

# chemistry

March 2016

in Australia



## Chemistry of a classic ceramic

[chemaust.raci.org.au](http://chemaust.raci.org.au)

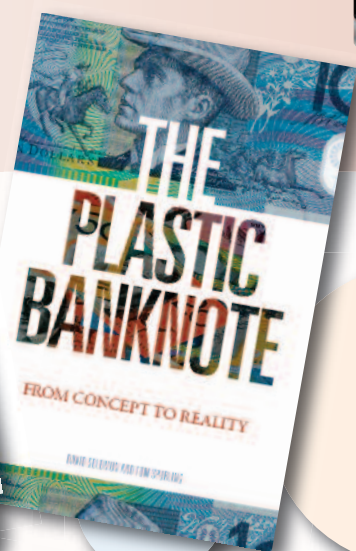
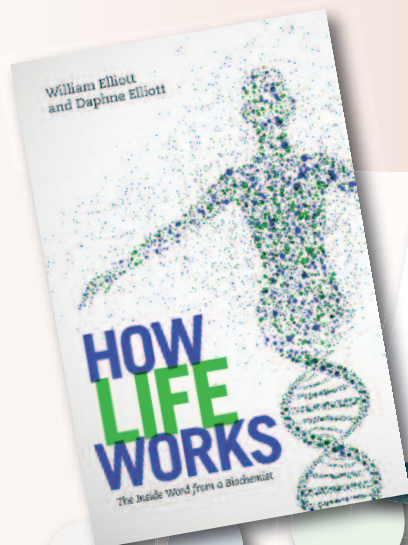
- Top online chemistry demos • Responding to science denial
- Does Australia need a high-tech start-up sector?



# Jump in to win!

Have your say at [chemaust.raci.org.au](http://chemaust.raci.org.au) for a chance to win a Lenovo tablet or the latest reads from CSIRO Publishing.

Visited us online lately? Now's the time to do it! Tell us what you like and what you'd like to see more of and you'll be in with a chance to win a Lenovo A1000L 7" portable entertainment tablet or some great books from CSIRO Publishing.



Conditions of entry: 1. One entry per person. 2. Entrants must be financial members of the Royal Australian Chemical Institute or paid subscribers to *Chemistry in Australia*. 3. Only entries sent via [chemaust.raci.org.au](http://chemaust.raci.org.au) will be accepted. 4. Entries close 5 p.m. AEST on Friday 11 March 2016. 5. Winners must be over 18 and will be selected from a random draw and notified by the Royal Australian Chemical Institute.





### cover story

#### The science and society of Wedgwood

Art, science and a quest for perfection are unmistakeable in the refined and classical ceramics of Wedgwood.

A 1975 reproduction of a Sydney Cove Medallion, from the collection of a member of the Wedgwood Society of NSW. The year 1789 on the medallions is the year the originals were made and sent back to Governor Phillip (see box p. 22).

# 20

#### 24 Chemistry on show: an online 'top 10'

Online demonstrations are a safe and time-saving teaching option. Jeff Hughes presents some of his favourites.

#### 28 Busting myths: a practical guide to countering science denial

It should go without saying that science should dictate how we respond to science denial. So what does scientific research tell us?



### news & research

- 6 News
- 14 On the market
- 16 Research
- 42 Cryptic chemistry
- 42 Events

### views & reviews

- 4 Editorial
- 5 Your say
- 32 Books
- 34 Economics
- 36 Technology & innovation
- 39 Grapevine
- 40 Environment
- 41 Letter from Melbourne

## Accentuating the negative

Ten years ago, a new type of journal was launched. *PLoS ONE* (Public Library of Science) was the first journal to publish purely on scientific rigour, not taking into account novelty or importance of research. The resulting lower rejection rates, and thus high publication volumes, earned *PloS One* and others of its kind the 'megajournal' tag.

Public Library of Science is a not-for-profit organisation and *PloS One* is open access. The journal includes articles from across all sciences, publishing more than 31 000 papers in 2013. The American Chemical Society's *ACS Omega*, launched last December, is one of the latest additions to the megajournal set.

Megajournals use article-level metrics to gather impact from various online sources. Authors usually pay a fee to publish, which is a source of funds for open-access journals.

*PloS ONE* specifically considers papers that report negative results. Bucking the trend of positive publication bias, some journals publish only negative results: *Journal of Negative Results* (ecology and evolutionary biology), *Journal of Cerebral Blood Flow & Metabolism* (a negative results section was introduced in 2010) and *New Negatives in Plant Science* (a pilot) are three examples.

Gabriella Anderson, development editor of *Journal of Negative Results in BioMedicine*, launched in 2002, said the journal began '... on the premise that "failure" is as important in science as in other aspects of life, and that scientific progress depends not only on the accomplishments of individuals but requires collaboration, teamwork, and open communication of all results – positive and negative. After all, the scientific community can only learn from negative results if the data are published' ([bit.ly/1lNF0kk](http://bit.ly/1lNF0kk)).

Many negative results never leave the lab, but this is not always a bad thing. Not everyone needs to read the details of every dead-end experiment. What sorts of negative result should be published? I put this question to Curt Wentrup, until recently Editor-in-Chief of the *Australian Journal of Chemistry*. 'If it is a question of well-executed research that goes against a prevailing theory, then certainly it should be published,' he said. 'If it is a case of clinical studies, then certainly the investigators have a moral duty to publish both negative and positive results. If it is a case of negative attempts to detect gravitational waves or dark matter particles, then yes, this is of interest to the world of science and should be published.'

Most of the journals dedicated to negative results seem to be in the biological or medical sciences. The *All Results Journal: Chemistry* was the only chemistry-related negative results journal I could find. Established in 2010, this open-access journal is amongst more than 10 000 journal members of the Committee on Publication Ethics (COPE) (<http://publicationethics.org>). Here, editors of affiliated peer-reviewed journals are supported and encouraged in their discussions of science ethics and integrity related to publication. The COPE best practice guidelines state that studies reporting negative results should not be excluded.

According to the Declaration of Helsinki, 'Researchers have a duty to make publicly available the results of their research ... Negative and inconclusive as well as positive results must be published or otherwise made publicly available' ([bit.ly/1UIIn1t](http://bit.ly/1UIIn1t)). Curt commented that conservatism in chemistry and the desire for high citations and impact factors leave little room for negative results in high-profile journals. Not having the impact barrier, megajournals should be able to publish negative results, provided they have the requisite scientific merit. Do we need a global imperative for the physical sciences? What are the consequences of negative results being limited to private discussions for fear of controversy, or because they have been unable to be published widely?

Of course, anyone can publish their own research results – positive or negative – in various ways online. Curt describes the 'unsustainable explosion' of open-access web-based science journals, not all of them reputable. There is no substitute for sound peer review and chemists are right to carefully consider their publication options.

Curt has contributed highlights from the journal to *Chemistry in Australia* throughout his editorship. Many thanks for your efforts, Curt, and I wish you well in your future endeavours. George Koutsantonis and John Wade have commenced their role as co-Editors-in-Chief of the *Australian Journal of Chemistry* (see p. 19). I look forward to hearing more from them as they settle in.



Sally Woollett ([editor@raci.org.au](mailto:editor@raci.org.au))

**chemistry**  
in Australia  
[chemaust.raci.org.au](http://chemaust.raci.org.au)

#### EDITOR

Sally Woollett  
Ph (03) 5623 3971  
[editor@raci.org.au](mailto:editor@raci.org.au)

#### PRODUCTION EDITOR

Catherine Greenwood  
[catherine.greenwood@bigpond.com](mailto:catherine.greenwood@bigpond.com)

#### ADVERTISING SALES

Gypsy Media & Marketing Services  
Marc Wilson, ph 0419 107 143  
[marc@gypsymedia.com.au](mailto:marc@gypsymedia.com.au)



#### PRODUCTION

Control Publications Pty Ltd  
Ph/fax (03) 9500 0015/0255  
[science@control.com.au](mailto:science@control.com.au)

#### BOOK REVIEWS

Damien Blackwell  
[damo34@internode.on.net](mailto:damo34@internode.on.net)

#### RESEARCH HIGHLIGHTS

David Huang  
[david.huang@adelaide.edu.au](mailto:david.huang@adelaide.edu.au)

#### GENERAL ENQUIRIES

Robyn Taylor  
Ph/fax (03) 9328 2033/2670  
[chemaust@raci.org.au](mailto:chemaust@raci.org.au)

#### PRESIDENT

Paul Bernhardt FRACI CChem

#### MANAGEMENT COMMITTEE

Sam Adegoju (Chair) [Sam.Adegoju@monash.edu.au](mailto:Sam.Adegoju@monash.edu.au), Amanda Ellis, Michael Gardiner, Helmut Hügel, Alan Jones, Amanda Saunders, Colin Scholes, Madeleine Schultz, Julia Stuthe, Richard Thwaites

#### CONTRIBUTIONS

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

© 2016 The Royal Australian Chemical Institute Inc. unless otherwise attributed. Content must not be reproduced wholly or in part without written permission. Further details on the website ([chemaust.raci.org.au](http://chemaust.raci.org.au)).

ISSN 0314-4240 e-ISSN 1839-2539

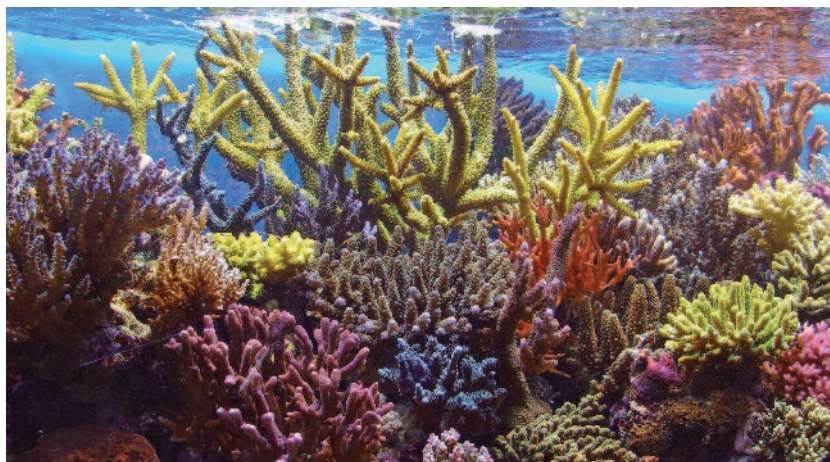






# Sunscreen ingredient polluting coral reefs

istockphoto/marcoap1974



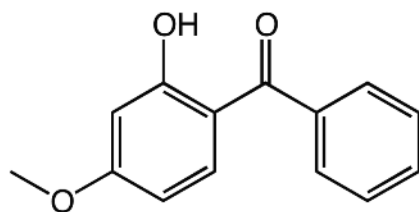
A study published in the *Archives of Environmental Contamination and Toxicology* (doi: 10.1007/s00244-015-0227-7) has found that a chemical widely used in personal care products such as sunscreen poses an ecological threat to corals and coral reefs and threatens their existence.

Oxybenzone ((2-hydroxy-5-methoxyphenyl)-phenylmethanone) (also known as BP-3, benzophenone-3) is found in more than 3500 sunscreen products worldwide, and pollutes coral reefs from swimmers wearing sunscreens and through wastewater discharges from municipal sewage outfalls and coastal septic systems.

The study came after the US National Oceanographic and Atmospheric Administration (NOAA) declared the third ever global coral bleaching event and warned that locally produced threats to coral, such as pollution, stress the health of corals and decrease the likelihood that they will resist bleaching, or recover from it.

Toxicopathological effects of the sunscreen UV filter oxybenzone on coral planulae (baby coral) demonstrates that exposure of planulae to oxybenzone produces gross morphological deformities, damages their DNA and, most alarmingly, acts as an endocrine disruptor. The last causes the coral to encase itself in its own skeleton, leading to death.

These effects were observed as low as 62 parts per trillion, the equivalent to a drop of water in six and a half Olympic-sized swimming pools. Measurements of oxybenzone in seawater within coral reefs in Hawaii and the US Virgin Islands found



oxybenzone

concentrations ranging from 800 parts per trillion to 1.4 parts per million. This is over 12 times higher than the concentrations necessary to impact on coral.

Marine scientists from Israel and the US undertook the study. Lead author Dr Craig Downs of Haereticus Environmental Laboratory Virginia said, 'The use of oxybenzone-containing products needs to be seriously deliberated in islands and areas where coral reef conservation is a critical issue. We have lost at least 80% of the coral reefs in the Caribbean. Any small effort to reduce oxybenzone pollution could mean that a coral reef survives a long, hot summer, or that a degraded area recovers. Everyone wants to build coral nurseries for reef restoration, but this will achieve little if the factors that originally killed off the reef remain or intensify in the environment.'

The study found that oxybenzone is a photo-toxicant with adverse impacts exacerbated in light but even in darkness, planulae were transformed from a motile (mobile) state to a deformed, sessile (immobile) condition and exhibited an increasing rate of coral bleaching in response to increasing concentrations of oxybenzone. This is particularly relevant for areas facing mass bleaching events, including Hawaii.

Between 6000 and 14 000 tonnes of sunscreen lotion are emitted into coral reef areas each year, much of which contains 1–10% oxybenzone. The authors estimate that this puts at least 10% of global reefs at risk of high exposure, based on reef distribution in coastal tourist areas.

This study is one of fewer than two-dozen scientific studies that closely examine the impact of personal care product ingredients on marine organisms and habitats. According to MarineSafe, a campaign concerned with the impact of these products on ocean health, there may be as many as 82 000 chemicals polluting our marine environments, just from personal care use.

Since the 1970s, coral reefs have been devastated on a global scale. Regional weather and climate events are often the cause of wide-scale mortality but the long-term causative processes of sustained demise are often locality specific and increasingly thought to be linked to pollution.

Oxybenzone is found in a range of products from lipstick and mascara to sunscreen and shampoo, it acts as a barrier to UV light, a task for which other ingredients are available. It has already been identified as a threat to human health. The European Union's International Chemical Secretariat has listed oxybenzone on its 'Substitute it Now' list of substances that should be replaced and meets the criteria for 'Substances of Very High Concern'.

HAERETICUS ENVIRONMENTAL LABORATORY

## New polymer lays waste to mercury pollution

A brand new, dirt cheap, non-toxic polymer that literally sucks mercury out of water and soil is set to become a game changer in the battle against one of the world's most reviled pollutants.

The dark red material, developed by Dr Justin Chalker MRACI, lecturer in synthetic chemistry at Flinders University, is made from sulfur and limonene and turns bright yellow when it absorbs mercury (see also p. 16).

Chalker says the new polymer is cheap to produce because of the global abundance of waste sulfur and limonene from industrial processes. That makes it affordable for use in large-scale environmental clean-ups, to coat water pipes carrying domestic and wastewater, and even in removing mercury from large bodies of water.

This has significant implications for human health and wellbeing: mercury exposure – whether through the skin or through ingestion, such as eating contaminated fish – damages the central nervous system and is particularly dangerous to pregnant women and children.

'Mercury contamination plagues many areas of the world, affecting both food and water supplies and creating a serious need for an efficient and cost-effective method to trap this mercury,' said Chalker.

'More than 70 million tonnes of sulfur is produced each year by the petroleum industry, so there are literally mountains of it lying, unused, around the globe, while more than 70 000 tonnes



Flinders University student Max Worthington (left) and Dr Justin Chalker with the new polymer, which removes mercury from water.

of limonene is produced each year by the citrus industry (limonene is found mainly in orange peels).

'So not only is this new polymer good for solving the problem of mercury pollution, but it also has the added environmental bonus of putting this waste material to good use while converting them into a form that is much easier to store so that once the material is "full" it can easily be removed and replaced.'

Chalker's research is published in an open-access article in *Angewandte Chemie International Edition* (doi: 10.1002/anie.201508708).

FLINDERS UNIVERSITY

## Simple errors limit scientific scrutiny

Researchers have found more than half of the public datasets provided with scientific papers are incomplete, which prevents reproducibility tests and follow-up studies. However, slight improvements to research practices could make a big difference.

Lead researcher Dr Dominique Roche from the Australian National University (ANU) said many peer-reviewed biological journals now require authors to publicly archive their data when a paper is published.

'Unfortunately, our study suggests that many public datasets may be unusable,' Roche said.

Making research data available improves the transparency and reproducibility of research results and avoids unnecessary duplication of data collection.

A survey of 100 papers published in

leading journals in ecology and evolution found that more than 50% of the datasets associated with these studies were incomplete due to missing data or essential information needed to interpret the data.

Roche said that making the data public is extremely useful, but that the process is often compromised by simple errors made by researchers.

'Many scientists, including myself, lack proper training in public data archiving and open science practices. These are new practices for most researchers,' he said.

'Biologists often deal with large and complex datasets that require good organisational skills to present in ways that others can use them. The archived datasets can be just as important as the published paper.

'Fortunately, many of the problems we

encountered in our study can be fixed relatively quickly and easily.'

The study, published in *PLOS Biology*, makes a number of suggestions such as providing basic but complete data descriptors, using standard file formats such as comma-separated values (csv) rather than pdfs or Excel files, and archiving datasets in an established, searchable online database, instead of as an appendix to the research paper.

Co-author Professor Loeske Kruuk from the ANU Research School of Biology said the paper recommended rewarding researchers who work transparently and collaboratively.

'Journals and databases don't have the resources to check whether archived data-sets are adequate,' she said.

'The quality of the archived data-sets relies on researchers' goodwill.'

