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December 2016/January 2017

in Australia



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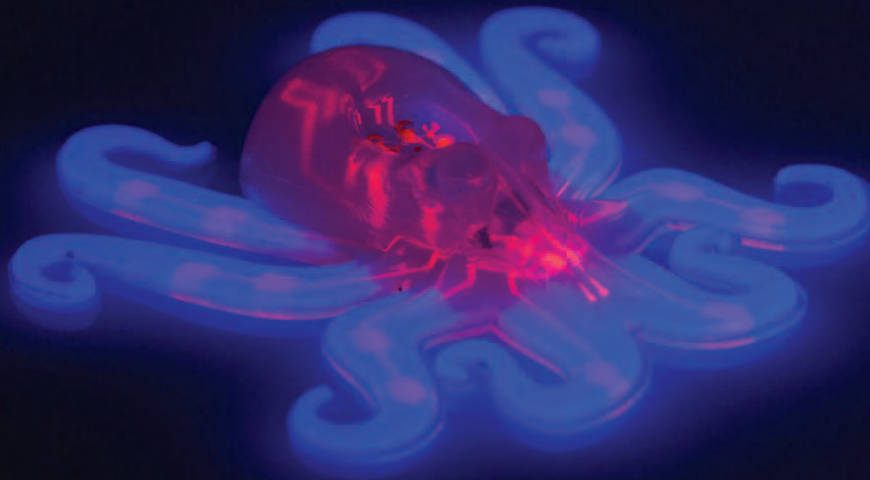
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From the President

At the recent RACI Annual General Meeting in November, the RACI President's baton was handed to me from our outgoing President Paul Bernhardt. Typically, a baton would be handed to another runner at close to full speed for a flying start, but as Paul noted in his last column he was pretty badly injured in a cycling accident in early 2016. Paul has made a rapid recovery, but still has some time to go before hitting top speed on the running track. It was very encouraging to see the effort Paul put into the RACI, particularly in this last year when he was incapacitated, and it showed his passion for chemistry and that leading the RACI was at the forefront of his mind. Well done, Paul, and good luck with the rest of your recovery.

It has been noted in this column previously that one doesn't really find out the full operations of the RACI until you are thrust onto the Board. I have been a member of the RACI for approximately 35 years, and while I spent some ten years as the Inorganic Division secretary, the mechanisms of the Board had eluded me. For the past two years, I have been President-elect, and have therefore attended three or four face-to-face meetings annually while having teleconference hook-ups on a monthly basis.

These meetings have really opened my eyes as to how the Board operates, and the amount of effort put in by members on a voluntary basis never ceases to amaze. The Board, state Branches, Divisions and Sections all have their place, and without the hard-working efforts of members, the RACI would not and could not exist.

As with many not-for-profit membership societies, the RACI is suffering from diminishing membership. The Board has been working very hard to attempt to alleviate this, and we must maintain our numbers or the RACI could die. We are 100 years old next year, and we need to make it to at least 200. With this in mind, the Board has been seeking to recruit a non-member of the RACI to the Board with marketing and communication skills, but also someone who has a non-chemist's point of view, to help the Institute broaden appeal and therefore membership.

2017 will be a big year for the RACI. The highlight of the year will be the Centenary Congress to be held in Melbourne 23–28 July 2017. This will be the largest chemistry conference organised in Australia and will bring together all Divisions of the RACI, plus the 17th Asian Chemical Congress, the 6th Asian Conference on Coordination Chemistry, the Asia Hub for e-Drug Discovery Symposium, the 11th Asian Federation for Medicinal Chemistry's International Medicinal Chemistry Symposium, Carbon 2017, Chemeca 2017, the 8th International Conference on Green and Sustainable Chemistry and the 18th Asian Edition Tetrahedron Symposium.

So far, we have been able to attract some outstanding plenary speakers, including two Nobel laureates – Professor Ada E. Yonath and Professor Robert Grubbs. Overall, there will be a large number of plenaries and keynotes at all conferences, with an expectation of about 3500 attendees. With such a wide variety of themes at this Congress, there will be something for everyone. Roger Stapleford (CEO of RACI) and Mark Buntine (Chair) are doing much of the organising with help from committees of all Divisions and Conferences involved. The logistics for this conference are astounding and all involved need to be congratulated by their efforts. I look forward to seeing you all there.

