching

Dae Woong Oh, Patent Attorney, FB Rice



It is common for researchers to search academic or industry journals to identify whether a research subject has already been investigated or what stage the research is at. However, it is less common to search for patent documents. This is understandable

because patent searching used to be a painful, time-consuming and expensive exercise.

Regardless of its difficulty and cost, the consequences of a failed patent search can be devastating. You may spend a significant amount of time and resources investigating a research subject to later discover that the research subject has already been patented by somebody else. In a worst-case scenario, you and your organisation may be sued for patent infringement.

Patent searching is the first step in preventing such a scenario from happening. The good news about patent searching is that with the development of internet and online patent databases it is much easier than ever before. Most national and regional patent offices provide free online patent databases, which include AusPat, Espacenet and PatentScope. Free online patent databases such as Google Patent are another handy tool for DIY patent searching.

One pitfall of these patent databases is that their data coverage may not be comprehensive. Furthermore, it may not be easy to perform sophisticated patent searching or to manage a large number of search results. For comprehensive patent searching, it may be helpful to subscribe to commercial patent databases or to outsource patent searching to patent searching professionals who subscribe to the commercial patent databases.

Keyword searching is a typical way to search patent databases. However, it has a number of limitations. For example, chemical compounds can also be defined by chemical structures. Accordingly, keyword searching alone cannot locate patent documents that refer to compounds only by their chemical structures. Therefore, in the chemical space, a keyword search should be supplemented by a chemical structure search. It can also be useful to search by inventors, applicants or patent classifications.

Further care should be taken if you search and review patent documents by yourself. Unlike a journal, a patent document contains claims that define the scope of patent protection. The title or abstract of a patent document is kept deliberately brief. Hence, keyword searching of titles or abstracts only in patent databases will not be sufficient to identify relevant patent documents.

To be patentable an invention must be new and inventive in any part of the world. Thus, if you plan to patent your invention, patent searching should not be limited by country, time or status of patents/applications. However, if your purpose of patent searching is to ensure that you can perform research or launch a product without infringing patents in certain countries, then limiting searching to the relevant countries and patents/applications with active statuses is an appropriate option. As a result of the lag period between filing and publication, which is typically about 18 months, patent searches should be regularly updated to identify newly published patent documents.

In conclusion, patent searching should be an integral part of your research and can be done by yourself. Owing to the possibility of patent infringement, a comprehensive patent search outsourced to patent searching professionals is highly recommended.

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

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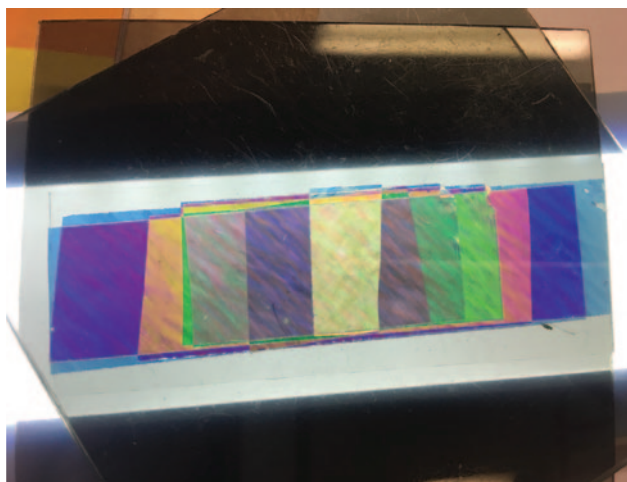
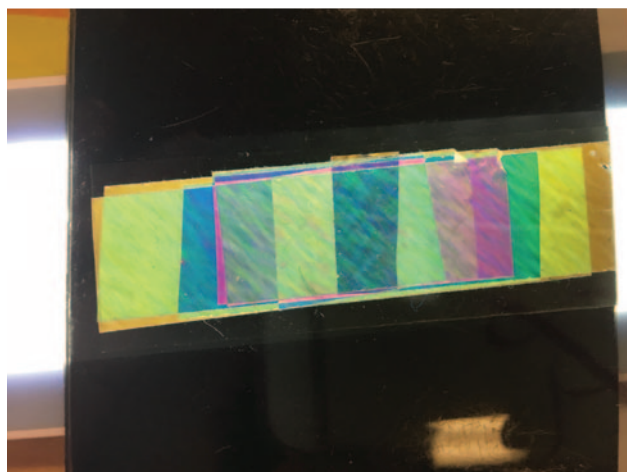


The IP Navigators

Sticky and sugary solutions for polarising questions



Polarising sunglasses are very common, but do we really know what makes them tick? We know they reduce glare because some annoying reflected light is polarised and can be blocked, but results in funny colours when looking at car windscreens and LCD displays. A sheet of polaroid transmits only light waves that align with the filter in the sunglasses.



Sticky tape with steps: with blocking polariser (top) and with 45° rotated polariser (bottom). Jenny Selinger

When light enters materials

On a summer's day by the pool, you've probably noticed (if you take your sunglasses off) that the legs of people in the pool appear to bend upwards. This is explained by a physical property called refractive index – the light beam changes direction when entering the water from the air. The amount of change differs between materials and decreases with the wavelength (blue to red) of light. That's how a glass prism works.