AUSTRALIAN NATIONAL UNIVERSITY

## Discovery and assignment of elements 113, 115, 117 and 118

The fourth IUPAC/IUPAP Joint Working Party (JWP) on the priority of claims to the discovery of new elements has reviewed the relevant literature for elements 113, 115, 117 and 118 and has determined that the claims for discovery of these elements have been fulfilled, in accordance with the criteria for the discovery of elements of the IUPAP/IUPAC Transfermium Working Group (TWG) 1991 discovery criteria. These elements complete the seventh row of the periodic table of the elements, and the discoverers from Japan, Russia and the US will now be invited to suggest permanent names and symbols.

The RIKEN collaboration team in Japan have fulfilled the criteria for element 113 (temporary working name and symbol: ununtrium, Uut) and will be invited to propose a permanent name and symbol.

The collaboration between the Joint Institute for Nuclear Research (Russia), Lawrence Livermore National Laboratory (US) and Oak Ridge National Laboratory (US) have fulfilled the criteria for element elements 115, 117 (temporary working names and symbols: ununpentium, Uup; ununseptium, Uus) and will be invited to propose permanent names and symbols.

The collaboration between the Joint Institute for Nuclear Research and Lawrence Livermore National Laboratory have fulfilled the criteria for element 118 (temporary working name and symbol: ununoctium, Uuo) and will be invited to propose a permanent name and symbol.

The priorities for four new chemical elements are being introduced simultaneously, after the careful verification of the discoveries and priorities. The decisions are detailed in two reports to be published in an early 2016 issue of *Pure and Applied Chemistry*.

'A particular difficulty in establishing these new elements is that they decay into hitherto unknown isotopes of slightly lighter elements that also need to be unequivocally identified', commented JWP chair Professor Paul J. Karol, 'but in the future we hope to improve methods that can directly measure the atomic number,  $Z$ '.

'The chemistry community is eager to see its most cherished table finally being completed down to the seventh row. IUPAC has now initiated the process of formalising names and symbols for these elements ...' said Professor Jan Reedijk, President of the Inorganic Chemistry Division of IUPAC.

The proposed names and symbols will be checked by the Inorganic Chemistry Division of IUPAC for consistency, translatability into other languages, possible prior historic use for other cases, etc. New elements can be named after a mythological concept, a mineral, a place or country, a property or a scientist. After Divisional acceptance, the names and two-letter symbols will be presented for public review for five months, before the highest body of IUPAC, the Council, will make a final decision on the names of these new chemical elements and their two-letter symbols and their introduction into the periodic table of the elements.

RIKEN

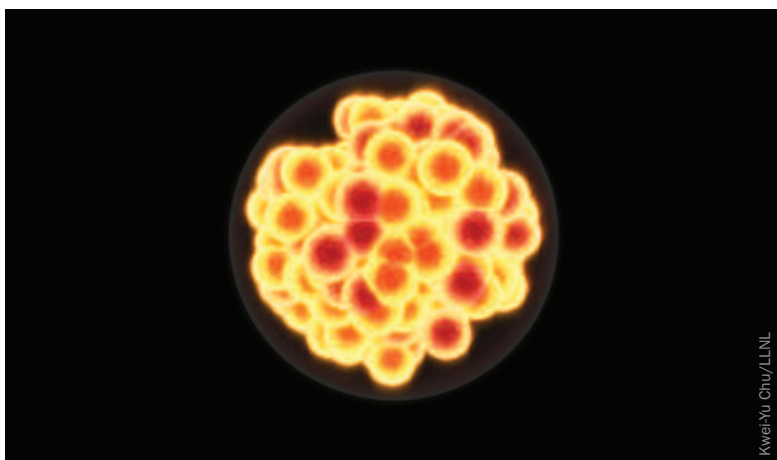


Illustration of element 117.



## Glyphosate: EFSA updates toxicological profile

The European Food Safety Authority (EFSA) and the EU Member States have finalised the re-assessment of glyphosate, a chemical that is used widely in pesticides. The report concludes that glyphosate is unlikely to pose a carcinogenic hazard to humans and proposes a new safety measure that will tighten the control of glyphosate residues in food. The conclusion will be used by the European Commission in deciding whether or not to keep glyphosate on the EU list of approved active substances, and by EU Member States to re-assess the safety of pesticide products containing glyphosate that are used in their territories.

An expert group made up of EFSA scientists and representatives from risk assessment bodies in EU Member States has set an acute reference dose (ARfD) for glyphosate of 0.5 mg/kg body weight, the first time such an exposure threshold has been applied to the substance.

The group concluded that glyphosate is unlikely to be genotoxic (i.e. damaging to DNA) or to pose a carcinogenic threat to humans. Glyphosate is not proposed to be classified as carcinogenic under the EU regulation for classification, labelling and packaging of chemical substances. In particular, all the Member State experts but one agreed that neither the epidemiological data (i.e. on humans) nor the evidence from animal studies

demonstrated causality between exposure to glyphosate and the development of cancer in humans.

EFSA also considered, at the request of the European Commission, the report published by the International Agency for Research on Cancer (IARC), which classified glyphosate as probably carcinogenic to humans.

The evaluation considered a large body of evidence, including a number of studies not assessed by the IARC, which is one of the reasons for reaching different conclusions.

As well as introducing the ARfD, the review proposed other toxicological safety thresholds to guide risk assessors: the acceptable operator exposure level (AOEL) was set at 0.1 mg/kg body weight per day and an acceptable daily intake (ADI) for consumers was set in line with the ARfD at 0.5 mg/kg body weight per day.

The EFSA conclusion will inform the European Commission in deciding whether or not to retain the substance on the EU's list of approved active substances. This is a condition for enabling Member States to authorise its continued use in pesticides in the EU.

EFSA has also produced a supplementary document ([bit.ly/1kYH0A2](http://bit.ly/1kYH0A2)) that takes an in-depth look at some of the scientific issues highlighted during the assessment. EFSA

The Australian Pesticides and Veterinary Medical Authority (APVMA) is currently examining the full IARC monograph in collaboration with the Office of Chemical Safety in the Department of Health. As part of a recent statement (<http://apvma.gov.au/node/13891>), it explained:

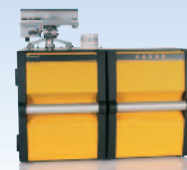
The IARC assessment looks at the intrinsic toxicity potential or 'hazard' of the chemical glyphosate as a cancer-causing agent only. Other components of the toxicity of glyphosate are not taken into account. As part of the regulatory process undertaken by the APVMA and pesticide regulators in other countries, a hazard assessment is just one part of the overall risk assessment required to determine the risks for people using a formulated chemical product.

It is not the role of the IARC to consider how a formulated chemical product is used, or how human exposure can be minimised by following safety directions on a product label. In this regard, the findings of IARC cannot be directly compared to assessments conducted by regulatory authorities for the purposes of approval or registration of a pesticide product, in which are included appropriate risk mitigation measures to allow safe use.

APVMA



**C. Gerhardt develops and manufactures analytical systems of the highest technical standard for food, feedstuff and environmental analysis**



Nitrogen determination system by Dumas (combustion)



Automatic solvent extraction systems



Automated hydrolysis system



Kjeldahl block digestors  
Steam distillation  
ADF, NDF, crude fibre determination  
Shakers

Authorised Distributor

**Perten**  
INSTRUMENTS  
a PerkinElmer company

Phone: 02 – 9870 3400  
Email: [support.australia@perten.com](mailto:support.australia@perten.com)



## UN: Biodegradable plastics are not the answer to reducing marine litter

Widespread adoption of products labelled 'biodegradable' will not significantly decrease the volume of plastic entering the ocean or the physical and chemical risks that plastics pose to marine environment, according to a United Nations report.

The report, entitled *Biodegradable Plastics and Marine Litter: Misconceptions, Concerns and Impacts on Marine Environments*, finds that complete biodegradation of plastics occurs in conditions that are rarely, if ever, met in marine environments, with some polymers requiring industrial composters and prolonged temperatures of above 50°C to disintegrate. There is also limited evidence suggesting that labelling products as 'biodegradable' increases the public's inclination to litter.

Its launch marks the 20th anniversary of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), an intergovernmental mechanism hosted by the UN Environment Programme (UNEP).

'Recent estimates from UNEP have shown as much as 20 million tonnes of plastic end up in the world's oceans each year,' said UNEP's Executive Director Achim Steiner.

'Once in the ocean, plastic does not go away, but breaks down into microplastic particles. This report shows there are no quick fixes, and a more responsible approach to managing the lifecycle of plastics will be needed to reduce their impacts on our oceans and ecosystems.'

In 2014, a study by UNEP and partners estimated that about 280 million tonnes of plastic is produced globally each year and only a very small percentage is recycled. Instead, some of that plastic ends up in the world's oceans, costing several billion dollars annually in environmental damage to marine ecosystems.

In recent years, concern has reportedly grown over microplastics, which are particles up to five millimetres in

diameter, either manufactured or created when plastic breaks down. Their ingestion has been widely reported in marine organisms, including seabirds, fish, mussels, worms and zooplankton.

The report aimed to verify a thesis that plastics considered 'biodegradable' may play an important role in reducing these negative environmental impacts.

It found that plastics most commonly used for general applications, such as polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC) are not biodegradable in marine environments. Polymers that biodegrade under favourable conditions on land are much slower to break up in the ocean and their widespread adoption is likely to contribute to marine litter and consequent undesirable consequences for marine ecosystems.

The study also analysed the environmental impacts of oxo-degradable plastics, enriched with a pro-oxidant, such as manganese, which precipitates their fragmentation. It found that in marine environments the fragmentation is fairly slow and can take up to five years, during which the plastic objects continue to litter the ocean.

According to UNEP, oxo-degradable plastics can pose a threat to marine ecosystems even after fragmentation. The report says it should be assumed that microplastics created in the fragmentation process remain in the ocean, where they can be ingested by marine organisms and facilitate the transport of harmful microbes, pathogens and algal species.

The report also cites research that suggested some people are attracted by 'technological solutions' as an alternative to changing behaviour. Labelling a product as biodegradable may be seen as a technical fix that removes responsibility from the individual, resulting in a reluctance to take action.

UNITED NATIONS

## Making STEM a priority in schools

The adoption by the Australian Government and all states and territories of a National STEM School Education Strategy was welcomed by Professor Ian Chubb, Australia's former Chief Scientist.

Chubb said the endorsement by the Education Council was an important step towards improving science, mathematics, engineering and technology (STEM) skills for all students.

'We now have pathway to a future where every Australian student will have improved STEM skills and the opportunity to pursue them at a challenging level,' Chubb said.

'This strategy will prepare school students in the best way possible for a world of rapid-technological change where innovation and creativity will be the keys to the future.'

The strategy aims to better coordinate and target efforts to improve STEM education in all jurisdictions and drew on recommendations from the Chief Scientist's report *STEM: Australia's Future*.

'I support all elements of this comprehensive strategy –

which includes five areas of national action and seven guiding principles,' Chubb said.

'In particular, I support the call to increase STEM teaching quality by lifting the standard of STEM content in initial teacher education as well as improving pathways and in-service support for teachers.

'Confident, well-prepared STEM teachers are the ones who can inspire students and sustain their natural curiosity in the world around them.

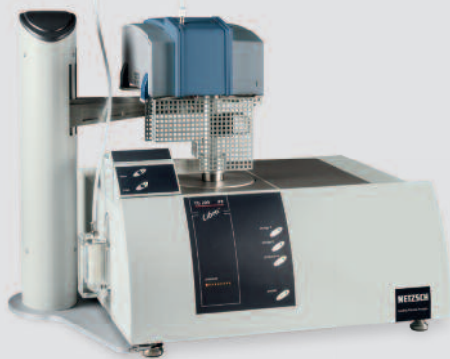
'Principals must lead by example in making STEM teaching a priority in schools and ensuring there is first-class professional development available.

'This is a great start and I congratulate all involved in this far-reaching strategy.'

The strategy is available at the Education Council website ([www.scseec.edu.au](http://www.scseec.edu.au)).

OFFICE OF THE CHIEF SCIENTIST

## Advanced Polymer Testing



PERSEUS TG 209 F1 Libra®

For all your Thermal Analysis needs

... also available Contract Testing Service: our extensively equipped application and service laboratories offer a comprehensive range of techniques to support you with all your thermal characterization needs.

**NETZSCH**

NETZSCH Australia Pty Ltd · 3/21 Binney Rd · Kings Park  
NSW 2148 · Tel: 02 9641 2846 · [at.au@netzsch.com](mailto:at.au@netzsch.com) ·  
[www.netzsch-thermal-analysis.com](http://www.netzsch-thermal-analysis.com)



## Australia's biotech industries promise economic security

Australia's future economic security depends on emerging technologies such as biomanufacturing, said QUT Professor John Bell who chaired a session at the Advanced Manufacturing Summit in Sydney last November.

'We have bemoaned the loss of Australia's traditional manufacturing sector but we are on the cusp of a bright new era of high-value, high-skilled manufacturing,' said Bell.

'Biomanufacturing includes technologies that produce sustainably derived and renewable feedstock and pharmaceuticals, and bioremediation services.

'The 3D bioprinting market, of which QUT is a leader, is estimated to be worth \$3 billion by 2025.

'We are finding more applications for industrial biotechnology and additive biomanufacturing all the time and these processes are becoming more established internationally.'

Professor Dietmar Hutmacher, from QUT's Institute of Health and Biomedical Innovation, is a world authority on the 3D printing of replacement human tissue using bio-inks, a process known as additive biomanufacturing.

'Australia is already well ahead on research and development of medical bioprinting, a strong facet of this emerging 'fourth industrial revolution' of biomanufacturing.

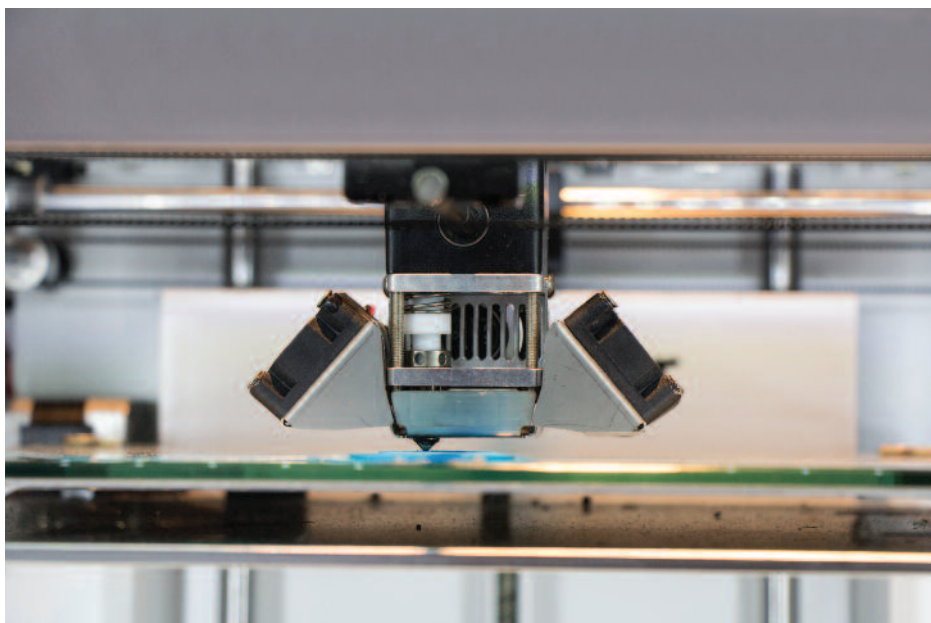
'Additive biomanufacturing will become a pillar of Australia's advanced manufacturing landscape and we must ensure we have the expertise to continue our lead in this area,' Hutmacher said.

'It is a multidisciplinary area requiring understanding of chemistry, physics, biology, medicine, robotics and computer science.

'QUT has already partnered with the University of Wollongong and universities in the Netherlands and Germany to offer the world's first dual Master of Biofabrication and is taking applications for the second intake of young scientists keen to make bioprinting their career.'

Bell cited MBD Energy as an example of an Australian firm exporting bioremediation services to Asia as well as operating in Australia.

'MBD is an example of a firm using biological processes, in this case algae, to clean up wastewater from aquaculture. The algae are then used to manufacture a range of high-value products ranging from fertilisers and feed to high-value nutrition products.



istockphoto/vansmuk

'Bioremediation services are growing into an important industry for Australia and one that is expanding rapidly into Asia.


'High-value products and long-term sustainable investment and jobs are a great outcome from advanced manufacturing.'

Bell said another thriving area for Australia to capitalise on was industrial biotechnology.

'This includes new and improved methods to manufacture a range of molecules with medical and industrial importance such as antibiotics, pain relievers and anticancer drugs or items like fuels and the building blocks for plastics and paints,' he said.

'Sun Pharmaceutical Industries (Australia) is an example of a major global manufacturer of medicinal opiates for pain relief earning millions of export dollars.'

QUEENSLAND UNIVERSITY OF TECHNOLOGY



**Rowe Scientific** PTY LTD  
www.rowe.com.au

**Suppliers of:**  
**CERTIFIED REFERENCE MATERIALS**

Reference materials from all major worldwide sources including:

- NIST (USA), CANMET (Canada), SABS (South Africa), BAS (UK), Standards Australia, BGS (UK), BCR (Belgium), NWRI (Canada), NRCC (Canada), Brammer (USA), Alpha (USA), Seishin (Japan)

**ADELAIDE**  
08 8186 0523  
rowesa@rowe.com.au

**BRISBANE**  
07 3376 9411  
roweqld@rowe.com.au

**HOBART**  
03 6272 0661  
rowetas@rowe.com.au

**MELBOURNE**  
03 9701 7077  
rowevic@rowe.com.au

**PERTH**  
08 9302 1911  
rowewa@rowe.com.au

**SYDNEY**  
02 9603 1205  
rowensw@rowe.com.au

Quality Endorsed Company  
No. 1000-2004  
01-1000  
04-1004

# Alan Finkel commences term as Chief Scientist

Dr Alan Finkel AO has been appointed Australia's next Chief Scientist, commencing in the role in January 2016.