With so many events taking place in 2017 and beyond, the RACI will be a flurry of activity and it is with some trepidation, but also excitement that I begin my two years of being President. It might be a little concerning that I may paraphrase a US President, but don't worry, this is from 55 years ago: 'Ask not what the RACI can do for you, ask what you can do for the RACI'. I don't feel bad about quoting this line because it is claimed it was attributed to President Kennedy's former school headmaster anyhow.



Peter Junk FRACI CChem (president@raci.org.au) is RACI President.

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Aviation fuels

Having read the article from AusBiotech (authors not identified) in the September 2016 issue (p. 38), I have the following point to make. There is reference, with no supporting argument, to 'the type of isoprenoid needed for jet fuel'. In the choice of fuel for a jet engine, the temperature at which the fuel starts to deposit solid and its viscosity at the temperatures experienced by an aircraft at full altitude are both very important. Until these physical properties are characterised, it is difficult to make a case for jet fuels derived from isoprenoids.

Some concern is expressed in the article at the fact that air transport contributes 1% to total carbon dioxide emissions. Attempts to reduce this are laudable, though I might put this perspective on them. Closer attention to the condition of the peatlands of the world could achieve carbon dioxide reductions much greater than this, and that is why there are proposals for issuance of carbon credits for peatland maintenance and restoration, for example re-wetting a drained peat deposit (www.imcg.net/media/newsletter/nl0703.pdf). Such rudimentary operations could be more productive of carbon credits than the very advanced chemistry proposed for making a particular biofuel.

Clifford Jones FRACI CChem

Professor Jones makes two points in his letter. The first point relates to the required physicochemical properties of compounds suitable for aviation fuel. Professor Jones is quite correct in that drop-in aviation fuels must have appropriate burn properties, viscosity, freezing point etc. to allow effective operation at aviation temperatures. The specific mix of C5 and C10 isoprenoid compounds (limonene, farnesane and *p*-cymene) that has these properties is described in the US patent granted to the project collaborator, Amyris (US7589243). This blend is compliant with Jet A/A-1 fuel specifications and has successfully gone through the strict requirements for aviation regulatory approval; indeed, it 'outperforms conventional petroleum-derived fuel in a range of performance metrics, including fit for purpose and greenhouse gas emission reduction potential, without compromising on performance or quality' (<http://investors.amyris.com/annuals-proxies.cfm>). The first passenger flight, using 10% renewable fuel blended with conventional petrochemical fuel, was on 30 July 2014 (GOL 7725 MCO-GRU). The fuel is now sold through Total, and there are ongoing (albeit limited) commercial flights using that fuel.

The second point made by Professor Jones is that other approaches for reduction of CO₂ emissions might be more effective compared to the 'very advanced chemistry proposed for making a particular biofuel'. Firstly, I would say that there is no one solution to the CO₂ emissions problem, and the ultimate solution will comprise myriad approaches in combination, one of which will be renewable liquid aviation fuels. Secondly,

fermentation is an old and well-established technology, and currently used to make fuel-grade ethanol. The same technology, also using engineered yeast cells, is used to make the isoprenoid-based fuels. Once the initial cell engineering is completed, the process is very similar. As stated in the article, at the moment, the rates/titres/yields are not economically competitive with the petrochemical product; but we are working towards the ultimate goal of achieving this.

Claudia Vickers, Australian Institute for Bioengineering and Nanotechnology, University of Queensland

Capture of atmospheric CO₂ by Lackner process

Recent issues of *Chemistry in Australia* contain articles on industrial processes using syngas, CO + 2H₂. The work of Professor Karl S. Lackner at Columbia University and earlier enables CO₂ to be taken from the atmosphere inexpensively. This can then be converted to the required carbon monoxide.

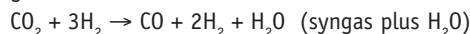
Lackner's work began with his daughter Claire winning a school prize for demonstrating that CO₂ could be removed from air using sodium hydroxide. He decided it should not be too difficult on a larger scale. First he tried air/liquid using NaOH solution. This was ineffective so he switched to air/solid using an anion exchange resin. This worked. The resin is supplied in chloride form and is treated with sodium hydroxide to convert it to hydroxide form. It then takes up CO₂ from air, first to the carbonate and then to the bicarbonate form. At this point, water is added to displace the CO₂ and revert it to carbonate form. It then cycles between the carbonate and bicarbonate forms.