A material can have different refractive indices in different orientations, such as some plastic materials that have been stretched in one direction. For other materials, such as crystals, this is a natural property. The difference between these refractive indices is called the birefringence of the material.

What you need

- 2 pieces of polaroid (such as the plastic in polaroid sunglasses)
- Glass microscope slide
- Clear sticky (adhesive) tape
- Sunlight or other light source

What to do

- 1 Cover the centre of the microscope slide lengthways with a section of clear sticky tape.
- 2 Place a slightly shorter length of sticky tape over the first piece, leaving a small gap at one end. Continue making this 'step ladder' for around ten steps.
- 3 Position your pieces of polaroid at 90° to each other.
- 4 Place your 'step ladder' between the crossed polarisers. A series of different colours should appear with each step. If not, make each step twice as thick or try another type of tape.

What's happening?

Tape is a birefringent material, and gradually increasing its thickness produces a sequence of colours as different wavelengths in turn are transmitted by the crossed (second, called analysing) polaroid. The colour sequence for crossed polarisers is, roughly, yellow, blue, magenta, lime green, purple, pale green, colourless.

When you have this working, rotate one of the polarisers gradually to 45° so that their complementary colour partners take over. You may even be able to get a second-order series higher up the ladder.

For a more detailed explanation of this complicated phenomenon see <https://physlab.lums.edu.pk/images/sc/cellophane1.pdf>. For an explanation of the relationship between the speed of light and refractive index with that wonderful 'principle of least action', see a familiar reference.*

Molecules rotating light

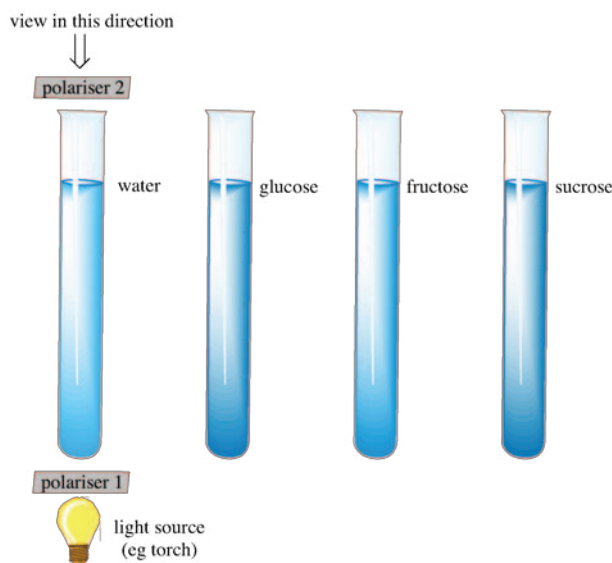
Certain molecules in solution can rotate the plane of (circularly) polarised light that travels in a corkscrew fashion, moving forward and rotating at the same time, either clockwise or anticlockwise.

What you need

- Sucrose (plain white sugar), glucose and fructose (available from health stores or bulk pharmacies)
- 2 pieces of polaroid
- Torch with LED globe
- Test tubes or tall (narrow) jars

What to do

- 1 Prepare solutions of sucrose, glucose and fructose by dissolving approximately three heaped tablespoons of each in half a (measuring) cup (125 mL) of water.
- 2 Three-quarters fill a test tube with each of the solutions and a fourth one with just water.
- 3 Line up the apparatus vertically as shown, with the light source at the bottom, followed by a polariser, then a test tube, then a second (analyser) polariser.
- 4 With pure water, rotate the analyser polariser to the point of maximum light extinction. Mark the edge of both polaroid sheets so you will know how much they are rotated in the next steps. Replace the water-containing test tube with each sugar solution in turn.
- 5 Light will come through the previously extinguished crossed polarisers. Rotate the analyser polariser to reach (approximate) extinction again.
- 6 One colour at a time (as seen in the sticky tape experiment) comes through. For sucrose and glucose, the rotation needed will be clockwise and for fructose it will be anticlockwise.
- 7 For ease, adjust the sugar concentrations and/or the depth of solution in the test tubes so that the rotation angles needed are around 20° .



Experimental set-up for measuring the rotation of polarised light.

What's happening?

The optical rotation caused by the sugar molecules is due to (circular) birefringence. The refractive indices (speed of light) of left-hand circularly polarised light and right-hand circularly polarised light are different. The ability of these sugar molecules to do this is a property (optical activity) of their molecular geometry.

Chemists use the single-colour sodium D-line (as seen with sodium vapour street lights) to obtain sharp extinctions. By using a (white) LED torch we do the opposite.

Sugar	Optical rotation*
Sucrose	$+66^\circ$
Glucose (dextrose)	$+53^\circ$
Fructose	-92°

*Relative rotation measured with yellow sodium D-line at 589 nm.