He succeeds Professor Ian Chubb AC who has served with distinction since May 2011.

Finkel is a prominent engineer, respected neuroscientist, successful entrepreneur and philanthropist with a personal commitment to innovation and commercialisation. He is currently the Chancellor of Monash University and is President of the Australian Academy of Technological Sciences and Engineering (ATSE).

Prime Minister Malcolm Turnbull said science and innovation are at the centre of the Government's agenda and key to Australia remaining a prosperous, first-world economy with a generous social welfare safety net. Minister for Industry, Innovation and Science, the Hon Christopher Pyne MP congratulated Dr Finkel, who was selected from a high-calibre field following an international search.

'Dr Finkel is renowned for his outstanding research, industrial and entrepreneurial achievements in Australia and overseas, his leadership and service in the university and education sector, the academies and national science bodies, and his experience in providing high-quality expert advice to government,' Pyne said.

'His will be a vital role in shaping Australia's economic future and leading our national conversation on science, innovation and commercialisation across the research, industry and education sectors and with the wider community.'

The new Chief Scientist will provide independent high-level advice to the government on science, innovation and commercialisation and lift the profile of Australian scientific endeavour domestically and internationally.

Finkel said he was thrilled with the opportunity to contribute to framing Australia's participation in the agile 21st century.

'My personal experience across research, business and STEM education will guide my ability to formulate relevant advice,' Finkel said.

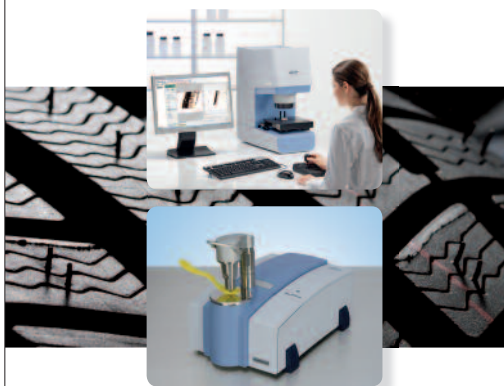
'We exist in a competitive international environment and to compete effectively, business needs science, science needs business, and Australia needs both.'

PRIME MINISTER OF AUSTRALIA AND OFFICE OF THE CHIEF SCIENTIST

**Finkel is a prominent engineer, respected neuroscientist, successful entrepreneur and philanthropist with a personal commitment to innovation and commercialisation.**



## Solutions for Quality Control and Failure Analysis



Bruker's FT-IR spectrometer ALPHA provides a quick, reliable and universally applicable identity control of your incoming raw materials.

The FT-IR microscope LUMOS allows the selective analysis of contaminations and of individual components in complex materials. This makes the LUMOS a powerful analytical tool for effective failure analysis and product development.

Contact us for more details: [www.bruker.com](http://www.bruker.com)

### ■ Quality Control

Verify the chemical identity of raw materials and products:  
Polymer pellets, elastomers, monomers, fillers, additives, plastic products

### ■ Failure Analysis

Determine the chemical reason behind product failure:  
Identify contaminations and detect wrong compositions

### ■ Product Development

Increase the knowledge about your product's composition:  
Check the distribution of components in complex materials and investigate laminates

### ■ Reverse Engineering

Identify the composition of competitor products.

### Bruker Pty Ltd

U7/163-167 McEvoy St  
Alexandria, NSW 2015  
Tel: +61 (0)2 9550 6422  
Email: [sales.anz@bruker.com](mailto:sales.anz@bruker.com)

## New business unit for Trajan at University of Adelaide

Trajan Scientific and Medical (Trajan) has announced the opening of a new Business Unit – Instruments, Sensors and Devices, to be located at the University of Adelaide's Institute for Photonics and Advanced Sensing (IPAS). Along with the new capabilities existing on that site such as glass modification and extrusion, the new Business Unit will have global responsibilities for new devices such as the recently revealed hemaPEN™ for dried blood spot sampling.

This announcement comes just two months after Trajan's landmark strategic collaboration with the University of Adelaide, supported by the South Australian Government, was revealed. This collaboration sees the realisation of the IPAS research and development and manufacturing hub based on a new generation of specialty glass products for the global science and medical equipment market, helping scientists to commercialise their research into products that ultimately benefit human health and wellbeing.

Chief Executive Officer of Trajan, Stephen Tomisich says the Business Unit marks another key milestone in Trajan's journey into technologies that impact human wellbeing.



Dr Anne Collins has been announced as the General Manager of the Business Unit. She is supported by Principal Scientist (Photonics), Dr Herbert Foo.

Dr Collins comments that the role of the new Business Unit is to lead the transition of Trajan into the new era of portable, sensitive and selective sensors and devices.

Trajan's goal is for the hub to become a global centre of excellence for sensing and device technologies. The company's focus is on developing and commercialising technologies that enable analytical systems to be more selective, sensitive and specific for biological, environmental or food-related measurements – especially those that can lead to portability, miniaturisation and affordability.

For more information, visit [www.trajanscimed.com](http://www.trajanscimed.com) and [www.adelaide.edu.au/ipas/pcp](http://www.adelaide.edu.au/ipas/pcp).

## Automatic solvent extraction and hydrolysis analysis

German company C. Gerhardt develops and manufactures analytical systems of the highest technical standard, which are used mainly in food, feedstuff and environmental analysis

The innovative SOXTHERM rapid extraction system offers the highest performance of all laboratory extraction systems available on the market. It is fast, is very versatile, can be upgraded easily at any time and provides the best analysis results reliably and consistently. With SOXTHERM you can process up to 24 different samples simultaneously. The device runs automatically and can be operated without supervision; it has a solvent recovery system to minimise solvent costs and has a protective front door to prevent operator contact with hot surfaces. The control software monitors and logs all processing and device data. The instrument is used for determination of fat in all kind of food and feeds, extraction of pollutants in soils, compost, sewage, extraction of pesticides, dioxins, coatings from textiles, pharmaceutical agents and more.

The HYDROTHERM is the world's first and only automatic acid hydrolysis system for fat determination according to Weibull-Stoldt. The automated procedure is patented and a revolutionary concept for fat analysis: the high level of automation saves up to 80% of the costs per sample in comparison to the traditional analysis. Up to six samples can be hydrolysed and filtered in a closed and controlled process. The instrument can process all samples types and sizes, including very inhomogeneous matrices and samples with very low fat content. The closed system completely prevents the handling of hot acids and acid vapours and the device can be operated outside a fume cupboard.

For further information, contact Perten Instruments, ph. (02) 9870 3400, email [support.australia@perten.com](mailto:support.australia@perten.com) or visit [www.gerhardt.de/en](http://www.gerhardt.de/en).





## New lab portal – better lab results one click away

Whether you have recently installed a brand new liquid dispenser or cherish a 10-year-old balance that serves you day in and day out, taking a moment to consider the health of your lab equipment can pay real dividends in enhanced performance and accuracy. And when it's time for a service call, Mettler Toledo is making it even easier to gain access to its worldwide network of more than 5000 qualified balance technicians with its new dedicated web portal ([www.mt.com/labbalances-service](http://www.mt.com/labbalances-service)).

For simple weighing, formulation, piece-counting and other sensitive lab protocols, daily accuracy checks only go so far to guarantee performance. Manufacturer guidelines are also typically not enough to ensure safe operating margins, particularly when taking a specific process into account. Annual or semi-annual calibration, even when not required by law, is one of the best ways to ensure reliable long-term performance.

The portal shows how calibration services help you run a leaner lab. The easy-to-read format allows you to directly request service and access regional contact information. Relevant educational materials on equipment servicing, including webinars and white papers, help you identify when service is recommended for best performance and equipment life.

In addition to maximising productivity and helping to guarantee uptime, regular service will also offer you audit-proof documentation that your instruments perform accurately. You'll gain the peace of mind that comes from knowing your equipment is doing the job it was meant to do in a way that complies with industry standards and government regulations.

For additional information about Mettler Toledo, visit [www.mt.com](http://www.mt.com).



## Malvern Kinexus – more than just a rheometer

The Malvern Kinexus rheometer is versatile analytical instrument used primarily for determining the viscous or viscoelastic properties of samples ranging from low viscosity liquids and gels through to stiff solids under controlled conditions. In addition to its rotational capabilities, it has advanced axial capabilities that can be utilised for tack testing, squeeze flow measurements and filament stretching tests. The simultaneous application of axial and shear formation has also been used to replicate mastication, the chewing of food. Engineered from the ground up the Kinexus rheometer series, it enables users to spend less time learning how to interact with their system and more time investigating ways to characterise and enhance a material's performance.

Malvern Kinexus incorporates many technological innovations in the most critical areas of rheometer design. Adaptive intelligence allows the Kinexus to actively guide users at every stage from sample preparation and loading, through measurement set-up and operation, to data analysis and reporting. The Kinexus is highly flexible and easy to expand, ready for further evolution as new applications emerge.

The Kinexus also comes with a wide range of specialised accessories. Two of the most recently added options include:

- **NEW High Temperature Cartridge (HTC)** (0°C to +300°C) is an easily interchangeable environmental controller that allows temperature control of applications from fluids through to soft solids, thermoset composites and polymer melts.
- **NEW UV/Visible Curing System** allows the progression of UV or visible light-initiated curing reactions to be followed in real time on samples including adhesives, sealants, coatings and inks.



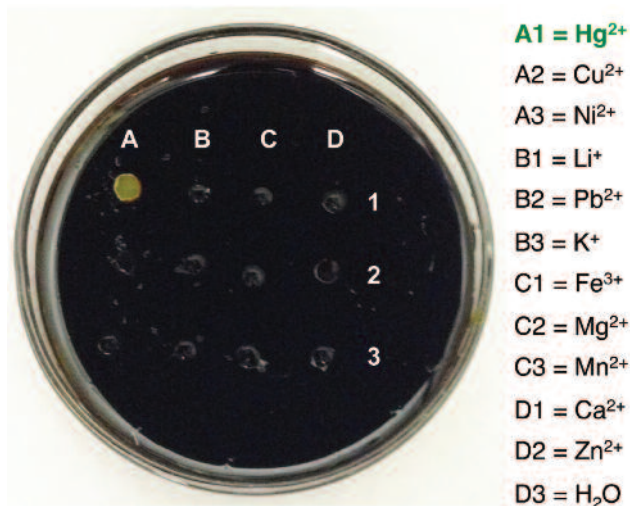
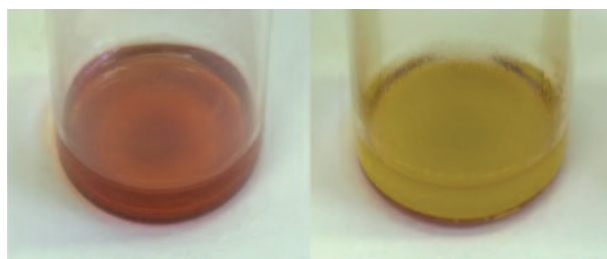
### Defining qualities:

- Unique cartridge system and geometry interchange for ease of use
- SOP-driven tests on a rheometer interface
- Complete sample history captured every time
- Total flexibility of control for unique test capabilities

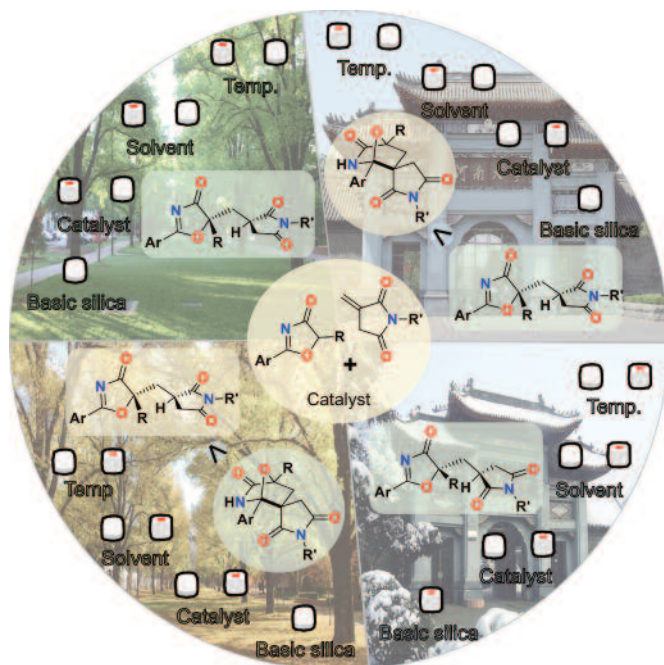
For further information or a free quote, contact ATA Scientific Pty Ltd, ph. (02) 9541 3500, email [enquiries@atascientific.com.au](mailto:enquiries@atascientific.com.au) or visit [www.atascientific.com.au](http://www.atascientific.com.au).

## Industrial byproduct-based material sequesters heavy metal

Mercury pollution affects the health of millions of people globally. In order to combat this environmental crisis, a cost-effective solution is needed. Dr Justin Chalker and researchers at Flinders University are addressing this challenge by developing an inexpensive mercury-binding polysulfide (Crockett M.P., Evans A.M., Worthington M.J.H., Albuquerque I.S., Slattery A.D., Gibson C.T., Campbell J.A., Lewis D.A., Bernardes G.J.L., Chalker J.M. *Angew. Chem. Int. Ed.* 2016, doi: 10.1002/anie.201508708). The material is synthesised entirely from sulfur and limonene, byproducts of the petroleum and citrus industries, respectively. Because of its high sulfur content, the polysulfide readily binds to mercury and removes it from water or soil. Additionally, the polysulfide turns from dark red to yellow after binding to higher levels of inorganic mercury. This selective chromogenic response may find use in monitoring the lifetime of a remediation device made from the polysulfide. The team is now working with chemical industry and non-profit organisations to initiate remediation field tests in polluted areas in Australia and at artisanal mining sites in developing nations.



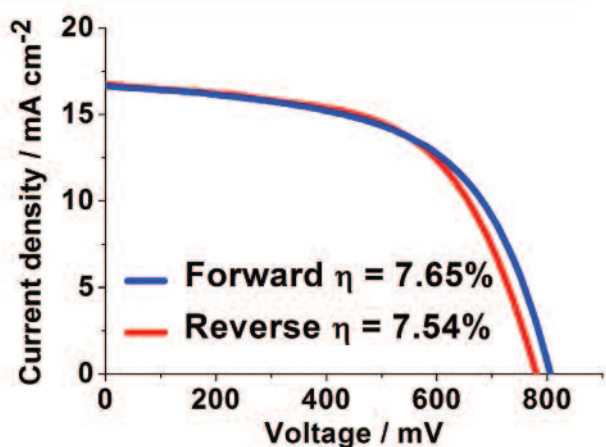
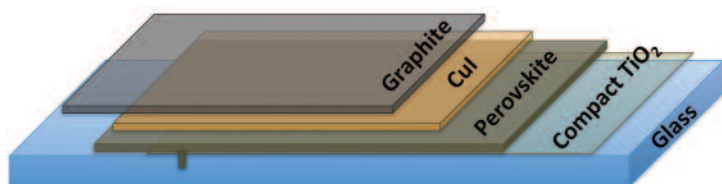
## Chemoselective switch in asymmetric organocatalysis



Most chemical reactions are straightforward and furnish only one set of products. However, a holy grail in synthesis is to design reactions that can be readily 'tuned' to deliver different products that can be selected according to the reaction conditions, reagents, catalysts and post-reaction purification strategies. This task is even more challenging when enantio- and diastereo-discrimination is required. Collaborative work by researchers from Henan University and the Australian National University has demonstrated a valuable synthetic strategy to access highly enantio- and diastereo-selective [4+2] cycloaddition or conjugate addition-protonation products from 5*H*-oxazol-4-ones and *N*-itaconimides as starting substrates, using an *L*-tert-leucine-derived tertiary amine catalyst (Zhu B., Lee R., Li J., Ye X., Hong S.-N., Qiu S., Coote M.L., Jiang Z. *Angew. Chem. Int. Ed.* 2016, doi: 10.1002/anie.201507796). By varying the reaction conditions – tuning the right chemical switches – enantio- and diastereo-enriched [4+2] or addition-protonation products could be achieved. Theoretical calculations accurately matched the observed product stereochemistry and indicated that the chemoselectivity is controlled by the relative thermodynamic stability of the [4+2] product, which transforms to the addition-protonation product once the reaction temperature is elevated.

## Beating hysteresis in perovskite solar cells

Research on thin-film solar cells based on organoammonium lead(II) trihalides is developing at a rapid rate, with a 20% certified efficiency achieved recently. The commercialisation of these devices, however, is hampered by their poor long-term stability. This instability can be partially attributed to the commonly used organic hole-transporting materials (HTMs) and additives introduced to improve charge transport within the HTM layer. Professor Leone Spiccia's group at Monash University have recently prepared devices based on a more stable inorganic HTM, copper(I) iodide (CuI), achieving a 7.5% efficiency (Sepalage G.A., Meyer S., Pascoe A., Scully A.D., Huang F., Bach U., Cheng Y.-B., Spiccia L. *Adv. Funct. Mater.* 2015, **25**, 5650–61). As is well established in the field, the efficiencies of devices based on the 'classical' organic HTM, spiro-OMeTAD, differ depending on the direction of measurement of the current–voltage ( $J$ – $V$ ) curve (high to low voltage or the converse), often referred to as ' $J$ – $V$  hysteresis'. In contrast, the CuI-based devices showed no  $J$ – $V$  hysteresis. Further investigations indicated that copper(I) iodide facilitates faster relaxation of the polarised perovskite material at the perovskite/HTM interface than spiro-OMeTAD. These findings contribute to the understanding of charge generation and transfer across material interfaces and may lead to broader application of inorganic HTMs in the future.