All of this is published in the *European Physics Journal Special Topics*, taking 14 pages of solid work (2009, vol. 176, pp. 93–106).

Lackner has set up a company to market the process using standard shipping containers. They can be located at suitable locations where there is wind and will collect about 1 tonne of CO₂ per day. The cost in 2009 was about \$200 000, dropping to \$20 000 with mass production.

Rather than bury CO₂, Lackner suggests it should be reused to make hydrocarbons etc. by the Fischer–Tropsch synthesis, for example, which uses syngas.

Carbon monoxide can be made from CO₂ by the reverse water gas shift reaction:



Here, extra hydrogen has been added to drive the reversible reaction this way.

(The opposite direction is the water gas shift reaction when coming from blue water gas (H₂ + CO) to get extra H₂.)

Geoff Peverell MRACI CChem

2016 science Nobel prizes

Physiology or Medicine: mechanisms of autophagy

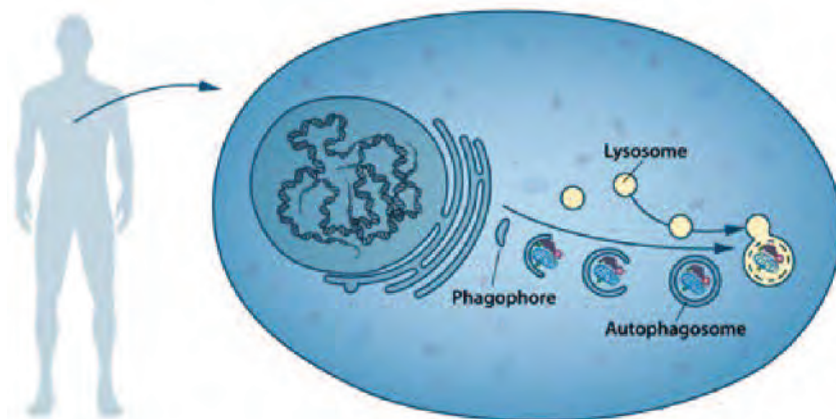
The Nobel Assembly at Karolinska Institutet has awarded the 2016 Nobel Prize in Physiology or Medicine to Yoshinori Ohsumi, Tokyo Institute of Technology, Japan, 'for his discoveries of mechanisms for autophagy.'

This year's Nobel Laureate discovered and elucidated mechanisms underlying autophagy, a fundamental process for degrading and recycling cellular components.

The word 'autophagy' originates from the Greek words *auto-*, meaning 'self', and *phagein*, meaning 'to eat'. Thus, autophagy denotes 'self-eating'. This concept emerged during the 1960s, when researchers first observed that the cell could destroy its own contents by enclosing it in membranes, forming sack-like vesicles that were transported to a recycling compartment, called the lysosome, for degradation. Difficulties in studying the phenomenon meant that little was known until, in a series of brilliant experiments in the early 1990s, Yoshinori Ohsumi used baker's yeast to identify genes essential for autophagy. He then went on to elucidate the underlying mechanisms for autophagy in yeast and showed that similar sophisticated machinery is used in our cells.

Ohsumi's discoveries led to a new paradigm in our understanding of how the cell recycles its contents. His discoveries opened the path to understanding the fundamental importance of autophagy in many physiological processes, such as in the adaptation to starvation or response to infection. Mutations in autophagy genes can cause disease, and the autophagic process is involved in several conditions, including cancer and neurological disease.