When sugar (sucrose) is broken into its two components glucose and fructose, the optical rotation reverses from $+66^\circ$ to -39° , and so this (roughly twice as sweet) mixture is known as invert sugar! Honey is a 'natural' example.

Acknowledgements

Thanks to Emeritus Professor Elmarz Krausz (ANU) for discussions on this and related optical topics and to Jenny Selinger (Head of Science, Emanuel College, Sydney) for comments and testing.

Ben Selinger FRACI CChem is Emeritus Professor of Chemistry at ANU and, along with ANU colleague Associate Professor Russell Barrow, released the sixth edition of *Chemistry in the marketplace* (CSIRO Publishing) in June 2017. For more information, visit www.publish.csiro.au/book/7366. As the author refuses to be called ambidextrous instead preferring ambi-sinistrous, he insists on calling fructose sinistrose. Nutritionists often agree. If glucose is also called dextrose, shouldn't fructose be called sinistrose?

*B. Selinger, R. Barrow, *Chemistry in the marketplace* CSIRO Publishing, 2017, 6th edn, pp. 483–4.

Future fuels – the expectation gap

I'd like to report a few observations on the future of transport gleaned from two international conferences and other meetings I have attended over the European summer.

Power to Fuel (PtX) is now a major research topic in Germany. The basic concept is that hydrogen is produced by electrolysis from renewable energy and this is used to reduce carbon dioxide to fuels; this can be by reduction to methane (synthetic natural gas) or by variations on the Fischer-Tropsch synthesis to fuels. PtX has many variants and, as yet, it is not clear what the optimum system is likely to be.

What is becoming clear is that for any system generating hydrogen by electrolysis, to avoid the high compression costs it will be necessary to produce hydrogen in high-pressure electrolyzers. To avoid distribution problems, retail forecourt electrolyzers can then deliver high-pressure hydrogen for fuel cell or hydrogen-powered vehicles. Several demonstration filling stations have been built and more are planned, including one in Canberra.

Another way to get around the hydrogen distribution problems (high-pressure pipelines, high compression costs, high leakage rates) is to use ammonia as an intermediate, a concept being pursued by CSIRO (see box). Ammonia is similar to LPG for which there is already an installed distribution infrastructure. The system would require the synthesis of ammonia at the source of the hydrogen, transportation by tanker to a retail forecourt (say) and there cracking back into hydrogen and nitrogen, which are separated by using advanced membranes to generate pure hydrogen for use.

The promotion of electric vehicles continues apace. However, apart from a few moneyed enthusiasts, electric vehicle sales are driven by spending other peoples' money (taxpayers, shareholders etc.). I was told by one enthusiast that not only is careful planning required on a long journey so that the vehicle can be recharged, but also the present state of distribution makes it necessary to check ahead that the charging point is actually connected to the grid and is working. There are charging stations in most UK motorway service areas but my observation is that they are presently rarely used outside the London area.

There seems to be a marked reluctance to grapple with the issue of power provision, power distribution and the upgrading of power transmission that would be required for a widespread transition to electric vehicles. The only answer to the generation of sufficient power at the present time is a massive expansion of nuclear power, which seems to be off the agenda in most countries. Perhaps this problem has changed the UK government's initiative to ban conventional fuelled vehicles from 2040 from being a definitive target to being an aspirational target.

However, there is a great deal of enthusiasm to fund battery research, which, together with quantum computing, is receiving a significant funding boost in the UK.

There is also a major push to use agricultural crops and waste for producing sustainable fuels. One of the more significant methods is to use pyrolysis or gasification to generate fuel gases. However, these routes, in general, produce unstable tarry by-products that are generally difficult to handle and convert into useful products. A new pyrolysis method is being demonstrated by Shell in Bangalore, India, which converts sawdust into energy without producing tars. The basic process, which was developed by the Gas Technology Institute (GTI) in the US, is to conduct the pyrolysis in two stages in the presence of high-pressure hydrogen and hydro-conversion catalysts. The first stage at high temperature de-oxygenates the biomass and produces a product that contains much less tarry matter; a second, lower temperature stage, cracks and reduces heavy hydrocarbons to gaseous products, gasoline and diesel fuel. The process is tailored to give a gaseous product rich in water and carbon monoxide, rather than carbon dioxide. Water is condensed and the carbon monoxide is passed to a reformer to produce hydrogen for the system. It is claimed that the system is balanced and no additional imported hydrogen is required.

One of the emerging issues with the top-down promotion of new energy sources for power generation and transport is that many people expect new and affordable technology to be deliverable within the next few years. For most technology breakthroughs that are required, such as batteries that can compete with diesel fuel on an energy density basis or cheap hydrogen supply or driverless vehicles, these developments are years if not decades away. This will lead to an 'expectation gap' by the general public. Failure to deliver in a timely fashion leads to disenchantment, which ultimately leads to lower funding of research in these areas; compare this with the once highly funded research into nuclear fusion for power generation.