Good things  
come in  
small packages.

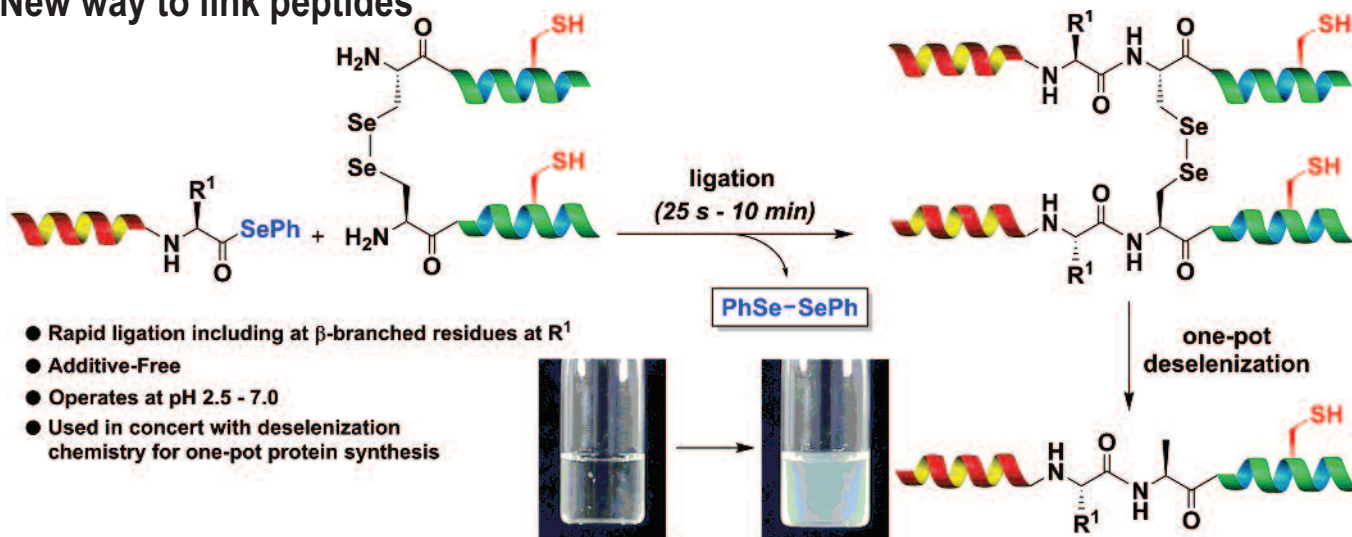


To present your product  
or service to our  
specialist market of  
chemistry professionals,  
contact  
Gypsy Media Services:  
Marc Wilson  
0419 107 143  
[marc@gypsymedia.com.au](mailto:marc@gypsymedia.com.au)

**chemistry**  
chemaustr.raci.org.au in Australia



## New way to link peptides



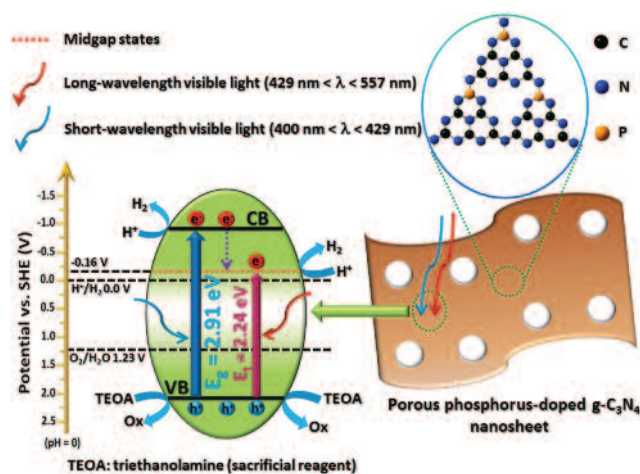
Researchers at the University of Sydney have reported a new technology to ligate peptide fragments for the chemical synthesis of large polypeptides and proteins (Mitchell N.J., Malins L.R., Liu X., Thompson R.E., Chan B., Radom L., Payne R.J. *J. Am. Chem. Soc.* 2015, **137**, 14011–4). The methodology facilitates the ligation of two peptide fragments, one containing an N-terminal selenocysteine residue and the other a C-terminal selenoester functionality, and generates native peptide linkages in

aqueous buffer without the addition of any other external reagents. Ligations are rapid, with most reaching completion in under a minute (orders of magnitude faster than the homologous reaction using native chemical ligation that is typically used for the chemical assembly of proteins). The authors also demonstrate that the 'additive-free selenocysteine-selenoester ligation' can be used in concert with a one-pot deselenisation transformation that converts the selenocysteine moiety to a

native alanine residue at the ligation junction. The efficiency of the novel methodology is further highlighted through the chemical synthesis of two proteins, a catalytically active enzyme (chorismate mutase) and a protective epitope from *Mycobacterium tuberculosis* called ESAT-6. This new technology significantly expands the repertoire of ligation chemistry and will underpin the construction of more challenging protein targets through chemical synthesis in the future.

## Efficient nanosheet photocatalyst for hydrogen production

The efficient production of clean and carbon-free hydrogen fuel from abundant solar energy through photocatalytic water splitting is a highly sought-after goal with the potential to address global energy needs, environmental contamination and the greenhouse effect. Graphitic carbon nitride ( $g\text{-C}_3\text{N}_4$ ) is a promising metal-free photocatalyst for hydrogen production, but is inefficient in its pristine form due to its limited capacity to harvest the full visible-light spectrum and its low specific surface area. To address these issues, Professor Shi Zhang Qiao at The University of Adelaide and co-workers have for the first time synthesised a photocatalyst made of porous phosphorus-doped graphitic carbon nitride nanosheets by a novel, facile and green strategy (Ran J., Ma T.Y., Gao G., Du X.-W., Qiao S.Z. *Energy Environ. Sci.* 2015, **8**, 3708–17). The phosphorus doping creates mid-bandgap electronic states that extend light harvesting to longer wavelengths. The new photocatalyst exhibits a high visible-light photocatalytic  $\text{H}_2$ -production activity of  $1596 \mu\text{mol h}^{-1} \text{g}^{-1}$  and an apparent quantum efficiency of 3.56% at 420 nm, making it one of the most highly active metal-free  $g\text{-C}_3\text{N}_4$  nanosheet photocatalysts.



## Changing of the guard at *Aust. J. Chem.*

The Editorial Board and CSIRO Publishing express their deepest gratitude to Professor Curt Wentrup, for his dedication to the role of Editor-in-Chief of *Australian Journal of Chemistry*, and for his strong advocacy for the journal over the last seven years.

Since his appointment in 2008, Curt has overseen the publication of 87 issues (12 427 pages) of the journal, including 73 Research Fronts and Special Issues. During this time, the journal has almost doubled its published output (from 1011 pages in 2008 to 1928 pages in 2015). To accommodate this growth, and to reflect the changing scope and geographical interest in the journal, we have continuously revised and grown the composition of our Editorial Board, which proudly boasts the names of excellent scientists from Australia, New Zealand, China, Japan, Singapore, the US, Ireland and Belgium.

Curt's awareness of the need to publish both in the national interest and internationally has seen a heartening 'return to the fold' for some Australian authors in recent times. Under Curt's stewardship, *Aust. J. Chem.* has, pleasingly, fostered informal but strong ties with the RACI – and we now share booths at major conferences, have a regular column in *Chemistry in Australia*, and – importantly – publish an annual

Research Front highlighting the works of recent recipients of RACI research awards.

Following from this groundwork, priorities over the coming years will include finding ways to further encourage and engage Australian chemists to publish their best work in *Aust. J. Chem.*, while also ensuring that we work towards attracting greater international awareness. With this in mind, I am very pleased to announce the appointment of two co-Editors-in-Chief, Professor George Koutsantonis and Professor John Wade. They will be sharing the leadership and vision to drive *Aust. J. Chem.* forward in 2016 and beyond.

Aside from their exemplary reputation as scientists, the strong leadership qualities possessed by George and John will ensure that there is a fine team continuing to lead *Aust. J. Chem.* forward in future years, to ensure a high level of local and international attractiveness that will make *Aust. J. Chem.* a preferred publication destination for Australian and international chemists.

Please join me in thanking Curt for his outstanding achievements during his time as Editor-in-Chief of *Australian Journal of Chemistry*, and in welcoming John and George to the team.

**Jennifer M. Foster** FRACI CChem  
(jenny.foster@csiro.au). Adapted from *Aust. J. Chem.* 2016, vol. 69, p. 1.



George Koutsantonis is a Professor at the School of Chemistry and Biochemistry at the University of Western Australia, where he works in the area of inorganic and organometallic chemistry. He has been an Associate

Editor with *Aust. J. Chem.* since 2012, and has had great success at commissioning papers for *Aust. J. Chem.*, including several special issues. George was also responsible for the implementation of the Primer Reviews as a new manuscript category for *Aust. J. Chem.*



John D. Wade is a Professor of Chemistry at the University of Melbourne, as well as a Professor of Neuroscience at the Florey Institute of Neuroscience and Mental Health, where he leads the

Neuropeptides Group in drug design and development. He is also Chief Editor of *Frontiers in Chemical Biology*, a journal that has grown substantially since his appointment to the role.



## Your advert could be here.

For further information about advertising here or on our website, contact:

**Marc Wilson ♦ Gypsy Media Services ♦ 0419 107 143 ♦ marc@gypsymedia.com.au**



Wedgwood Jasper Vase with cover; Shape No 1, black dip with white relief of Muses, c. 1875. Photography M. Coupe.

Art, science and a quest for perfection are unmistakable in the refined and classical ceramics of Wedgwood.

BY **DAVE SAMMUT**

England, 1759. An ailing King George II sits upon a throne in torment. British troops are at war in Canada, and have just captured Quebec. The restive American colonies are just a few years from open revolution. Railway lines are rolling out across the green fields of England with the speed and power of the steam engines they will carry. An entirely new class of 'industrialists' is growing wealthy from great endeavours of earth, fire and steel.

Josiah Wedgwood (1730–95) has just leased his first factory, the Ivy House Works, in Burslem, Staffordshire. Already the fourth generation in a family of potters, he has been working since he was just nine, when his father died. He has only a basic education, yet he has a keen intellect and a spirit for problem-solving.

Wedgwood throws himself at the task of refining and industrialising the manufacture of ceramics, developing techniques for their mass production. Within just three years, he releases the first of three signature styles of earthenware. Queen's Ware, released in 1762, was a cream-coloured, lead-glazed product, a durable mixture of flint and white clay and the first example of coloured ceramics.

The new Queen Charlotte (wife of King George III) was so pleased with Wedgwood's tea set that Wedgwood was granted permission to style

# The science and society of WEDGWOOD



himself 'Potter to Her Majesty', and his fame spread quickly across Europe. Just a few years later, Catherine the Great ordered the famous Frog Service of 982 individually painted English views and the green frog emblem of her country estate *La Grenouillère*.

Two key challenges for any scientist of that era were measurement and control. For Wedgwood, the uniformity and quality of his materials, and the temperature control of his furnaces, were crucial. Daniel Gabriel Fahrenheit's mercury thermometer was at that time a relatively recent invention, and not suitable for the high temperatures at which kilns fire clay – around 1200–1300°C.

With the growing international success of his products, Wedgwood rapidly gained a reputation for his tireless experimentation. Wedgwood received clay and mineral samples from all over the world. He sought constantly to refine the purity and uniformity of his starting materials and to refine production processes. His innovations helped the Wedgwood factory to gain a reputation for product quality and consistency.

The chemistry of ceramics is too diverse and complex to cover here. The elements can be metal, non-metal or alkaloid, with ionic or covalent bonding. Generally, ceramics are characterised by key attributes – hardness, toughness, poor conductivity and chemical resistance.

Wedgwood's experimentation with materials allowed him to create consistently coloured ceramics that did not rely on glazes for colour, where coloured glazes were unreliable. However, he continued to experiment with these ideas for other production purposes, and to create the unique products for which he is famous.

An early idea for gauging temperature that Wedgwood trialled was to place discs of clay doped with iron oxide in the kilns. On firing, the oxide would darken from beige through to brown and black,



Tray of Jasper trials, 1773. Each trial piece is marked with a number that corresponds to an entry in Wedgwood's 'Experiment Book'. Many pieces are impressed with the firing instructions, for example 'TTBO' for 'tip-top of biscuit oven'.

**Wedgwood's experimentation with materials allowed him to create consistently coloured ceramics that did not rely on glazes for colour, where coloured glazes were unreliable.**

Photo © Wedgwood Museum/WWRD.



## The Sydney Cove Medallion

Following the establishment of the New South Wales colony in 1788, Governor Arthur Phillip sent a sample of clay from Sydney Cove to Sir Joseph Banks, who in turn gave it to Josiah Wedgwood. Using this sample, Wedgwood created a commemorative medallion titled 'Hope encouraging Art and Labour, under the influence of Peace, to pursue the employments necessary to give security and happiness to an infant settlement'. The Sydney Cove Medallion illustrated dates from the 1920s and is from the collection of a member of the Wedgwood Society of NSW. The year 1789 on the medallions is the year the originals were made and sent back to Governor Phillip.

depending on the temperature reached. However, he was concerned that the 'phlogistic vapours' (see July 2014 issue, p. 22) in the kiln would contaminate the discs, leading to false results. He also trialled the use of metal rods, but measuring the expansion at high temperatures was impractical.

Instead, he pursued experiments based on the shrinkage properties of clay itself. Using the purest Cornish clay, he created moulded cylinders that he placed in the kiln with each firing.

After cooling, the plug was pushed into a brass gauge with a tapering, graduated groove of his own scale, 'degrees Wedgwood'. Using precise measurements of the degree of contraction of the plug, Wedgwood could determine the temperature of the kiln.

Wedgwood's 1782 paper 'An attempt to make a thermometer for measuring the higher degrees of heat, from a red heat up to the strongest that vessels made of clay can support', in the *Philosophical Transactions of the Royal Society of London*, saw him elected a Fellow of the Society the following year.

The way that Wedgwood marketed his products – particularly via advance order from catalogues and travelling salesmen – allowed him to plan his production and minimise waste. He developed multiple innovations in the production processes, such as simplifying shapes for higher volume production. Wedgwood is also credited with perfecting the revolutionary use of transfer printing to achieve interchangeable patterns for pre-ordered plates, replacing the laborious and inconsistent practice of hand-painting designs.

Various fortunes and misfortunes in Wedgwood's life meant that his influence extended well beyond his work in ceramics.

Having survived smallpox as a child, Wedgwood had a permanently weakened knee. After a bad fall in 1762, around the time of his initial fame, his doctor introduced him to a rich and educated businessman, Thomas Bentley, who opened up the classical world to Wedgwood and redefined his taste. Classical themes came to be a signature of Wedgwood's ceramics.

Wedgwood became fascinated with classical ceramics, and he continued to research these thoroughly. His second signature line, Black Basalt (1768), was in the Etruscan style, the basis for the name of his newly constructed Etruria Works in Staffordshire, in 1766. This

Wedgwood became friends with Joseph Priestly through the Lunar Society and corresponded with many of the great scientists of the day.

facility continued production for 180 years, across another five generations of Wedgwoods.

Through his new connections, Wedgwood later came into contact with Erasmus Darwin (see 'Curious connections'). Together, they were among the founders of the Lunar Society, which in part reflected the changing relationship between technology and science, moving from an artisanal craft practice to one with a more scientific basis, even as the scientific method was first coming to be developed and codified.

Wedgwood became friends with Joseph Priestly through the Lunar Society and corresponded with many of the great scientists of the day. He came to supply scientific instruments to Priestly, Lavoisier and others – pyrometers, retorts, crucibles and tubing. Another of Wedgwood's papers to the Royal Society concerns his experiments with Lavoisier's idea that heat could be measured by determining the quantity of ice that a warm body could melt.

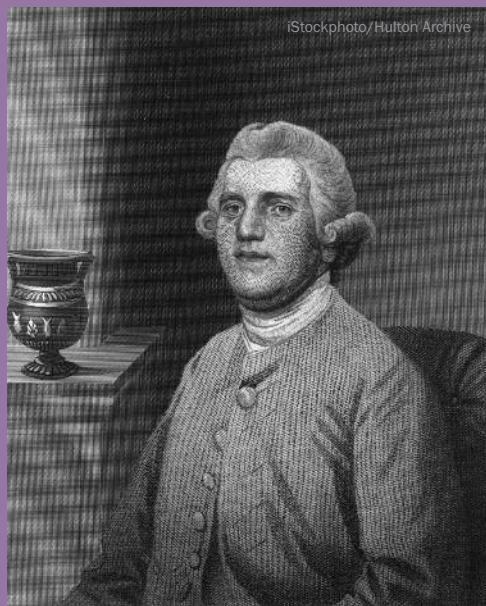
The Etruria factory included a laboratory where Wedgwood pursued his investigations. His favourite phrase was 'Everything yields to its

## Curious connections

Because of the friendship between Wedgwood and Erasmus Darwin, their children had plenty of opportunity to become acquainted. Robert Darwin married Wedgwood's eldest daughter, Susannah, in 1796. Among their children was Charles Darwin, who in 1839 married Emma Wedgwood, daughter of another of Josiah Wedgwood's children, Josiah Wedgwood II (himself a member of parliament and a patron of the arts – he donated a life annuity of £150 to Samuel Taylor Coleridge to free him from financial worry and allow him to pursue his literary and philosophical interests). Yes, Emma was Charles' first cousin, if you're counting.