In the mid 1950s, scientists observed a new specialised cellular compartment, called an organelle, containing enzymes



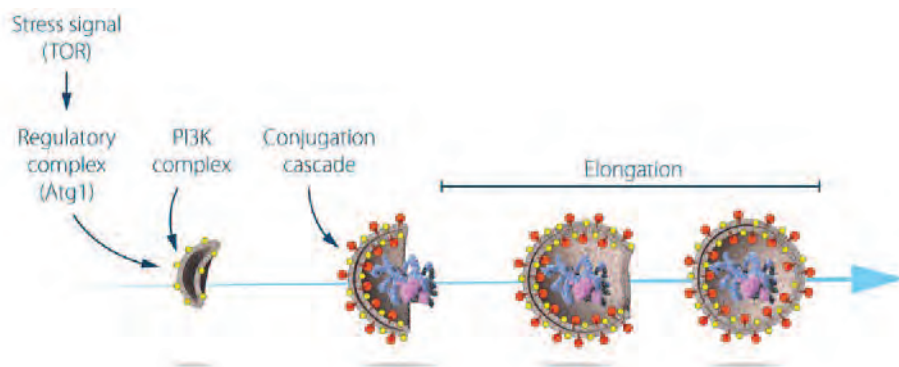
Our cells have different specialised compartments. Lysosomes constitute one such compartment and contain enzymes for digestion of cellular contents. A new type of vesicle called an autophagosome was observed within the cell. As the autophagosome forms, it engulfs cellular contents such as damaged proteins and organelles. Finally, it fuses with the lysosome, where the contents are degraded into smaller constituents. This process provides the cell with nutrients and building blocks for renewal.

that digest proteins, carbohydrates and lipids. This specialised compartment is referred to as a 'lysosome' and functions as a workstation for degradation of cellular constituents. The Belgian scientist Christian de Duve was awarded the Nobel Prize in Physiology or Medicine in 1974 for the discovery of the lysosome. New observations during the 1960s showed that large amounts of cellular content, and even whole organelles, could sometimes be found inside lysosomes. The cell therefore appeared to have a strategy for delivering large cargo to the lysosome. Further biochemical and microscopic analysis revealed a new type of vesicle transporting cellular cargo to the lysosome for degradation. Christian de Duve, the scientist behind the discovery of the lysosome, coined the term 'autophagy' to describe this process. The new vesicles were named autophagosomes.

During the 1970s and 1980s, researchers focused on elucidating another system used to degrade proteins, namely the 'proteasome'. Within this research field, Aaron Ciechanover, Avram Hershko and Irwin Rose were awarded the

2004 Nobel Prize in Chemistry for 'the discovery of ubiquitin-mediated protein degradation'. The proteasome efficiently degrades proteins one by one, but this mechanism did not explain how the cell got rid of larger protein complexes and worn-out organelles. Could the process of autophagy be the answer and, if so, what were the mechanisms?

Yoshinori Ohsumi had been active in various research areas, but upon starting his own lab in 1988, he focused his efforts on protein degradation in the vacuole, an organelle that corresponds to the lysosome in human cells. Yeast cells are relatively easy to study and consequently they are often used as a model for human cells. They are particularly useful for the identification of genes that are important in complex cellular pathways. But Ohsumi faced a major challenge: yeast cells are small and their inner structures are not easily distinguished under the microscope and thus he was uncertain whether autophagy even existed in this organism. Ohsumi reasoned that if he could disrupt the degradation process in the vacuole while the process of autophagy was active, then autophagosomes should accumulate



Ohsumi studied the function of the proteins encoded by key autophagy genes. He delineated how stress signals initiate autophagy and the mechanism by which proteins and protein complexes promote distinct stages of autophagosome formation.

within the vacuole and become visible under the microscope. He therefore cultured mutated yeast lacking vacuolar degradation enzymes and simultaneously stimulated autophagy by starving the cells. The results were striking. Within hours, the vacuoles were filled with small vesicles that had not been degraded. The vesicles were autophagosomes and Ohsumi's experiment proved that autophagy exists in yeast cells. But even more importantly, he now had a method to identify and characterise key genes involved in this process. This was a major breakthrough and Ohsumi published the results in 1992.

Ohsumi now took advantage of his engineered yeast strains in which autophagosomes accumulated during starvation. This accumulation should not occur if genes important for autophagy were inactivated. Ohsumi exposed the

yeast cells to a chemical that randomly introduced mutations in many genes, and then he induced autophagy. His strategy worked. Within a year of his discovery of autophagy in yeast, Ohsumi had identified the first genes essential for autophagy. In his subsequent series of elegant studies, the proteins encoded by these genes were functionally characterised. The results showed that autophagy is controlled by a cascade of proteins and protein complexes, each regulating a distinct stage of autophagosome initiation and formation.