Another interesting event in the recent British summer was concern about the shortage of carbon dioxide for beer (mainly fizzy lager) and food (crumpets) production. This is an example of the law of unintended consequences. The shortage has been caused by the simultaneous shutdown of several of the UK's ammonia plants, which produce food-grade carbon dioxide as a by-product. The principal use for ammonia is for the production of fertiliser and manufacturing operations generally target shut-down and maintenance for the summer months because demand for fertiliser is generally low in this season. This year, several major ammonia facilities have been shut-down for an extended maintenance period. Several German fertiliser operations have also entered into maintenance shut-down, which has exacerbated the problem.

Fortunately, Australia can source carbon dioxide from natural gas as well as ammonia plants. However, as Australia moves to further decarbonise its economy and use more imported gas (LNG) and coal seam gas, which are both devoid of carbon dioxide, then in future we risk a similar shortage of carbon dioxide for the food industry.

A disturbing report has emerged that the concentration of the chlorofluorocarbon CFC-11 (trichlorofluoromethane) has increased in the atmosphere. This is despite it being banned by the Montreal Protocol, which aims to eliminate such compounds, because under UV light they destroy the ozone layer in the upper atmosphere. The source of the emission appears to be Chinese producers of urethane foam rubbers and the like, who should be targeted for sanction. However, industrial fluorine chemistry is not simple and CFC users would probably not be the producers. The question to be asked is who is making these compounds in defiance of the Protocol and what other CFCs are being produced and possibly used in industries with a slower release rate than foam producers; for example, CFC use in refrigeration equipment. If the Montreal Protocol can be so easily flouted then it does not bode well for regulation of the more complex Kyoto Protocol and Paris Agreements limiting carbon dioxide emissions.



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RACI Board elections

The following Board position terms end in November, and a nomination and election process is required to fill the positions for the following two years ending November 2020:

- President Elect
- Treasurer
- Ordinary Board member – one position.

The RACI is looking for nominations for these three positions, so please consider proposing worthy candidates.

Board members are equivalent to company directors, and information on director's duties can be found at bit.ly/2vbgH1R.

Nomination forms can be found at bit.ly/2LTbrcU.

Please email your completed nomination forms to elections@RACI.org.au.

CSIRO membrane technology accelerates hydrogen production

Australia is a step closer to a new hydrogen production and export industry following CSIRO's successful refuelling of two fuel cell vehicles.

CSIRO Chief Executive Larry Marshall was one of the first to ride in the Toyota Mirai and Hyundai Nexo vehicles powered by ultra-high purity hydrogen, produced in Queensland using CSIRO's membrane technology.

This technology will pave the way for bulk hydrogen to be transported in the form of ammonia, using existing infrastructure, and then reconverted back to hydrogen at the point of use.

It has the potential to fill the gap in the technology chain to supply fuel cell vehicles around the world with low-emissions hydrogen sourced from Australia.

The membrane separates ultra-high-purity hydrogen from ammonia, while blocking all other gases.

It links hydrogen production, distribution and delivery in the form of a modular unit that can be used at, or near, a refuelling station.

This means that the transportation and storage of hydrogen – currently a complex and relatively expensive process – is simplified, allowing bulk

hydrogen to be transported economically and efficiently in the form of liquid ammonia.

Recent advances in solar and electrochemical technologies mean renewable hydrogen production is expected to become competitive with fossil-fuel-based production, providing an opportunity to decarbonise both the energy and transport sectors while creating new export opportunities.

Following this successful demonstration, the technology will be

increased in scale and deployed in several larger-scale demonstrations, in Australia and abroad.

In addition to its membrane technology, CSIRO is looking at all stages of the hydrogen technology chain (including solar photovoltaics, solar thermal, grid management, water electrolysis, ammonia synthesis, direct ammonia utilisation via combustion and/or fuel cells, as well as hydrogen production).

CSIRO



The Toyota Mirai fuel cell vehicle, ready to be fuelled with CSIRO-produced hydrogen.

Natural wines – a love/hate story

Lately, natural wines have received considerable attention in the wine media. For example, in February this year, Fairfax Media's *Good Food* published two columns in the 'Milkcrate' section, one supporting natural wines (bit.ly/2K5H1iJ) and one raising a series of questions, including terminology (bit.ly/2mRnJ7n). This was followed by a two-page summary of a tasting and discussion (bit.ly/2jZpI8i), which at times generated considerable passion in the love/hate camps.

The challenge with the term 'natural wine' is to understand what it means to each user. Wine publication *Decanter*, for example, suggests the term is one of convenience 'to describe a complex, sprawling ideology that includes organic and biodynamic viticulture, minimal intervention in the winery, and sometimes radical views on sulfur dioxide' (bit.ly/2AnRXZs and bit.ly/2OuuMiP).

Hand-harvesting and fermentation by indigenous yeasts only are two requirements for natural wines.

Any broad approach to 'defining' natural wines is fraught with difficulty. The viticulture practices of 'organic' and 'biodynamic', said to be essential in natural wine production, cannot be solely claimed or owned by supporters of natural wine. Both these approaches to vineyard management are widely practised here and in Europe, but most producers would not label their wines as 'natural'. A good example is Henschke Hill of Grace: this vineyard is under biodynamic management and the 2012 vintage demands about \$800 per bottle. Certainly, many grapegrowers aspire to developing a self-sustaining vineyard. The biodynamic approach follows the concepts proposed by Rudolf Steiner. Basing viticulture on the cycles of the moon is an approach that many of my colleagues regard as totally unscientific.