Charles Darwin's dual access to the Wedgwood fortune (via his mother and wife) substantially contributed to the opportunities he had in life, first to join the voyage of the *Beagle*, and later to pursue his interests in natural history.

Wedgwood was also known as the 'Father of Potters'. In a curious loop, about a century later Beatrix Potter was to write *The tale of Peter Rabbit*, and there would be few English children in the century that followed that didn't have an item of Wedgwood pottery decorated with Potter's illustrations.



Josiah Wedgwood (1730–95).

experiment'. After three years of experimentation, including more than 5000 recorded experiments, Wedgwood went on to develop his third and possibly most famous product: Jasper Ware (1774), a coloured stoneware with applied relief decoration.

In general terms, decoration applied directly to the pottery (which can be raw, 'green' or 'biscuit-fired') can include colourants (such as iron oxides,  $\text{CuCO}_3$  and  $\text{CoCO}_3$ ) or opacifiers (such as  $\text{SnO}$  and  $\text{ZrO}$ ). A wet, usually transparent glaze (primarily of silica as the main glass former, with metal oxides (often Na, K or Ca) to act as flux, and often with alumina for stiffening to prevent it

running off the piece) is applied over the decoration. The pigment fuses with the glaze, and appears to be underneath a clear layer. This is the basis of Jasper Ware, with the striking colour of the blue pieces coming from cobalt as  $\text{CoO}$  or  $\text{CoCO}_3$ .

There remains disagreement about how scientific Wedgwood was in his experimentation. It seems that he was less interested in the intellectual science of his day than in empirical application. According to the Wedgwood Museum's website, 'Josiah was using materials which were full of unidentified impurities and which consequently produced infuriatingly, unpredictable variations in behaviour. His success was purely the result of

trial and error.'

From my perspective, the differentiation is unnecessary. There is no doubt that Wedgwood saw the value of science in his work. At his Etruria factory he engaged a chemist (whose name I have unfortunately been unable to find. Readers are encouraged to write in if they know). He actively participated in the learned societies of his day, corresponding with and assisting some of the names we hold great, and he ensured that his own children were educated in chemistry.

---

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



# Chemistry on show An online 'top 10'

Online demonstrations are a safe and time-saving teaching option. **JEFF HUGHES** presents some of his favourites.

Chemistry is a very visual science, and its teaching – and enjoyment – can be greatly enhanced by demonstration. A pioneer in classroom demonstrations was E.W. Hartung, who was Professor of Physical Chemistry at the University of Melbourne in the 1950s. He had the Masson Theatre specially designed with a space for his huge lantern projector, with a stage to perform experiments that could be projected. He had not only the right apparatus but also laboratory assistants to prepare his demonstrations.

Teaching time, space and OHS regulations limit what teachers can practically do. Today we only dream of Masson's facilities, but we can still spice up our lectures with online videos, largely from YouTube. Many of the demonstrations shown would be difficult or dangerous for teachers to set up, but we can still see what happens when someone is brave (or foolish) enough to try it or has access to the necessary resources.

The prince of sites for chemistry videos is the Periodic Table of Videos



A research professor at the University of Nottingham, Martyn Poliakoff is also a pioneer in green chemistry.

([www.periodicvideos.com](http://www.periodicvideos.com)), set up by Sir Martyn Poliakoff, Research Professor of Chemistry at the University of Nottingham. Each element has a video, with demonstrations and a talk by Martyn.

The following 'top 10' are from a collection of my favourite videos that I have used in classes or talks to students. They show some very interesting chemistry and are fun to see (although not always safe to do).

## 1 Helium near absolute zero

↖ [bit.ly/1MuZvCp](http://bit.ly/1MuZvCp)

The quest to liquefy helium was a milestone in chemistry. Gases with boiling points below 0°C could mostly be liquefied by pressure (e.g. carbon dioxide). However, the four 'permanent' gases – hydrogen, helium, oxygen and nitrogen – could not be liquefied by pressure alone.

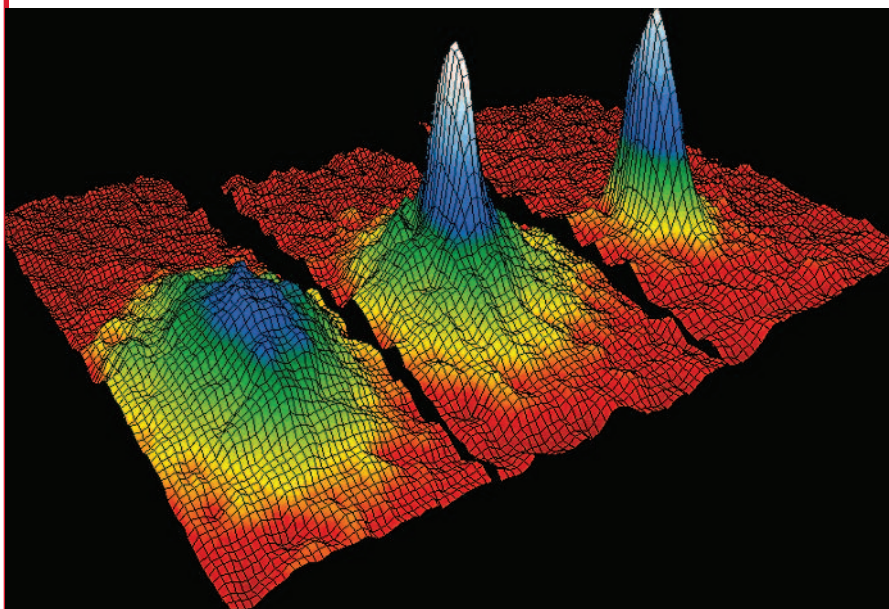
James Dewar was the first to liquefy hydrogen, at about 20°C. He used a 'cascade' experimental construction and the Joule–Thompson effect. A gas under high pressure, when escaping from a narrow orifice, cools rapidly and this cooling can be used to liquefy a gas with a lower boiling point. A 'cascade' of gases, each with lower boiling points than the gas above in the cascade, can lower temperatures sufficiently to liquefy the permanent gases. James Dewar and Heike Kamerlingh Onnes raced each other to be the first to liquefy the last of the gases not yet liquefied. Onnes beat Dewar, mainly because Dewar did not have enough helium. Because of his disagreeable personality, Dewar had problems getting other researchers to supply him.

Helium does not liquefy till about 5 K, but if it is cooled further a new state is achieved. When helium is cooled below 2.18 K, a 'superfluid' state of helium, called helium II, is formed, and its properties are very odd indeed. This video demonstrates these properties.

## 2 Bose Einstein condensates

↖ [bit.ly/1MuZG0G](http://bit.ly/1MuZG0G)

If the cooling is continued further, to within a few nanokelvin degrees above absolute zero, a new state is entered where things become even more weird. Atoms settle into their lowest quantum state, and their wavefunctions merge into a 'super atom'. Although we can't see the actual condensates, this video nicely explains what they are and how they behave.



Three-dimensional successive snap shots in time in which rubidium atoms cooled to less than 170 billionths of a degree above absolute zero condensed from less dense red, yellow and green areas into very dense blue to white areas – a 'superatom' behaving as a single entity. Wiki/NIST/JILA/CU-Boulder

## 3 Cornflour

↖ [bit.ly/1S9QWo2](http://bit.ly/1S9QWo2)

We move from a substance that can only be created with great difficulty in a research lab to one we can get off the supermarket shelves. Cornflour is a thixotropic substance, exhibiting non-Newtonian flow. A thixotropic substance behaves differently depending on the stress applied to it. The Mythbusters demonstrate this type of behaviour by 'walking on water'.

In other videos, the Mythbusters fill a swimming pool with cornflour slurry ([bit.ly/1V53nRu](http://bit.ly/1V53nRu)) and put it on speaker cones ([bit.ly/1OJSZJN](http://bit.ly/1OJSZJN)).



Macro photograph of ferrofluid influenced by a magnet.

## 4 Ferrofluid

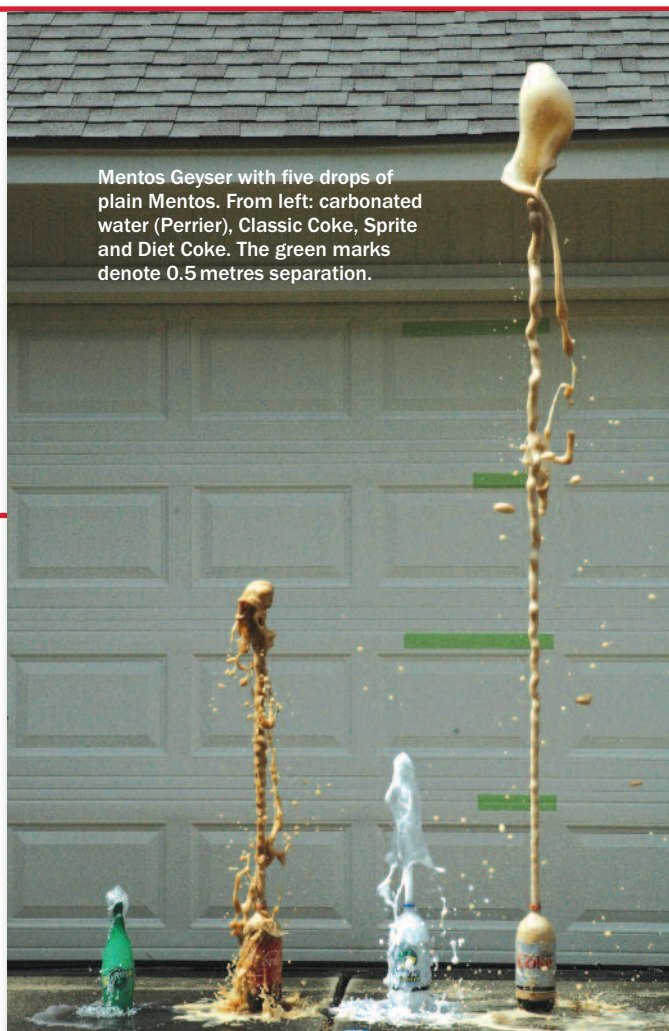
↖ [bit.ly/1mgaJWI](http://bit.ly/1mgaJWI)

This very unusual substance has become quite a hit on YouTube. It can be made as shown at [bit.ly/1ZojRqn](http://bit.ly/1ZojRqn). Further methods of preparing it and demonstrations are at [bit.ly/1TgilnE](http://bit.ly/1TgilnE).

## 5 Mentos fountain

↖ [bit.ly/1mgb4rY](http://bit.ly/1mgb4rY)

This demonstration has been around for some time but this is a special version, a twist on the 'domino' effect. Some people have way too much time on their hands! It is another example of an experiment with ingredients you can get from a supermarket shelf but should be done outdoors. It's not dangerous but very messy! Apparently the effect differs according to the country in which you purchase your soft drink (ingredient amounts vary).



Mentos Geyser with five drops of plain Mentos. From left: carbonated water (Perrier), Classic Coke, Sprite and Diet Coke. The green marks denote 0.5 metres separation.

## 6 Sulfur hexafluoride

↖ [bit.ly/1Jtquyz](http://bit.ly/1Jtquyz)

Chemistry is getting a wider exposure through demonstrations such as this one from the Jimmy Fallon show. We have seen it in Australia on the ABC with Dr Karl and Adam Spencer in 'Sleek Geeks'. This demonstration is of a really heavy gas. We all know what happens to the voice when helium is breathed (the lightest gas), but what happens when we breathe a heavy gas like sulfur hexafluoride?



## 7 The barking dog

↖ [bit.ly/1YvUnKD](http://bit.ly/1YvUnKD)

Why 'barking'? Watch the video and see! This is another clip from a TV science presenter. This demonstration has quite a history. German chemist Justus von Liebig performed it for the Bavarian royal family in 1853. The glass tube exploded and the Queen was wounded in the cheek. Liebig was saved from possible death by his snuff box. Without the box, a shard of glass might have penetrated one of his arteries.

The chemiluminescence is caused by a reaction between nitric oxide and carbon disulfide. Apparently explosions can happen if nitrogen dioxide is present, and this may be what happened in Liebig's experiment. This can be prevented by having some water in the bottom of the tube.



Before the invention of camera flashes, the 'barking dog' reaction was often used as an illuminator in photography.

## 8 Nitrogen triiodide ('touch powder')

↖ [bit.ly/1YA2DnE](http://bit.ly/1YA2DnE)

This demonstration is always a great hit when I show it in class. In my younger days it was a common prank to prepare a solution of nitrogen triiodide, pour it on the floor and let the solvent evaporate. Then if any unsuspecting person (e.g. a teacher) walked on the floor, there would be mini explosions as the touch powder was set off. How sensitive it is to impact can be seen from the demonstration. It is not recommended you try this demonstration.

## 9 Self-siphoning polymer

↖ [bit.ly/1YvVES4](http://bit.ly/1YvVES4)

Can liquids flow uphill? Yes, if confined to a narrow capillary tube. However, the 'polyox' polymer (poly(ethylene oxide)) can show capillary flow just by pouring it from one beaker to another. The demonstration not only displays the uphill flow, but gives a nice explanation of how it works.



Capillary flow demonstrated with 'polyox', a self-siphoning gel.

www.teachersource.com

## 10 Supercritical fluid

↖ [bit.ly/1V5aadP](http://bit.ly/1V5aadP)

It seems appropriate to finish my top 10 with a Poliakoff demonstration. This one is actually set up in his office – it beats most desktop toys! He uses it to screen potential research students. If they show no interest in his demonstration, he gets them to look elsewhere.

### Also worth a look

With any top 10, there are always some near misses. Elephant's toothpaste ([bit.ly/1SOVkJN](http://bit.ly/1SOVkJN)), the thermite reaction ([bit.ly/201lmZm](http://bit.ly/201lmZm)) and gun cotton ([bit.ly/1PkCAAo](http://bit.ly/1PkCAAo)) are all worth a look. It's so much easier to blow things up on video!

**Jeff Hughes** MRACI CChem is Program Leader, Chemistry, at the School of Applied Science, RMIT University. All links in this article are live at [chemaust.raci.org.au](http://chemaust.raci.org.au).

# Busting myths

A practical guide to  
countering science denial

It should go without saying that science should dictate how we respond to science denial. So what does scientific research tell us?



One effective way to reduce the influence of science denial is through 'inoculation': you can build resistance to misinformation by exposing people to a weak form of the misinformation.

How do we practically achieve that? There are two key elements to refuting misinformation. The first half of a debunking is offering a factual

alternative. To understand what I mean by this, you need to understand what happens in a person's mind when you correct a misconception.

People build mental models of how the world works, where all the different parts of the model fit together like cogs. Imagine one of those cogs is a myth. When you explain that the myth is false, you pluck out that cog, leaving a gap in their mental model.

But people feel uncomfortable with an incomplete model. They want to feel as if they know what's going on. So if you create a gap, you need to fill the gap with an alternative fact.

For example, it's not enough to just provide evidence that a suspect in a murder trial is innocent. To prove them innocent – at least in people's minds – you need to provide an alternative suspect.

However, it's not enough to simply explain the facts. The golden rule of debunking, from the book *Made to stick*, by Chip and Dan Heath, is to fight sticky myths with even stickier facts. So you need to make your science *sticky*, meaning simple, concrete messages that grab attention and stick in the memory.

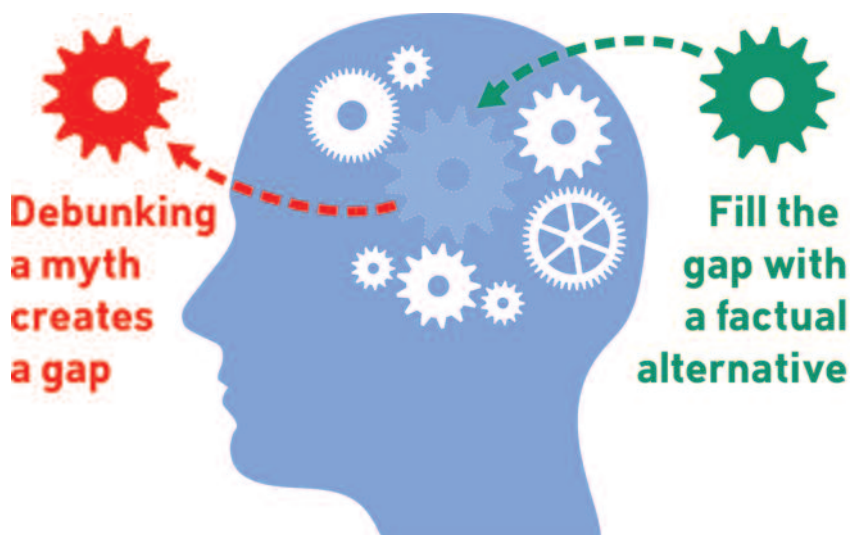
How do you make science sticky? Chip and Dan Heath suggest the acronym SUCCES to summarise the characteristics of sticky science:

- **Simple:** To paraphrase a quote from Nobel Prize winner Ernest Rutherford: if you can't explain your physics simply, it's probably not very good physics.
- **Unexpected:** If your science is counter-intuitive, embrace it! Use the unexpectedness to take people by surprise.
- **Credible:** Ideally, source your information from the most credible source of information available: peer-reviewed scientific research.
- **Concrete:** One of the most powerful tools to make abstract science concrete is analogies or metaphors.
- **Emotional:** Scientists are trained to remove emotion from their science. However, even scientists are human and it can be quite powerful when we express our passion for science or communicate how our results affect us personally.
- **Stories:** Shape your science into a compelling narrative.



BY JOHN COOK





Debunking myths creates gaps in people's mental models. That gap needs to be filled with an alternative fact.

John Cook

As well as explaining why the facts are right, you also need to explain why the myth is wrong. But there's a psychological danger to be wary of when refuting misinformation.