After the identification of the machinery for autophagy in yeast, a key question remained. Was there a corresponding mechanism to control this process in other organisms? Soon it became clear that virtually identical mechanisms operate in our own cells. The research tools required to investigate the

importance of autophagy in humans were now available.

Thanks to Ohsumi and others following in his footsteps, we now know that autophagy controls important physiological functions where cellular components need to be degraded and recycled. Autophagy can rapidly provide fuel for energy and building blocks for renewal of cellular components, and is therefore essential for the cellular response to starvation and other types of stress. After infection, autophagy can eliminate invading intracellular bacteria and viruses. Autophagy contributes to embryo development and cell differentiation. Cells also use autophagy to eliminate damaged proteins and organelles, a quality control mechanism that is critical for counteracting the negative consequences of ageing.

Disrupted autophagy has been linked to Parkinson's disease, type 2 diabetes and other disorders that appear in the elderly. Mutations in autophagy genes can cause genetic disease. Disturbances in the autophagic machinery have also been linked to cancer. Intense research is now ongoing to develop drugs that can target autophagy in various diseases.

Autophagy has been known for over 50 years but its fundamental importance in physiology and medicine was only recognised after Yoshinori Ohsumi's paradigm-shifting research in the 1990s. For his discoveries, he is awarded this year's Nobel Prize in Physiology or Medicine.

Chemistry: molecular machines

The Nobel Prize in Chemistry 2016 was awarded jointly to Jean-Pierre Sauvage (University of Strasbourg, France), Sir J. Fraser Stoddart (Northwestern University, USA) and Bernard L. Feringa (University of Groningen, the Netherlands) 'for the design and synthesis of molecular machines'. These laureates and their work will be featured in *Chemistry in Australia* early in 2017.

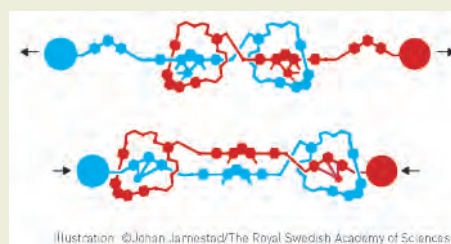


Illustration ©Johan Jarnestedt/The Royal Swedish Academy of Sciences.

Physics: revealing the secrets of exotic matter

The Royal Swedish Academy of Sciences has awarded the Nobel Prize in Physics 2016 with one half to David J. Thouless, University of Washington, USA, and the other half to F. Duncan M. Haldane, Princeton University, USA, and J. Michael Kosterlitz, Brown University, USA, 'for theoretical discoveries of topological phase transitions and topological phases of matter'.

This year's laureates opened the door on an unknown world where matter can assume strange states. They have used advanced mathematical methods to study unusual phases of matter, such as superconductors, superfluids and thin magnetic films. Thanks to their pioneering work, the hunt is now on for new and exotic phases of matter. Many people are hopeful of future applications in both materials science and electronics.

The three laureates' use of topological concepts in physics was decisive for their discoveries. Topology is a branch of mathematics that describes properties that only change step-wise. Using topology as a tool, they were able to astound the experts. In the early 1970s, Michael Kosterlitz and David Thouless overturned the then current theory that superconductivity or suprafluidity could not occur in thin layers. They demonstrated that superconductivity could occur at low temperatures and also explained the mechanism, phase transition, that makes superconductivity disappear at higher temperatures.

In the 1980s, Thouless was able to explain a previous experiment with very thin electrically conducting layers in which conductance was precisely measured as integer steps. He showed that these integers were topological in their nature. At around the same time, Duncan Haldane discovered how topological concepts can be used to understand the properties of chains of small magnets found in some materials.

We now know of many topological phases, not only in thin layers and threads, but also in ordinary three-dimensional materials. Over the last decade, this area has boosted frontline research in condensed matter physics, not least because of the hope that topological materials could be used in new generations of electronics and superconductors, or in future quantum computers.

Current research is revealing the secrets of matter in the exotic worlds discovered by this year's Nobel laureates.