Hand-harvesting and fermentation by indigenous yeasts only are two requirements for natural wines. Indigenous (or 'wild') yeasts are found on the skin of the grape and on the surface of any equipment, such as picking buckets, as well as in the atmosphere in the winery environment. Hand-harvesting and fermentation by indigenous yeasts are both widely used in wine production and are not sufficient to distinguish natural wine per se because many great wines are produced by fermentation with indigenous yeasts. Little is known about how long it takes for a vineyard to produce a stable and consistent microflora that can be reproduced vintage after vintage to give some consistency in the fermentation. Newer vineyards are likely to

have an unstable, or changing, microflora population that may not always result in a totally effective fermentation from one vintage to the next.

There are, however, significant differences in production strategy once the grapes have been processed. Additives are not allowed in natural wine production, whereas in most Australian wine production it is common to add tartaric acid to adjust the acidity, because this is claimed to give a more efficient fermentation. Australia's ancient soils produce grapes that are commonly low in yeast-available nitrogen and so diammonium phosphate may be added to supplement the amount of nitrogen, again to enhance the fermentation. Enzymes, whether pectolytic or flavour enhancing, are not used and tannin addition in red wine production is not part of the natural wine method. Settling the freshly fermented wine prior to bottling is the norm for natural wines, although some are 'lightly' (say, 3 μm) filtered.

Perhaps the most contentious issue is the role of sulfur dioxide. SO_2 has a dual role in winemaking – as an antimicrobial agent and as an anti-oxidant. The 'purists' in natural wine production will not add SO_2 because it is an 'additive': small amounts will be produced in the fermentation anyway, so supplementation through external addition is not performed. Jancis Robinson has noted that the lack of acid addition creates high pH conditions and so the non-use of SO_2 can lead to the growth of non-preferred yeast and bacteria (bit.ly/2NR9dIj). This results in what might be politely called 'funky' aromas, but many producers and consumers see this as a positive.

Of course, the non-use of SO_2 is not reserved for natural wine producers – some very expensive wines are produced to meet the demand of those who are allergic to SO_2 . Drappier Brut *nature sans soufre Champagne* is one that comes to mind. The production of this wine actually shows some commonality with the natural wine community (see download at bit.ly/1MTw1PM), even if the term 'natural' is not used.

There does seem to be a move towards allowing some SO_2 addition in natural wines. Isabelle Legeron, on her Raw Wine site, includes wines with added 'sulfites' up to a total of 70 mg/L in the category of natural, artisan wines. The site links to a long list of wines that meet the low SO_2 requirement as well as satisfying the other requirements for natural wines discussed above.

The reasons for people's fascination with natural wines would take another column at least to discuss. For some more background on the concept, check out an article on the Wine Australia website (bit.ly/2uXLNkg), which gives an Australian perspective.



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

Great balls of fire

The obituary for Jack Norman Gregory (1920–80), written by Dal Swaine and published in *Chemistry in Australia*, omitted the most interesting of the projects that he worked on. Gregory completed his BSc at the University of Melbourne, studying part time while working with the CSIR Division of Forest Products. During World War II, he was with CSIR's Lubricants and Bearings Section, working on lubricants and related materials under the general direction of Philip Bowden. In the late 1940s, Gregory was awarded the MSc degree for a collection of reports and publications arising from his CSIR work. Later, he moved to the Australian Atomic Energy Commission where he became Deputy Director of Research. His DSc was awarded by the University of Melbourne in 1954, again for a collection of work. The breadth of his interests and achievements stamped him as jack-of-all-trades chemist.

... several tons of Geletrol were manufactured each week by Australian chemical companies Fletcher Chemical in Melbourne and Robert Corbet Pty Ltd in Sydney, and the army used large quantities of it in the closing stages of the war.

What I was most interested to learn about, however, was a wartime project on the production of a local version of napalm, a military weapon that was compounded from a flammable liquid such as petrol or diesel and a gelling agent. Products of this type could be used in bombs and other incendiary devices, but the best-known application was in flamethrowers that could squirt a burning mixture up to 100 metres. Because the gelling slowed down combustion, the product was still burning when it reached its target and continued to do so for some time. Napalm came in several varieties. The one we know best was based on polystyrene as gelling agent: it was very sticky when it reached its target, and very hard to extinguish. This variety was said to have been invented by Louis Fieser, Professor of Chemistry at Harvard University.

Following a request from the Australian Army in 1944, Gregory led a small team to produce a local version of this fearsome weapon. One of his colleagues was a Dutch naval officer, presumably displaced from the East Indies (Indonesia) by the advance of Japanese forces. Examination of a sample of

napalm provided by the US military showed that it contained an aluminium soap. Metallic soaps were familiar to the CSIR researchers: they render lubricating oils more or less solid so they can adhere to bearing surfaces. Sodium, potassium, calcium and strontium soaps (salts of long-chain fatty acids) are in common use, as I recall from my studies at Footscray Tech all those years ago, where one of the exercises was to determine, by flame colour, what metal was involved in each of a number of grease samples.