Third, explain the fallacy that the myth uses to distort the facts. This gives people the ability to reconcile the facts with the myth. A useful framework for identifying fallacies is the five characteristics of science denial (which includes a number of characteristics, particularly under logical fallacies).

Pulling this all together, if you debunk misinformation with an article, presentation or even in casual conversation, try to lead with a sticky fact. Before you mention the myth, warn people that you're about to mention a myth. Then explain the fallacy that the myth uses to distort the facts.

## 5 CHARACTERISTICS OF SCIENCE DENIAL



Five characteristics of science denial.

John Cook

### Mythbusting

Let's say you've put in the hard yards and shaped your science into a simple, concrete, sticky message. Congratulations, you're halfway there! As well as explaining why the facts are right, you also need to explain why the myth is wrong. But there's a psychological danger to be wary of when refuting misinformation.

When you mention a myth, you make people more familiar with it. But the more familiar people are with a piece of information, the more likely they are to think it's true. This means you risk a 'familiarity backfire effect',

reinforcing the myth in people's minds.

There are several simple techniques to avoid the familiarity backfire effect. First, put the emphasis on the facts rather than the myth. Lead with the science you wish to communicate rather than the myth. Unfortunately, most debunking articles take the worst possible approach: repeat the myth in the headline.

Second, provide an explicit warning before mentioning the myth. This puts people cognitively on guard so they're less likely to be influenced by the myth. An explicit warning can be as simple as 'A common myth is ...'.

### Putting into practice

Let me give an example of this debunking technique in action. Say someone says to you that global warming is a myth. Here's how you might respond:

*97% of climate scientists agree that humans are causing global warming. This has been found in a number of studies, using independent methods. A 2009 survey conducted by the University of Illinois found that among actively publishing climate scientists, 97.4% agreed that human activity was increasing global temperatures. A 2010 study from Princeton University analysed public statements about climate change*

and found that among scientists who had published peer-reviewed research about climate change, 97.5% agreed with the consensus.

*I was part of a team that in 2013 found that among relevant climate papers published over 21 years, 97.1% affirmed human-caused global warming.*

*However, one myth argues that there is no scientific consensus on climate change, citing a petition of 31 000 dissenting scientists. This myth uses the technique of fake experts: 99.9% of those 31 000 scientists are not climate scientists. The qualification to be listed in the petition is a science degree, so that the list includes computer scientists, engineers and medical scientists, but very few with actual expertise in climate science.*

And there you have it.

In our online course, Making Sense of Climate Science Denial (see box), we debunk 50 of the most common myths about climate change. Each lecture adopts the fact-myth-fallacy structure where we first explain the science, then introduce the myth then explain the fallacy that the myth uses.

In our sixth week on the psychology of debunking, we also stress the importance of an evidence-based approach to science communication itself. It would be most ironic, after all, if we were to ignore the science in our response to science denial.

**John Cook** is Climate Communication Research Fellow at the University of Queensland. First published at *The Conversation*, [www.theconversation.com](http://www.theconversation.com).

## 'Myth-busting' climate change fallacies

Researchers from around the world have contributed to a University of Queensland course that uncovers why the topic of climate change is so controversial, exploding a number of climate myths along the way.

The free massive open online course (MOOC) includes renowned researchers from universities in Canada, USA and the UK – and even Sir David Attenborough lends his support.

UQ Global Change Institute Climate Communication Fellow and MOOC coordinator John Cook said the course tackled climate myths and exposed techniques used to mislead the public.

'97 per cent of climate scientists agree that humans are causing global warming; however, less than half of Australians are aware of humanity's role in climate change, while half of the US Senate has voted that humans weren't causing global warming,' he said.

'This free course explains why there is such a huge gap between the scientific community and the public.'

He said removing this gap was an important step in ensuring science supported policy development, leading to maximum benefit for communities, economies and the environment.

The course, Making Sense of Climate Science Denial, is a seven-week program featuring interviews with 75 notable scientific experts.

'The key to understanding the controversy is the science of science denial,' Mr Cook said.

'Our course looks at what's driving climate science denial and the most common myths about climate change.'

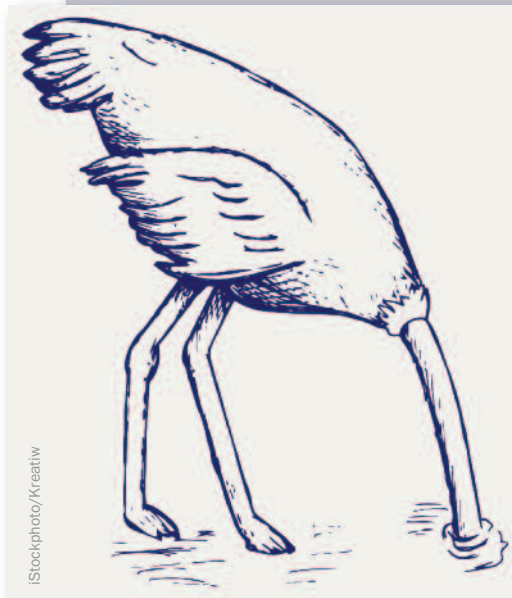
'We also examine what the science says about how to respond to science denial, equipping participants with the tools they need to see through the fog of denialism.'

Mr Cook interviewed leading scientists and researchers in England, the USA, Canada and Australia, with Sir David Attenborough a stand-out star.

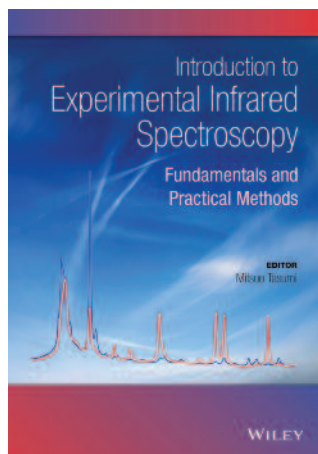
The course incorporates climate science and the psychology of climate change to explain the most common climate myths and to detail how to respond to them.

'This isn't just a climate MOOC. It's a MOOC about how people think about climate change,' Mr Cook said.

The UQx course is offered via the edX not-for-profit online learning platform.  
UNIVERSITY OF QUEENSLAND



istockphoto/Kreatiw



## Introduction to experimental infrared spectroscopy: fundamentals and practical methods

Tasumi M. (Ed.), Wiley, 2014, paperback, ISBN 9780470665671, 408 pp., \$100.95

If your next assignment incorporates any aspect of infrared spectroscopy, then *Introduction to experimental infrared spectroscopy: fundamentals and practical methods* is for you. This

book integrates both theory and practice to offer a comprehensive and balanced textbook. The *Fundamentals* section provides seven chapters of theoretical material, supported by the *Practical methods* portion, which is almost stand-alone as a practical IR spectroscopy handbook.

The *Fundamentals* section works through the history of IR spectroscopy and contains chapters related to the required software, hardware and potential chemometric applications, although there is little discussion surrounding spectral interpretation. This is one of the book's limitations, as while generating the ideal sample spectra is valuable, so too is gaining the most information possible through correct interpretation. There are plenty of spectra scattered throughout the book, but the specific examples don't lend themselves to learning the nuances of spectral interpretation. *Fundamentals* also incorporates modern FT-IR spectroscopy methods with the six appendices providing further details of the Fourier transform equations and electromagnetic wave functions. The material covered isn't critical if you aren't mathematically inclined, but does provide additional background.

The *Practical methods* section incorporates a number of chapters discussing a series of IR spectroscopy applications. Each chapter provides diagrams of the related instrumentation or sampling apparatus in addition to example spectra (the book focuses primarily on materials science applications). There are 15 chapters in this section, which at first blush may seem daunting. However, each chapter discusses the practical execution of one specific type of IR spectroscopy, including photoacoustic spectrometry and time-resolved IR absorption measurements. These methods are not as common as standard FT-IR or attenuated reflection spectroscopy, but the discussion is no less complete. This section also includes laboratory-specific details for each method and discusses the challenges surrounding the handling of solid, liquid or gas samples. In many situations, preparing the perfect sample can be difficult, but each *Practical methods* chapter discusses the finer points of obtaining the best possible results.

Whether your foray into the world of IR spectroscopy will be a theoretical or a practical experience, *Introduction to experimental infrared spectroscopy* is sure to provide a valuable reference.

Samantha Profke MRACI

## Food, energy, and water – the chemistry connection

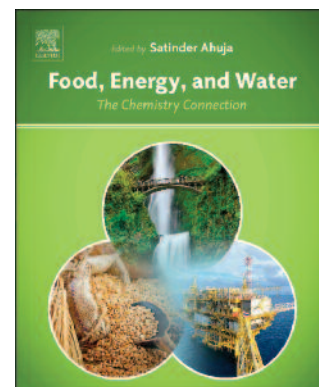
Ahuja S. (Ed.), Elsevier, 2015, hardcover, ISBN 9780128002117, 460 pp., approx. \$176.95

*Food, energy, and water – the chemistry connection* is an exploration of the interrelationships between the production of energy (which generally/frequently involves either consumption of, or contamination of, fresh water); the needs to husband, recover and recycle a scarce resource (fresh, potable water); and the requirements of agriculture for reasonably uncontaminated water to produce food. Despite our living on the 'blue planet', most of the blue is, of course, seawater and the supply of fresh water is really quite meagre. There is, if you like, a tension between the demands placed on this scarce resource by our requirements for energy, for safe and nutritious food and for potable water (although whether we absolutely need this to flush our toilets is, at least, debatable). It's all a bit like James Lovelock's Gaia theory – everything is interconnected. You want more fresh water? Sure! You can get it by desalination of seawater by reverse osmosis. OK, but doesn't this need energy? Sure! No problems, you can get that by fracking, for example. What about the contaminated waste water from (virtually all) energy generation? Put it on the fields to irrigate the crops! But won't that contaminate the food we eat? ... You see where I'm going?

There are 17 chapters and 34 contributing authors, so it is not surprising to find some variability in quality and relevance. A couple of chapters seemed marginal, but generally the content is relevant, interesting and well written. On the face of it, the contributors appear well selected and well positioned to justify their contributions, which are extensively referenced. There does not seem to be much repetition, which can be a problem with multi-author works like this, and the editor has made a valiant attempt to tie the work together in an opening chapter.

The book concentrates principally on the nexus between energy production and water (and the contamination of the latter by the former) and less on the food apex of the food–water–energy triangle. In a world hungry for both energy and food, water is a valuable, possibly undervalued, currency. It is a currency we have to pay to produce energy and food. The coinage has a restricted circulation life (it gets grubby pretty quickly and drops in value), so we have to send it back to 'the mint' to clean it up before we can recycle or reuse it. Almost everything we do has a cost, in water currency, and a benefit.

The real value of this book, for me anyway, was enhancing my understanding of water's centrality in our clever 21st-century lives. As with most other developments post-Industrial Revolution, we, as a species, seem to have made a jolly decent

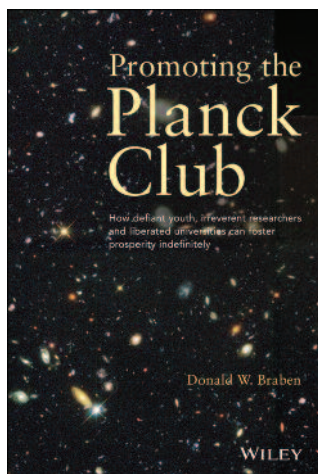




fist of engaging in activities inimical to the purity and availability of fresh clean water.

The book is jam-packed with information and strategies to inform future water usage and guide us towards wiser choices. This is a book well worth dipping into. Natural resource planners and managers, as well as people with broad interests (professional or otherwise) in environmental issues, could benefit from it, while for a broader audience it provides a worthy introduction to a range of complex, topical issues.

R. John Casey FRACI CChem



## Promoting the Planck Club

Braben D.W., John Wiley, 2014, paperback, ISBN 9781118546420, 222 pp., \$88.95

*Promoting the Planck Club* is a passionate development exploring the proposition that defiant youth, irreverent researchers and liberated universities can foster prosperity indefinitely. Author Donald Braben presents interesting vignettes on scientists from Max Planck onwards, who exemplify these characteristics,

thus qualifying for membership of his Planck Club, and who have made enormous contributions to scientific progress. Most of the book is devoted to the biographies of this select group. Inevitably, these interesting tales feature instances of adversity, resolute and often unrecognised genius, and a certain amount of serendipity. They are enjoyable reading.

Braben concludes the way to foster future prosperity is to withdraw a lot of the shackles constraining scientific research and let more people follow their passions and ideas. The pay-off will be significant societal advantage from discoveries arising from this strategy, just as there has been great economic and social advancement from discoveries made by members of the Planck Club. Does the argument hold up? Well, only partly in my view.

Dr Davis McCaughey AC, one of Victoria's notable governors, said of students 'students need time to waste and places to waste it in, if they are to become reflective men and women'. You could equally say this of scientists: if you want people to reflect, and to think deeply, then you are unlikely to succeed if you feed them a diet of research grant applications to apply for, reinforced by smacking them about the ears for enhanced productivity and basing their promotion on the length of their publications. ('Never mind the quality: just feel the width!') And imposing what must seem like an interminable regime of justifying their very existence. And yet, many (most?) young Australian researchers are faced not only with fierce competition in the job market, but extreme competition in career advancement, often based on some score achieved on

what is a quintessentially un-scorable scale. Not a lot of attention to Pasteur's 'Chance favours the prepared mind'. A very Hobbesian world view, indeed, unleavened by McClelland's Theory X–Theory Y! Fortunately, the Australian Government has flagged an end to the 'publish or perish' culture hitherto applied to university research funding (*The Age*, 16 November 2015, p. 8), although adopting a cautionary approach, one ought probably 'always keep a hold of nurse for fear of finding something worse'.

How do you judge quality? Well, for a start you'd need some agreed definition. Everybody knows quality when they see it, but then everybody looks through different eyes. If you want to explore this further, then try Robert M. Pirsig's *Zen and the art of motorcycle maintenance*. One thing is for sure, it is not something you are likely to be able to quantify with a number (and isn't that exactly what we try to do?). I suppose if you equate quality with output, then where research grants are concerned, about the best you can do is apply a version of the Markovnikov Rule, which I learnt as 'To him who hath shall be given'. It more or less works with racehorses, so why not scientists? Alas, not much help to the maiden (of either gender).

We seem to lurch about in Australia, unfettered by anything remotely resembling a national science policy. What should be our national balance between pure research (in a sense our membership dues for 'world knowledge incorporated') and applied research (directed at attaining some national economic advantage)? How do we balance serendipity, by its very nature probabilistic, against strategic research, by its very nature goal-oriented? And perish the thought of what you can do when purity strays! Lewis and Randall, in the introduction to their seminal thermodynamics text, wrote of 'cathedrals of science', constructed by 'a few architects and many workers'. How do we pick the architects of the future? (And particularly when most of us are closer to the bricklaying end of things than to the drawing board.)

My short answer (my long answer too) is, I don't know! Having read Braben's book, which I enjoyed, I really have more questions than answers. I'm pretty sure the present system is seriously broken, but Braben's book doesn't lead me to pontificate on any solution. It's worth reading. See what you think!

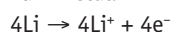
R. John Casey FRACI CChem

**John Wiley & Sons** books are now available to RACI members at a 20% discount. Log in to the members area of the RACI website, register on the Wiley Landing Page, in the Members Benefits area, search and buy. Your 20% discount will be applied to your purchase at the end of the process.

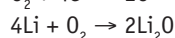
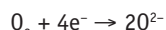
Receive 25% off Elsevier books at [www.store.elsevier.com](http://www.store.elsevier.com) (use promotion code PBTY15).

## Lithium production

There is considerable enthusiasm for innovative battery technology for both electric vehicles and domestic solar power back-up. Central to this new technology are developments in rechargeable batteries using lithium, of which there are many types and variants. Of particular interest are developments of the lithium–air battery, which has as its basis the oxidation of lithium metal:



and



The interest in batteries based on this reaction is because the theoretical energy density of the battery (40.6 MJ/kg) approaches that for conventional transport fuels such as diesel (about 44 MJ/kg) and theoretically the battery can recover full efficiency following deep discharge. Efficient recharge is a problem with many other lithium-based batteries and a major issue with lead–acid batteries.

In practice, the energy density of the lithium–air battery will be less than 40.6 MJ/kg and current practice is far from this ideal; for example, the battery pack in the Tesla car (which is a complex lithium ion battery) weighs approximately 400 kg compared to a tank of conventional fuel at about 50 kg.