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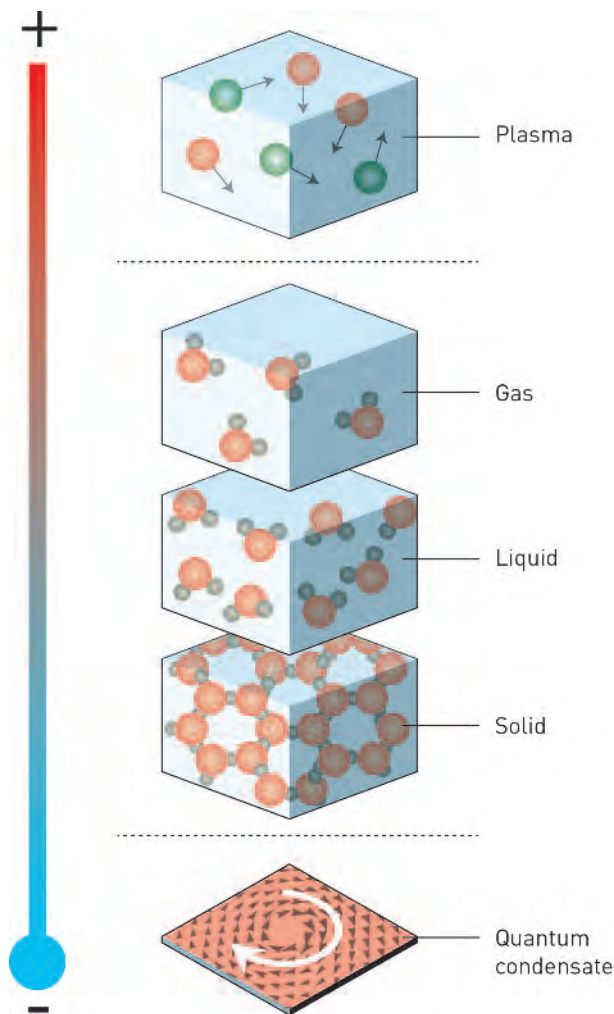


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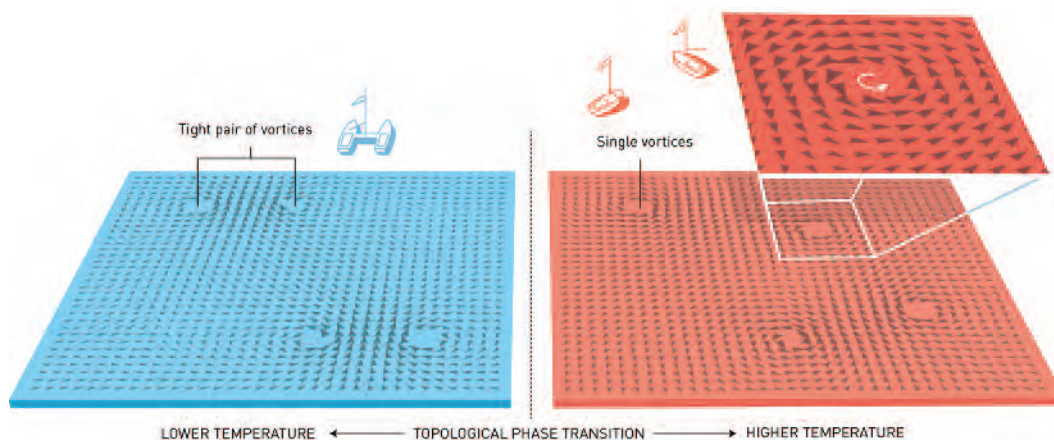


Illustration: ©Johan Jarnestad/The Royal Swedish Academy of Sciences

About the Nobel laureates

Yoshinori Ohsumi was born in 1945 in Fukuoka, Japan. He received a PhD from the University of Tokyo in 1974. After spending three years at Rockefeller University, USA, he returned to the University of Tokyo where he established his research group in 1988. He has been a professor at the Tokyo Institute of Technology since 2009.

David J. Thouless was born in 1934 in Bearsden, UK. He has a PhD (1958) from Cornell University, USA. He is Emeritus Professor at the University of Washington, USA.

F. Duncan M. Haldane was born in 1951 in London, UK. He has a PhD (1978) from Cambridge University, UK. He is the Eugene Higgins Professor of Physics at Princeton University, USA.

J. Michael Kosterlitz was born in 1942 in Aberdeen, UK. He has a PhD (1969) from Oxford University, UK. He is the Harrison E. Farnsworth Professor of Physics at Brown University, USA.