The Australian product, Gelatrol, was prepared from an aqueous solution of alum and oleic acid, by the addition of caustic soda to produce a granular precipitate. It had the overall formula $\text{Al}(\text{OH})_{1.3}(\text{C}_{17}\text{H}_{33}\text{COO})_{1.7}$, representing a mixture of aluminium monohydroxy dioleate and dihydroxy mono-oleate. In the field, the gelling agent was mixed at a level of about 5% with motor transport fuel to produce a stable gel in a few minutes. The development of Geletrol is described in a series of CSIR reports marked 'SECRET', but by the time that Gregory's collected papers were submitted for the MSc the main lines of the work had been published in 1946 in the *Journal of the Council for Scientific and Industrial Research*. Something revealed in one of the later reports was the improved gelation by incorporation of a small quantity of ethyl cellosolve (2-ethoxy ethanol). A touch of β -naphthol was added, too, as an anti-oxidant. Batches of a modified version of Geletrol were made by CSIR's Chemical Engineering Section. Their gelling agent was an aluminium alkoxide, and counterintuitively it was the ethoxide that out-performed longer-chain alkoxides. Designed for 'blaze bombs' to be used by the Royal Navy, it was tested in bombs dropped by a Mustang aircraft at Laverton, south-west of Melbourne, where there was a military airfield.

Commercially, however, several tons of Geletrol were manufactured each week by Australian chemical companies Fletcher Chemical in Melbourne and Robert Corbet Pty Ltd in Sydney, and the army used large quantities of it in the closing stages of the war.

'Great balls of fire' was the exclamation I heard in the early 1960s from others who were excited about happenings in their daily life, but I'd never wondered about the origin of the phrase until it jumped into my mind when I was composing this Letter. Turns out it was the title of popular song from late 1957, sung by Jerry Lee Lewis, and the opening lyrics are a pretty good description of the flamethrower: 'You shake my nerves and you rattle my soul'.

Readers can find a great photo of long-range flame throwing on the Digger History website (bit.ly/2MPJwb2) or the Australian War Memorial website.



Ian D. Rae FRACI CChem (idrae@unimelb.edu.au) is a veteran columnist, having begun his Letters in 1984. When he is not compiling columns, he writes on the history of chemistry and provides advice on chemical hazards and pollution.

2017 Royal Society of Chemistry Australasian Lectureship

In October 2016, Alan Bond (Monash) asked me if I would accept the 2017 Royal Society of Chemistry (RSC) Australasian Lectureship. I think my exact answer was 'In a heartbeat'.

The award began in 1960 and by 1995 when the Kiwis joined in, it became the RSC Australasian Lectureship. Aside from a few temporal hiccups, 52 chemists from 18 universities and the CSIRO have presented on topics from galactochemistry to chemical education. My lecture was a light-hearted perspective on my sojourn through analytical chemistry over the last 40 years. It began at RMIT and meandered purposefully through to Deakin. Interwoven across this collage of amnesia were acknowledgements to friends, collaborators and mentors, without whose positive influence and encouragement I would not have given this celebrated lectureship.

Discussions with previous lecturers revealed a considerable diversity of approaches to their tours. I decided it would be good fun to present the lecture at as many rural and regional universities as possible plus one in each of the state capitals.

After making arrangements, I was ready for my road trip from Geelong to Townsville via Wagga Wagga, Canberra, Wollongong, Sydney, Newcastle, Armidale, Southport, Brisbane and Rockhampton, then on to Darwin and Perth. Equipped with the relevant Radio National frequencies, a satellite telephone, fishing gear, computer and USB drive (holding the lecture), I set off in early May last year, returning home to Geelong in July before further lectures in New Zealand and Hobart in October and December. Some selected highlights follow.

8 May: I arrived at Charles Sturt University for a tour of their impressive new laboratories and coffee with Chris Blanchard. The lecture went well and the 45-minute discussion afterwards was very pleasing.

15 May: The second week of lectures began at the University of New England. I met most of the chemists and gave a lecture that seemed to go down quite well with lots of questions and interest. Leaving the glorious University of New England campus, I arrived in Yamba in time to enjoy grilled salmon, Riesling and a spectacular view of the Pacific.



The 2017 RSC Lecturer at Uluru; we managed to drag Geelong's weather all the way to Central Australia in the dry season.

17 May: Pulling into carpark 12 at the University of Queensland was very strange, knowing that I was not going to see my friend and colleague Graeme Hanson, who died in February 2015. Graeme was an enthusiastic collaborator and was instrumental in elucidating the identity of key radical intermediates in several important chemiluminescence reactions. I was looking forward to acknowledging his considerable contribution to our work.