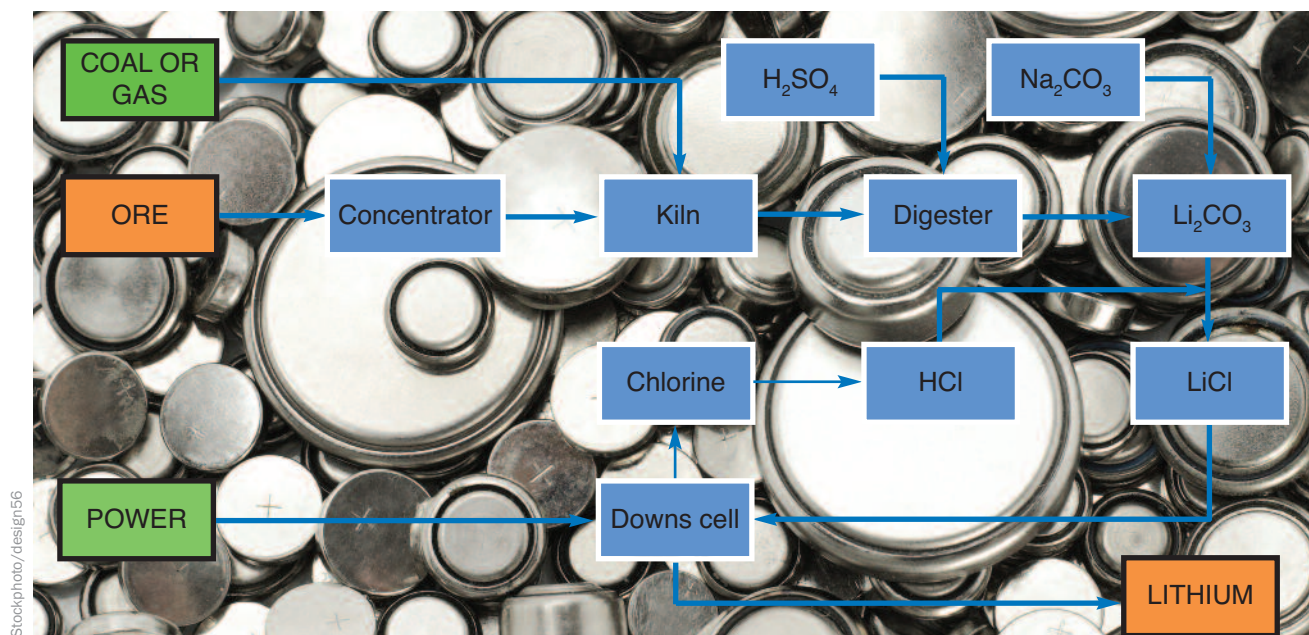
Simply, the lithium–air battery comprises a lithium metal anode and a graphene cathode. The cathode absorbs oxygen from the atmosphere and converts it into  $\text{O}^{2-}$  ions, which diffuse through to a conductive layer separating the cathode and anode. Recharge is the reverse of the process. Of particular concern is that on re-charge build up of metallic bridges of lithium from the anode through the conducting layer can occur.

This ultimately leads to an internal short circuit, which can cause the battery to catch fire.

If solar power back-up is to take-off as is widely predicted by proponents of this technology, there will be a major demand for lithium batteries and hence lithium metal. Australia is a significant producer of lithium ores from the Talison Lithium mine at Greenbushes in Western Australia and there are several prospects for new lithium mining ventures. These projects are in competition to extraction of lithium from brine lakes mainly in South America.

The steps in the production of lithium from ore are shown in the flowchart. The principal ore for lithium production is *alpha*-spodumene, which is a lithium aluminosilicate of empirical formula  $\text{LiAlSi}_2\text{O}_6$ ; in its pure form it contains 8% lithium (as  $\text{Li}_2\text{O}$ ) but most productive ore contains much less, typically 1.5–4.5%  $\text{Li}_2\text{O}$ . The first step is to concentrate the ore to about 90% spodumene by flotation and gravity separation. Australian processing operations generally end here and the concentrate is exported.

*Alpha*-spodumene is very refractory and cannot be processed to extract the lithium. The *alpha*-spodumene is converted into the *beta* form, which is less dense and from which the lithium can be extracted by sulfuric acid digestion. The transformation requires the *alpha*-spodumene to be heated to over  $1100^\circ\text{C}$  and is typically performed in a rotary kiln using coal or gas. The product is crushed in a ball-mill and after extraction with sulfuric acid, the excess acid is neutralised with limestone. Then sodium carbonate (soda ash) is added to produce a lithium carbonate solution, which is evaporated prior to the addition of more soda ash, which precipitates the carbonate. This material



Process flow for production of lithium metal from spodumene ore.

## Outline economics for the production of lithium metal from spodumene ore

Lithium carbonate production		US\$/unit	US\$/t lithium
Ore (t)	3.0% Li <sub>2</sub> O	70	5023.05
Kiln heat (GJ)	80.2 GJ/t Li	5	401.20
Kiln & ball mill power (MWh)	1.1 MWh/t Li	70	76.99
Sulfuric acid (incl. allowance) (t)	7.77 t/t Li	120	931.99
Limestone (t)	0.72 t/t Li	30	21.64
Soda ash (t)	7.64 t/t Li	250	1909.22
Subtotal			8364.09
Capital costs			2509.23
Other costs (15% Capex)			376.38
Total			11 249.71
Lithium carbonate		2113.51	

Lithium metal production			
Lithium carbonate + allowance (t)	0.9139 t/t LiCl		
LiCl (with HCl allowance) (t)	6.42 t LiCl/t Li		15 030.38
(assumes Cl <sub>2</sub> and HCl have equivalent value)			
Power demand (MWh)	35.11 MWh/t Li	50	1755.67
			16 786.05
Capital costs			5035.81
Other (15% Capex)			755.37
Lithium metal			22 577.23

is widely traded and competes with lithium carbonate produced from brine lakes.

Lithium metal is produced by electrolysis of a lithium chloride/potassium chloride eutectic at about 450°C. To perform this operation the lithium carbonate is converted into lithium chloride by the addition of hydrochloric acid. The lithium chloride is charged to the electrolysis cell (Downs cell) where by-product chlorine is also produced. The chlorine can be traded for or converted into hydrochloric acid. The molten metal is extracted and cast into ingots. This process is very power intensive, typically 35 kWh/kg. The outline economics are shown in the table.

Starting with ore at a notional 3% Li<sub>2</sub>O content, the cost of production of lithium carbonate is over \$2000/t, which is equivalent to a lithium value of over \$11 000/t. This production cost of lithium carbonate compares favourably with recent prices for this material, which stand at over \$5000/t, but the lithium carbonate may require further purification for battery grade product. Of

note is the very high energy demand for this part of the process (80 GJ/t Li and 1.1 MWh/t Li). This is mainly associated with calcining the ore to produce the *beta*-spodumene.

Transforming the carbonate to lithium chloride and producing the metal doubles the production cost to around \$22 000/t, which is also well below recent traded prices. But again further purification and metal casting may be required for the battery grade material.

Clearly producing the high valued metal is very energy intensive and increased production of lithium will be favoured by low energy prices. Since energy prices in Australia are no longer competitive with those in other parts of the world, it is highly likely that Australia's role will remain as a provider of ore and concentrate to industrialised nations with low energy costs such as the US, China and India.

Also, if we assume theoretical efficiency of the battery, then at a notional power requirement of 20 kWh/day for an average home, the lithium required for one week's power supply as back-up would be 12.5 kg.

Allowing for efficiency losses and non-ideal operation, in practice the lithium required may be many times this amount. This is a significant amount of lithium metal to be carried by an ordinary household. Those of us who have experienced small laboratory fires involving a few grams of alkali or alkaline earth metals, may find the thought of a fire involving more than 12 kg of metal somewhat alarming. International airlines prohibit the transport of lithium batteries except under strict conditions because of their tendency to spontaneously ignite (due to internal shorting within the battery). Safety concerns about the widespread use of large lithium batteries in the household are largely ignored by the proponents of lithium battery technology and safety issues could become a major hurdle for the widespread uptake of solar/battery storage.

There are many challenging problems to be solved in the development of lithium battery technology, which will require innovative chemical solutions. Large electronics conglomerates (mainly Japanese and Korean) are becoming dominant in the development of new battery chemistry and battery manufacture and many of the vehicle manufacturers are in joint venture with them (Tesla is reported to have an agreement with Panasonic). Of relevance to Australia would be new technology to extract the lithium from *alpha*-spodumene at lower energy cost than the current practice.



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



## Australia's high-tech start-up sector – who actually wants one?

Some time back I wrote a paper ([bit.ly/1WdmKjM](http://bit.ly/1WdmKjM)) outlining one hypothesis as to how the corporations in the Australian services sector could be encouraged by government intervention to require new sources of innovation as developed by a high-tech start-up sector.

In that paper I stated a view shared by many, that the world only needs one Silicon Valley.

The evidence? Firstly, Silicon Valley doesn't just serve the USA, it is a magnet for entrepreneurs and risk capital from all over the world. Secondly, as Vivek Wadwha noted ([bit.ly/20y9Ubl](http://bit.ly/20y9Ubl)), 'hundreds of regions all over the world [have] collectively spent tens of billions of dollars trying to build their versions of Silicon Valley. I don't know of a single success.'

Recently I was included in an email conversation that included a small number of Australian high-tech start-up industry veterans. The group had taken it upon themselves to educate the incoming Australian Federal Minister for Science (sic) on what is needed to 'fix' the local technology start-up sector.

The reason the email train existed at all is that we have never had a sparkling start-up high-tech sector in Australia. At times this sector has shown a little self-promoted promise with the odd moderate success, but that is all. Most people with the required expertise recognise this fact. One trip to Silicon Valley convinces them that over there they have something that we do not.

And yet our local media mostly runs high-tech sector story that are blazingly upbeat. I think this is because the high-tech sector stories are run as 'feel good' stories.

For example, a two-man start-up might be promoted as the next unicorn and then it will quietly disappear never to be heard of again. Your local medical researcher doing some exploratory effort into determining the cause of Alzheimer's will win a Eureka Prize and the public may think there is a cure and a large Australian medical corporation on the way. It just about never happens.

The experts that can see past the positive media coverage seem to all have a pet hypothesis as to the root cause of the 'problem' that haunts the Australian high-tech start-up sector. Variably they will say, not enough skilled entrepreneurs, or not enough quality innovation, or not enough investment capital, or not enough qualified venture capitalists, and the list goes on.

Some of them then start promoting to the government their hypothesised solutions; for example (working through the example list above), creating university courses to up-skill entrepreneurs, or by government investing more into university R&D to create more innovation, or by removing barriers to crowd-funded venture funds, or by giving venture capital at friendly terms to Australian venture capitalists returning from Silicon Valley (and the list goes on).

There is a pattern here.

Firstly, the experts announce that there is a problem, the lack of a vibrant tech sector in Australia, without ever defining exactly what a vibrant tech sector would look like. To this I would note that it doesn't make much sense to start looking for a solution to a problem until the problem has been properly defined.

Secondly, the experts propose a solution without ever realising that their idea is just a hypothesis. That is, it could be wrong and it needs to be stress-tested before being implemented. Since different people have different hypotheses, you'd think they'd catch on. But no, everyone just thinks that everyone else is wrong.

Thirdly, most of the experts look at the problem in 'kinetic' terms. That is, they believe that the lack of vibrancy in the Australian tech sector is caused by certain missing or under-performing elements of a tech start-up food chain (which comprises innovation, entrepreneurs, skilled tech employees, risk capital, venture capital managers, investment bankers, corporate acquirers and tech-friendly public stock markets). Fix the under-performing element they say, and then magically all would be OK despite the evidence to the contrary from past efforts over 35 years of government intervention.

I would assert that the problem is actually 'thermodynamic' in nature. By this I mean that there is no actual current need in our economy for a tech sector to exist.

The commodities sectors do not need one; they have their own R&D channels. The oligarchies in the services sector don't need one; they buy their technology from overseas vendors. The educational exporters don't need one; they only innovate to reduce costs and improve their marketing. And the list goes on.

Basically there is no major corporate sector in Australia that requires a steady stream of new platform technologies served up by start-ups. They are doing just fine as they are. Without this high level 'driving force', no amount of fiddling with the tech start-up food chain will do any good.

Until one of the Australian corporate sectors buys into the idea of buying start-ups and attacking global markets with the so-acquired platform technologies, we will never have a thriving tech start-up environment.

To make matters worse, any start-ups that do succeed pretty quickly disappear overseas to serve larger markets with cheaper capital, thus leaving the local environment devoid of their potentially positive influence. This fact underlies the need for local corporate adoption of successful start-up technologies.

Just as a short historical segue, Silicon Valley was built on defence, semiconductor and computer technology companies in the post-war era. After decades of slow developments the VC sector really took off in the 90s (in terms of capital deployed) when three things occurred.

Firstly, the corporate sector in the US saw Silicon Valley as a

reliable and viable source of new platform technologies. The opportunity they saw was to cut much of their under-performing corporate R&D expenses and use those funds to acquire start-ups or listed tech companies; this turned out to be a more cost-efficient way to innovate.

Secondly, Silicon Valley caught the first internet boom and saw an opportunity to seize a once-in-a-millennium IPO market for new global technology companies.

Finally, the 1978 ERISA amendments allowed US pension funds to 'prudently' invest in early stage unlisted companies. Before then the VC industry was much smaller and limited by capital supply; these amendments had fixed this issue by the 90s.

As you might imagine, not much of this story aligns to anything we might conjure up in Australia. If we want to have a vibrant high-tech start-up sector, then we need to come up with our own need to have one rather than attempt to copy and compete with Silicon Valley, because it won't work; never has.

Now if we accept all that as gospel (and most of you won't and good on you for your scepticism), then it seems to me that we have two choices.

- 1 Create a new export-orientated corporate sector from scratch that needs the technology platforms served up by local start-ups, or
- 2 Encourage one of our existing corporate sectors to start buying the technology platforms and to start exporting.

Which of these has the highest chance of success, do you think?

For the former to succeed we would have to miraculously create both a new export-orientated corporate sector and a thriving start-up community. This takes me back to the 90s when many in the Australian start-up community used to look to Nokia as the template for success. 'Create enough start-ups,' they said, 'and you will eventually get a Nokia.' Nokia, they argued, created a new technology-export sector for Finland and it also supported a local technology start-up community. Well after 35 years of trying we haven't got a Nokia, and neither does Finland for that matter.

My money is on using government incentives to encourage our plumpish corporates in the services sector to morph from being domestic oligarchies that use third-party off-the-shelf technology platforms to global vendors of disintermediating technology platforms in their own sector. They have the capital to execute this plan, if not the management or the culture. I never said it would be easy; I just think this is the higher probability approach of the myriad that I have heard proposed.



**Ian A. Maxwell** (maxwell.comms@gmail.com) is a serial (and sometimes parallel) entrepreneur, venture capitalist and Adjunct Professor in Electrical and Computer Engineering at RMIT University and Visiting Professor in the Faculty of Engineering and Information Technology, UTS, who started out his career as a physical polymer chemist. First published at startup88.com.

# National Awards 2016

The RACI National Awards recognise and promote the contributions and achievements of our members.

The awards cover a broad range of areas and are aimed at the full membership demographics.

They are open to all members of the RACI. Some can be applied for by the candidate; others have to be nominated by third parties.

## Academia:

Applied Research Award  
Cornforth Award  
CS Piper Award  
HG Smith Memorial Award  
Rennie Memorial Award

## Distinction:

Citation  
Distinguished Contribution to Economic Advancement (Weickhardt) Award  
Distinguished Fellowship Award  
Leighton Memorial Award

## Education:

Fensham Award for Outstanding Contribution to Chemical Education  
RACI Chemistry Educator of the Year Award

## Young Chemists: Masson Memorial Award

## MRACI Post Graduate Student Travel Bursary

An amount of \$2000 to assist Post Graduate Student members of the RACI to travel professionally from their home institution, to collaborate with a research group, at another Australian university or overseas, or to make use of specialised research facilities (e.g. an advanced light source), or to deliver a paper at a meeting overseas.

Full details of the awards and the requirement criteria can be found on the RACI website at: [www.raci.org.au/events-awards/national-awards-2016](http://www.raci.org.au/events-awards/national-awards-2016)

## Take advantage of your member benefits...



**OzForex** offers fee free transfers on all transactions above AUD \$1000 or equivalent (normally AUD \$15).



**HCF Health Insurance** offer their exclusive Corporate Product range to RACI members.



**Qantas Club Airline Lounge** offer discounted corporate rates, saving up to \$372.50.

**Avis and Europcar** offer reduced excess car hire liability of \$1000 in Australia and NZ, or 10% off best rate of the day (Europcar only).



**Private Fleet** offers you savings of up to 20% off your next car purchase. Free access to the service (normally \$178), 12 months road side assistance and more is included.

For more information visit [www.memberadvantage.com.au/raci](http://www.memberadvantage.com.au/raci) or call 1300 853 352.



## Wine and health

I have long argued that wine consumed as part of a meal is particularly beneficial to one's health. The benefits result from the relaxation that occurs after the meal as the body's system slows down and stress levels reduce. The long lunch that one can still experience in some southern European countries is, from my own considerable and on-going experimentation, highly beneficial in stress reduction.

An intriguing study on the potential health benefits of minor autochthonous grape cultivars in Sardinia was presented at the In Vino Analytica Scientia conference in July last year. The project was based on the knowledge that there is a high number of centenarians in Sardinia (a *blue zone* demographic area). The 'Sardinia diet' consists of meat, sheep milk cheese (pecorino and casu marzu) and fava beans, all washed down with at least two or three glasses a day of the indigenous red wine. The research suggests that the regional wine has a very high anti-oxidant status, thereby contributing to its health-promoting advantage. The specific compounds that give this anti-oxidant status are still under study. The health effect of the red wine, however, cannot be isolated from that of the casu marzu cheese. This is a rotten pecorino containing live maggots, which may boost the body's immune system, but only if one consumes the live maggots. The locals also claim that the cheese is an aphrodisiac.

There is a major worldwide research effort to determine the critical health-benefit role of specific wine components. The wine and medical literature abounds with studies and I am grateful to Dr Zyta Ziara from the Institute for Molecular Bioscience at the University of Queensland for advising me of a September 2013 column in *Medical News Today* ([bit.ly/1ajewpt](http://bit.ly/1ajewpt)). More than a dozen benefits of moderate consumption were identified, including prevention of colon cancer, breast cancer, dementia, liver disease, prostate cancer and type 2 diabetes as well as an anti-ageing effect, reducing the risk of depression, improving lung function and protection from severe sunburn. All sounds rather wonderful. However, a quick search of *MNT* will identify several articles that outline the negative health issues associated with alcohol consumption.

One of the key issues in trying to understand the science behind wine and health is the importance of 'moderate consumption' and certainly the *MNT* article emphasises this point. In Australia, a standard drink contains 10 grams of alcohol, as ethanol. So, for example, 150 mL of a 13% red wine equates to 1.5 standard drinks. The Australian guideline for 'safe' alcohol consumption is 'For healthy men and women, drinking no more than two standard drinks on any day reduces the lifetime risk of harm from alcohol-related disease or injury' (download at [bit.ly/10Fdnlq](http://bit.ly/10Fdnlq)). This means that 200 mL of the

13% red wine gives the two standard drinks. In the US, moderate consumption is proposed as up to one drink per day for women and two per day for men ('one drink' is about five fluid ounces of a 12% wine or around 150 mL). In the UK, where a unit of alcohol is 8 grams, it is recommended that men should not drink more than three or four units a day while women should consume only two or three units. It is intriguing that in Australia we do not have a gender limit in our guidelines for 'healthy' women and men, although there is a specific guideline for pregnant women, for example.

The role of food in alcohol metabolism has not received sufficient attention. Together with Dr Creina Stockly of the AWRI and the late Dr David Leaver of the University of Melbourne, we looked at the blood alcohol content of a small group of healthy young people (four of each gender) when consuming wine after a fast and after eating a defined meal. Much lower blood alcohol levels resulted when the wine was consumed with food in the stomach and the difference between the women and men was also less compared to the fasting condition. We proposed that the results supported the concept of 'first pass metabolism' in the stomach, an effect that would slow the transfer of alcohol to the bloodstream and onto the liver. In reality, it is supporting evidence for the tradition of drinking wine with a meal.

Tracking the fate and specific activity of wine components following wine consumption remains a challenge. In a study from the Institute of Food Research in Madrid (Munoz-Gonzalez et al., *J. Agric. Food Chem.* 2014, vol. 62, pp. 10567–75), analysis of immune markers in faeces before and after a four-week period of red wine consumption provided tentative evidence that 'moderate consumption of red wine could modulate inflammatory intestinal response in vivo'. In a study on rats, the brain was found to be a specific target organ for about 40% of the intravenously administered polyphenolic metabolites (Gasperotti et al., *ACS Chem. Neurosci.* 2015, vol. 6, pp. 1341–52). A rather difficult experiment to perform on humans, however.

I became aware about 15 years ago of a project that was designed to track the fate of specific phenolic compounds by adding to wine (+)-catechin with a  $^{13}\text{C}$  label at specific sites in the molecule. The plan was to analyse body fluids by NMR, locating the catechin or its metabolites in these fluids. But for some unknown reason, the project did not get off the ground. So, there may be a nice NMR activity for someone here.



**Geoffrey R. Scollary** FRACI CChem ([scollary@unimelb.edu.au](mailto: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.

## Introductions all round

The first week of November is one of Melbourne's big weeks, with the Spring Racing Carnival in full flow. The highlight is Melbourne Cup Day, which is observed as a public holiday. In 2015, to avoid the hoopla, I took off to the south island of New Zealand for the week. In doing so, I completed a Queenstown quinella, flying into that charming tourist hub, and having visited the Tasmanian namesake in the summer of 1982–3. Readers may recall that was the summer of the Franklin Dam.

There are several similarities between the two Queenstowns. Both have a history of mining, and are the jump-off points for boat trips to World Heritage-listed waterways. Both towns also have environmental problems with trees. In the Tasmanian case, it is a lack of trees in a landscape denuded by timber felling to



Wilding conifers at Queenstown, New Zealand.

support the early mining operations, and due to the effects of acid rain as a result of sulfur dioxide emissions from the associated smelter. In the New Zealand case, the problem is too many trees, of the wrong type. Many of the stands of trees, which seem to give this part of New Zealand an alpine look are, in fact, pest species known as 'wilding conifers'. These trees, such as Douglas firs, out-compete the native plants for nutrients and create a closed canopy that blocks out sunlight, killing the native plants on the surface, and altering the environment for native bird and animal species. This predominance by a single species reduces the original biodiversity. The steeply sloped landscapes mean that attempts to remove these trees can result in unwanted erosion of the surface soils, but control measures are being implemented

New Zealander co-workers over the years had alerted me to the pest status of the Australian brushtail possum, but wilding conifers are an introduced pest in New Zealand of which I wasn't aware. Brushtail possums have found some use, their fur being blended with wool to make warm clothing. I understood,

too, that rabbits would be an issue in New Zealand, just as they are in Australia, but I didn't know that an attempt at biological control, by introducing stoats as predators, had back-fired, and stoats now pose a threat to the kiwi population.

Attempts at biological control of pests, whether introduced or native, have similarly not been universally successful in Australia. After the success of introducing the cactoblastis moth (*Cactoblastis cactorum*) to control prickly pear infestations in the tropical north, attempts were made to tackle other pests with biological controls. For example, the rabbit population was initially affected quite severely when myxomatosis was introduced in 1950. However, because the virus initially killed very quickly, there was little time for the infection to spread. A less virulent form of the virus then became prevalent, which spread more effectively by being less lethal, but rabbits also developed immunity. Hence, the kill rate went down. There is a similar story with the use of rabbit calicivirus, which 'escaped quarantine' from its test site on Wardang Island in South Australia's Spencer Gulf in 1995. Initially, there was a high death rate, but over the past 20 years its effectiveness has diminished.

The mixed blessings of biological controls of rabbits pale into insignificance against the impact of the introduction of the cane toad (*Rhinella marina*). This species was introduced in 1935 to control the native grey-backed cane beetle, which was considered a pest in the northern Queensland sugarcane fields. However, the toad exudes a milky poison from glands behind its ears, which kills potential predators (including some crocodile species) if they try to eat it. The cane toad's march across the continent has since been extensive, reaching Darwin in the west and well into New South Wales in the south. While there have been some observations of native species adapting their modes of predation so that they can kill and eat the toad without being affected by the poison, this doesn't seem to have been a major contributor in controlling the toad's advance.

While the introductions of cane toads in Australia and stoats in New Zealand are examples of attempts at biological control having gone wrong, what is truly amazing, with the benefit of hindsight, is that the cane toad was introduced to deal with a native 'pest', which was deemed to be a threat to an imported agricultural crop. These events occurred in the mid 1930s, just before the introduction and widespread use of synthetic organic pesticides, such as the organochlorines. These compounds are not without their attendant problems (and I will have more to say about them in a later article) but, in this case, the use of pesticides as non-biological control agents might not have been worse than the alternative.



**Paul Moritz** MRACI CChem (Paul.Moritz@douglaspartners.com.au) is a Principal Contaminated Land Consultant with Douglas Partners, and an EPA-appointed Environmental Auditor in Victoria and the Northern Territory.

## My first chemistry book

Hilda Groening was the stepsister of my maternal grandmother, and a qualified pharmacist. Hilda and her pharmacist father, Frederick, had a pharmacy – always known as a chemist shop – just a few blocks from where I was growing up. Visiting the shop provided me with a glimpse of the world of practical chemistry. Sensing my interest in the subject, and perhaps a bit of cross-family competition, my paternal grandmother gave me a chemistry set for my 12th birthday. I'll say more about that set another time but for now I want to write about the book that Hilda had used as an adjunct to her studies of inorganic chemistry at the Victorian College of Pharmacy, and passed on to me.

It was *An elementary text-book of chemistry* by William Gilbert Mixer of Yale University, the fourth edition, published in 1893. During the 60+ years since I received the book, I had dipped into it from time to time but until I donned my historian's hat and took a serious interest in it, I did not understand who Mixer was and just how unusual his book was. My story was published last year in the *American Chemical Society's Bulletin for the History of Chemistry* (vol. 39(2), pp. 138–44) and what follows is a summary of what I found.

Mixer (1846–1936) completed his bachelor degree at Yale and served as instructor in chemistry 1870–72 and 1874–5, the two-year interregnum being spent in Germany, first with Bunsen at Heidelberg and then with A.W. von Hofmann at Berlin. Back at Yale, he was appointed to a newly created chair of chemistry that he occupied until his retirement in 1913, followed by 23 years as emeritus professor.

That he was in charge of freshman chemistry for 38 years speaks of Mixer's interest in practical chemistry, but he also had an extensive record of research publication with 33 papers in the *American Journal of Science* (founded by Yale's Benjamin Silliman in 1818) and 19 in the *American Chemical Journal* (founded by Ira Remsen of Johns Hopkins University, in 1879). His research topics included mineral chemistry, organic chemistry, thermal reactions of gases, heats of reaction, and heats of formation of metal oxides.

Mixer was obviously a careful experimentalist. He reported that his bomb calorimeter, a silver one he used for eight years, had lost seven grams in mass that he ascribed to 'corrosion, especially by sulfur, and polishing'. In providing details of a method for estimation of carbon by fusion of the sample with lead chromate and collection of the resulting carbon dioxide, he observed that lead chromate exposed to the air could pick up carbonaceous dust and lead to high analytical results.

Mixer began his textbook with the periodic table of the elements but used Mendelejeff's (sic) 1869 'vertical table' in

which the periods were shown in vertical columns and the groups were along the horizontal. This meant it was oriented at 90° to the more familiar form (Mendelejeff's 'horizontal' form of 1871). Mixer then worked through the groups of elements in order VII, I, VI, II, V, III, IV and VIII. This enabled him and the reader to avoid duplication but the modern reader, more familiar with textbooks that simply work through the groups in order, might find it hard to guess where a particular compound will be covered. Since this was my first textbook, I didn't know what 'normal' was and it was only later that I realised that Mixer's approach was idiosyncratic. I think he recognised that this way of sequencing information might confuse students because he recommended that they cultivate the habit of consulting the literature, specifically recommending Roscoe and Schorlemmer's *Treatise of chemistry* and Watts' *Dictionary of chemistry*. There is an excellent index.

I was able to perform some of the many experiments that Mixer described in his text but others seemed altogether too dangerous, such as the preparation of nitrogen trichloride. 'This dangerous compound is prepared by inverting a thin flask filled with chlorine gas in a warm solution of ammonium chloride', he wrote. 'The gas is absorbed, and impure nitrogen chloride in the form of oily drops separates. These may be collected in a lead dish and exploded by touching with a feather moistened with turpentine and held on a long rod.' This is the chemical equivalent of taking a long spoon when you sup with the devil. Mixer also described a preparation by electrolysis of a warm saturated solution of ammonium chloride overlain by a layer of turpentine so the liberated  $\text{NCl}_3$  'rises in minute particles, and explodes on coming into contact with the turpentine'.

Would  $\text{NCl}_3$  really float on water? Its specific gravity is reported to be 1.653. A 24% solution of ammonium chloride, the most concentrated for which I could find data, has specific gravity 1.07 so I had my doubts about floating  $\text{NCl}_3$ . However, a saturated solution of ammonium chloride in water contains 30 g/100 mL at 0°C and 76 g/100 mL at 100°C so maybe it is possible to get a solution with specific gravity above 1.653.

Many old chemistry textbooks can still be found in archival collections and secondhand bookshops, but I wonder if I have the only copy of Mixer's *Text-book* in Australia since I cannot find it in any library catalogue. Curiously, though, digitised versions are available (at a price) on the internet.



**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.



**IChemE Fundamentals of Process Safety**

11–15 April 2016, Perth, WA

[www.icheme.org/fpsperth](http://www.icheme.org/fpsperth)

**ISE Satellite Student Regional Symposium on**

**Electrochemistry & 20th Australasian and**

**Electrochemistry Symposium**

17 April 2016, University of Auckland, Auckland, NZ

[www.raci.org.au/events/event/20th-australasian-electrochemistry-symposium](http://www.raci.org.au/events/event/20th-australasian-electrochemistry-symposium)

**Fire Australia & Hazmat 2016**

4 and 5 May 2016, Melbourne Convention and Exhibition Centre, Melbourne, Vic.

[www.fpaa.com.au/events/fire-australia.aspx](http://www.fpaa.com.au/events/fire-australia.aspx)

**7th Heron Island Conference on Reactive Intermediates and Unusual Molecules**

9–15 July 2016, Heron Island, Qld

[www.Heron7.org](http://www.Heron7.org)

**European Symposium of Biochemical Engineering Sciences (ESBES)**

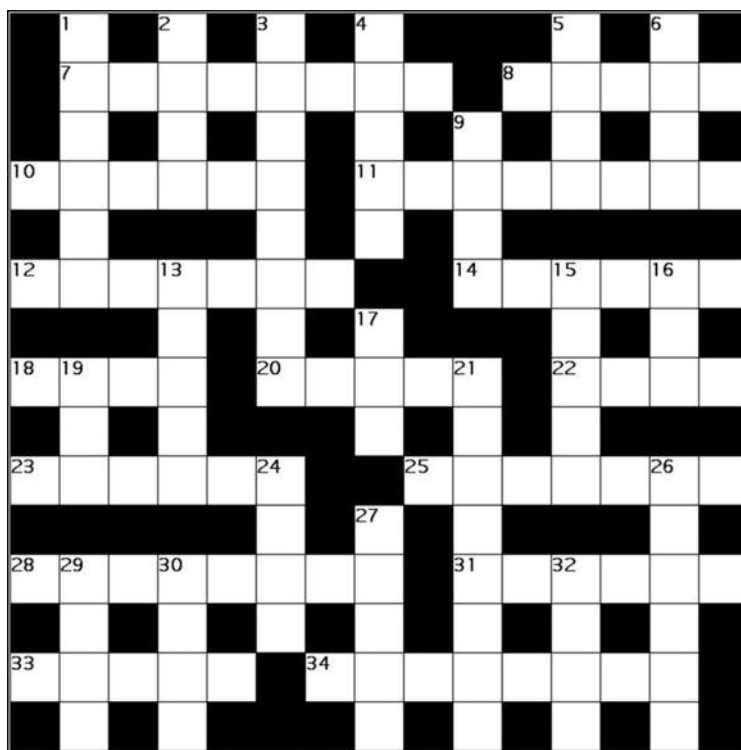
11–14 September 2016, Dublin, Ireland

[www.esbes2016.org](http://www.esbes2016.org)



Coming up

- 2015 Nobel Prize winners part II
- Antimicrobial drug discovery
- RACI youth lecturers: an Australian tour
- Looking at the new VCE chemistry curriculum



The clues for the Across words plus 30 Down do not contain a definition, but they do have something in common.

**Across**

- 7 Came to gory end itself. (8)  
 8 Unknown changes to 30 Down. (5)  
 10 Horse around with barium. (6)  
 11 Sickness or in final stage? (8)  
 12 Asked the kids' question, symbolically. (7)  
 14 Hesitate to contain iodine in transient. (6)  
 18 The last company. (4)  
 20 Advantage over radical. (5)  
 22 Shortly called out: 'Eh you!'. (4)  
 23 Heat. (6)  
 25 33 Across's nice to be around. (7)  
 28 Rum can if shaken. (8)  
 31 Violent revolutions take out on letters. (6)  
 33 Dairy ground seconds. (5)  
 34 Startling ring tone. (8)

**Down**

- 1 Narrow passage or that mess. (6)  
 2 Aide sorted out the notion. (4)  
 3 Little bloke was crackers. (3,5)  
 4 See 28 Across about underwater obstacles. (5)  
 5 4 Down loses 9 around one making predictions. (4)  
 6 Names something 78927. (4)  
 9 Deceptive? Not sure. (4)  
 13 Summarises a cheap tyre. (5)  
 15 Sniffer instrument. (5)  
 16 Address of *Futurama* 23 Across. (3)  
 17 33 Across carbon curve. (3)  
 19 Setting the standards raised in two-sided conversation. (3)  
 21 Rorts one makes without access. (2,6)  
 24 Water down precipitation. (4)  
 26 Caught by police in Gladstone parking a non-electric vehicle in an electric-car charging space. (6)  
 27 Extent of ABC Radio programme segment? (5)  
 29 It is not done, but 8 Across, 33 Across and 30 Down were once so described. (4)  
 30 Putting itself on. (4)  
 32 Is it the symbol for -infinity?! (4)

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

Australians pay almost  
twice as much for movie tickets  
than in the USA\*.

As for me, I use my RACI  
member benefits to buy  
them for only \$12.95 each^.



1300 853 352 | [www.memberadvantage.com.au/raci](http://www.memberadvantage.com.au/raci)

\* Source: The Sydney Morning Herald, July 20, 2011. ^ Based on adult movie ticket prices for Hoyts cinemas when purchased through Member Advantage. Not valid for Saturday night screenings after 5pm.



# Your one-stop-shop for all laboratory supplies... face to face service or online ordering, we give you the choice.

## ROWE SCIENTIFIC

PTY LTD ABN 63 009 437 790

ADELAIDE | BRISBANE | HOBART | MELBOURNE | PERTH

100% Australian owned company, supplying scientific laboratories since 1987.



LABORATORY CONSUMABLES - CHEMICALS - INSTRUMENTATION - REPAIR SERVICES

Order online at your convenience at: [www.rowe.com.au](http://www.rowe.com.au)



Bel-Art Products



Contherm

cowie



Gilian



KartellLABWARE



New South Wales & ACT  
Ph: (02) 9603 1205  
[rowensw@rowe.com.au](mailto:rowensw@rowe.com.au)

Queensland & PNG  
Ph: (07) 3376 9411  
[roweqld@rowe.com.au](mailto:roweqld@rowe.com.au)

South Australia & NT  
Ph: (08) 8186 0523  
[rowesa@rowe.com.au](mailto:rowesa@rowe.com.au)

Victoria & Tasmania  
Ph: (03) 9701 7077  
[rowevic@rowe.com.au](mailto:rowevic@rowe.com.au)

Western Australia  
Ph: (08) 9302 1911  
[rowewa@rowe.com.au](mailto:rowewa@rowe.com.au)