23 May: An early start avoiding the wildlife crossing the A6 on the way to Charters Towers saw me in Emerald for luncheon and Roma for dinner. The weather became cooler as I approached Parkes the following afternoon. That evening, dining for the final time during the first phase of the tour, I realised just how much pleasure it was visiting enthusiastic chemists.

24 June: After a side trip to Canberra for a meeting, the second phase of the tour began properly on a very cold Saturday. The first gig was to be at Charles Darwin University in Darwin on 30 June. My wife joined me for this phase, and the journey took us to Mildura, Port Augusta, Coober Pedy, Curtin Springs, Yulara, Alice Springs, Hermannsburg and Daly Waters.

3 July: The drive to Kununurra and onward to Broome was punctuated with spectacular scenery. We had a break in Broome and took in some of the local attractions.

11 July: We arrived in a wet and cold Margaret River after overnight stays in Karratha, Carnarvon and Cervantes. The trip saw us at the impressive Pinnacles National Park and the ancient stromatolites at Lake Thetis.

14 July: Nicole Smith (University of Western Australia) had kindly organised my lecture for Bastille Day and it was to be part of the Bayliss seminar series. I was flattered to be presenting as part of a series named in honour of Sir Noel Stanley Bayliss KB FAA, who was one of the pioneers of spectroscopy in this country and the recipient of the 1964 Chemical Society Lectureship.

15 July: We began to head eastwards, with excursions to Esperance and Port Lincoln. We marvelled at Wave Rock and the magnificent coastline near Esperance, staying overnight in Norseman before proceeding across the Nullarbor proper. The



Cable Beach, near-Broome: alternative transport arrangements.

famous treeless plain was most interesting and we viewed some of the Skylab wreckage at the Balladonia Roadhouse, then through to Eucla with its unofficial time zone and whale watching at the head of the Great Australian Bight.

21 July: Strolling towards the University of Adelaide's Badger building, I met my host Stephen Bell, who had a full day's program organised. The seminar at midday was extremely well attended and later that afternoon we repaired to the famous University of Adelaide Staff Club to continue the scientific discourse.

It seemed prudent to delay the New Zealand leg until at least some of the snow had melted and the downhill racers had left town, if only to get better hotel prices. Consequently, I proposed mid-October to the New Zealand RSC representative.

21 October: The ferry trip from Wellington to Picton was spectacular. Nelson (or more correctly Brightwater nearby) is the birthplace of one of my favourite scientists, Lord Ernest Rutherford OM FRS. This giant of 20th-century physics became a Nobel Laureate in Chemistry at just 37 years of age and went on to mentor and inspire others to reach the same pinnacle of achievement.

24 October: We were off to Christchurch via Arthur's Pass and, at 739 metres, New Zealand's Southern Alps were absolutely stunning. Stopping for a coffee, we were reminded of how friendly the locals are.

6 December: I was honoured to present the 21st iteration of the 2017 RSC Lecture at the 25th RACI Research and Development Topics Meeting in Hobart (University of Tasmania). For almost a quarter of a century, this meeting has been an important scientific forum for Honours and PhD students in analytical and environmental chemistry across Australia. The annual event also has its moments of conviviality and exuberance.



A local inhabitant of Arthur's Pass, New Zealand.

I am privileged to have been awarded this prestigious lectureship and I must thank Alan Bond and the members of RSC Australasian Section for the honour. The welcome and cordiality I was afforded everywhere in Australia and New Zealand was absolutely fantastic. It has been a joy conversing with my colleagues across our two nations only to realise that we all face the same professional problems and pressures.

The tour statistics include just over 28 000 km of driving, three ferry trips, three airline flights, 51 hotels/motels, four crossings of the Tropic of Capricorn and countless long black coffees and toasted ham and cheese sandwiches.

I wish to express my sincere gratitude to the RSC for generously providing the funding that allowed me to travel and attend the centenary congress. Finally, it behoves me to congratulate Mary Garson (University of Queensland), who is the 2018 RSC Australasian Lecturer. I do hope she is enjoying her year as much as I did mine.

Neil W. Barnett FRACI CChem, Deakin University

The author with the Deakin University analytical chemists in Hobart.



8th IUPAC International Conference on Green Chemistry

9–14 September 2018, Bangkok, Thailand
greeniupac2018.com

8th International Conference on Environmental Chemistry and Engineering

20–22 September 2018, Berlin, Germany
environmentalchemistry.conferenceseries.com

CBEE 2018 – 10th International Conference on Chemical, Biological and Environmental Engineering

27–29 September 2018, Hotel Berlin, Berlin, Germany
icbee.org

26th Annual RACI R&D Topics Conference in Analytical and Environmental Chemistry

2–5 December 2018, University of Canberra
rndtopics.com

Organic 18 – 24th RACI Organic Chemistry Conference

2–6 December 2018, University of Western Australia, WA
ivvy.com.au/event/OGD780

4th Future of Surfactants Summit

6–7 February 2019, Madrid, Spain
wplgroup.com/aci/event/surfactants-summit

RACI events are shown in blue.

RACI Mentoring Programme 2019

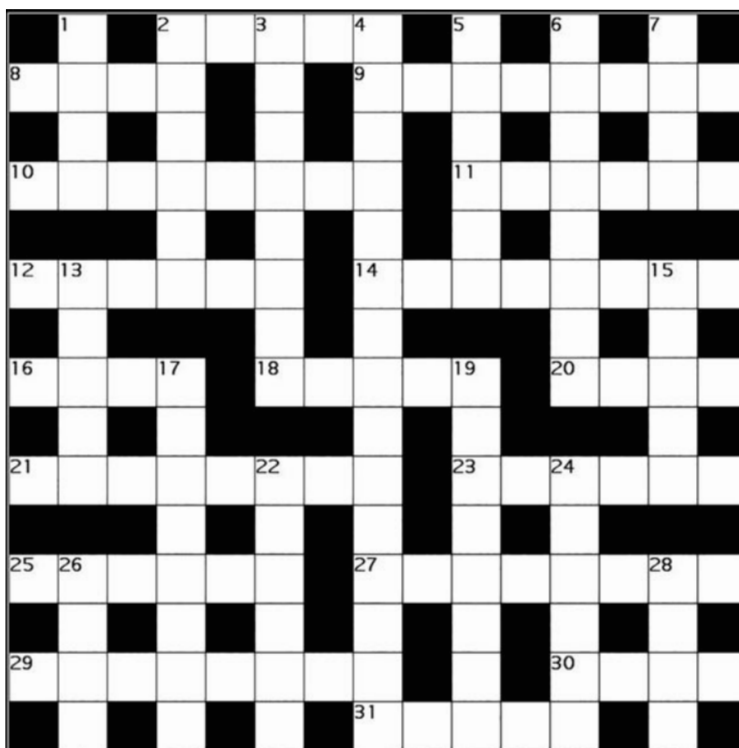
Applications for the RACI Mentoring Programme are now open for 2019. The Programme aims to prepare young chemists preferably in the final year of their undergraduate degrees for a successful career in the industry. Past mentees report an extremely positive experience, particularly in job-readiness and tangible outcomes (professional network and job interviews versus other graduates).

For the first time, applications are accepted from outside NSW as the Programme goes national. Students from NSW, SA, QLD and VIC are all encouraged to apply.

RACI student membership is required for participation in the Mentoring Programme.

Applications close 30 September 2018

For further information and how to apply, visit <https://bit.ly/2LTbrCU>



Across

- 2** Help Page holds back reference to manufacturer. (5)
8 See 12 Across.
9 Ha! Next an order to make $C_{13}H_{10}O$ (8)
10 Lasagne I cooked in the English style. (8)
11 See 14 Across.
12 & 8 Across Banned old/new docs being shredded. (6,4)
14 & 11 Across Make bigger Centres, healing wounds. (8,6)
16 Containers of three or four elements. (4)
18 Look back on carbon for gradual slip. (5)
20 Sulfur dioxide – time for residue. (4)
21 Strange men do cut paper. (8)
23 An obsolete term for 1,2-ketoaldoses: soon 76 will be used. (6)
25 C_2H_2 – the compound with two other elements. (6)
27 Composed to obtain helium radical. (8)
29 A biotin/iodine compound produced from the ground up. (2,6)
30 It's fashionable to get more than half a bird. (4)
31 Lacks dense structure. (5)

Down

- 1** Dream satellite. (4)
2 Viewpoints measured by degrees. (6)
3 Regular HIO_4 or H_5IO_6 as an acid. (8)
4 Tests ion mix. Penetrate result. (15)
5 Cineol used to describe $>C=C(OH)-$. (6)
6 Four elements are precursors to first live sand media. (8)
7 Flat group. (4)
13 White compound in cordon bleu cooking. (5)
15 Second mule leaves 20 Across. (5)
17 Auditing with a view to sign duty rundown. (8)
19 Hops around the code for $COCl_2$. (8)
22 Makes use of 28 Down, adding erbium and sulfur and removing iodine. (6)
24 How a branch of physics is perceived. (6)
26 Underground pipe. (4)
28 Flame it! Way out! (4)

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

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December 2 – 6, 2018 / The University of Western Australia

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Professor Sarah Reisman
California Institute of Technology



Professor Dave MacMillan
Princeton University



Professor Benjamin Davis
University of Oxford



Professor Veronique Gouverneur
University of Oxford



Professor Erick Carreira
ETH Zürich



Professor Donna Blackmond
The Scripps Research Institute



Professor Mary Garson
University of Queensland
Margaret Sheil Leadership Award Lecture

KEYNOTE SPEAKERS

Professor Mike Kerr
University of Western Ontario
Canada

Professor Bradley Moore
Scripps Institution of
Oceanography

Professor Louis Barriault
University of Ottawa
Canada

Professor Masahiro Murakami
Kyoto University

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Women in Organic Chemistry Pre-Symposium

Organised by Professor Jonathan Morris and Professor Mary Garson. Hosted by Professor Kate Jolliffe
Invited Speaker: Professor Margaret Brimble, The University of Auckland

For more information visit www.organic18.com.au