Jean-Pierre Sauvage was born in 1944 in Paris, France. He has a PhD from the Université Louis-Pasteur (1971), France. He is at the University of Strasbourg, France.

Sir J. Fraser Stoddart was born in 1942 in Edinburgh, UK. He has a PhD from Edinburgh University (1966.) He is at Northwestern University, USA.

Bernard L. Feringa was born in 1951 in Barger-Compascuum, the Netherlands. He has a PhD (1978) from the University of Groningen, the Netherlands. He is at the University of Groningen.

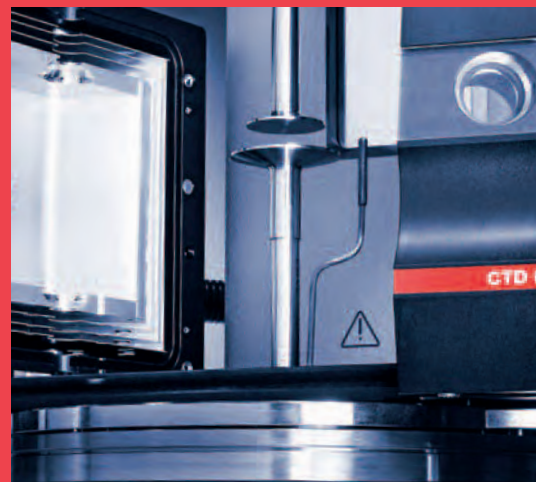
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Mechanism of natural gas conversion to methanol discovered

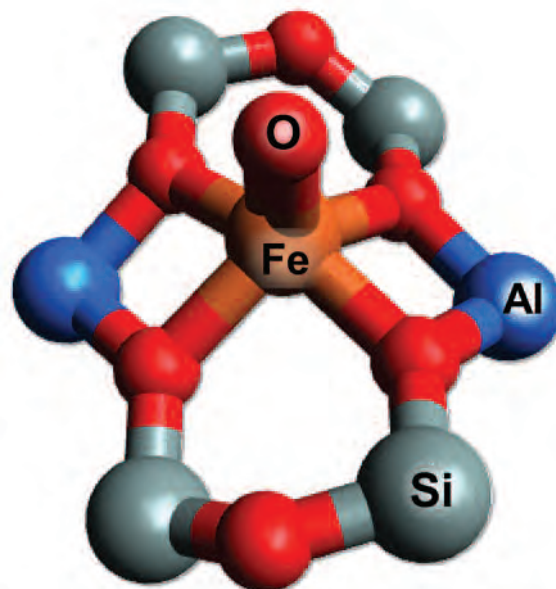
Twenty years after the technique was developed, the mechanism behind the direct conversion process of natural gas into methanol at room temperature has been determined by scientists at KU Leuven (University of Leuven), Belgium, and Stanford University, USA (doi: 10.1038/nature19059). This will have major consequences for the future use of methanol.

The large-scale conversion of methane into methanol currently involves various steps under high pressure and at a high temperature, making it a process that requires a lot of energy.

In the 1990s, scientists developed a more direct method to produce methanol – a process that even produces energy.

Twenty years later, postdoctoral researcher Pieter Vanelderen from the Centre for Surface Chemistry and Catalysis at KU Leuven, has unravelled the mechanism behind the process in collaboration with chemists from Stanford University.

The chemical reaction involves adding a zeolite catalyst containing a specific atom. For the direct conversion of methane into methanol, this catalyst is a zeolite with added iron. Co-author Professor Bert Sels said: 'We found that the iron needs to bind to the zeolite in a flat, bound orientation.'



Now that scientists know exactly what the catalyst looks like, they can start imitating and optimising it in the lab. This opens up quite a few possibilities for the future. For one thing, the production of the methanol needed to produce plastic will become a lot cheaper. The catalyst is also useful for the conversion of nitrogen oxides. It could be used, for instance, to clean the exhaust fumes of cars.

KU Leuven

The first autonomous, entirely soft robot

Harvard University researchers with expertise in 3D printing, mechanical engineering and microfluidics have demonstrated the first autonomous, untethered, entirely soft robot. This small, 3D-printed robot – nicknamed the ‘octobot’ – could pave the way for a new generation of such machines.

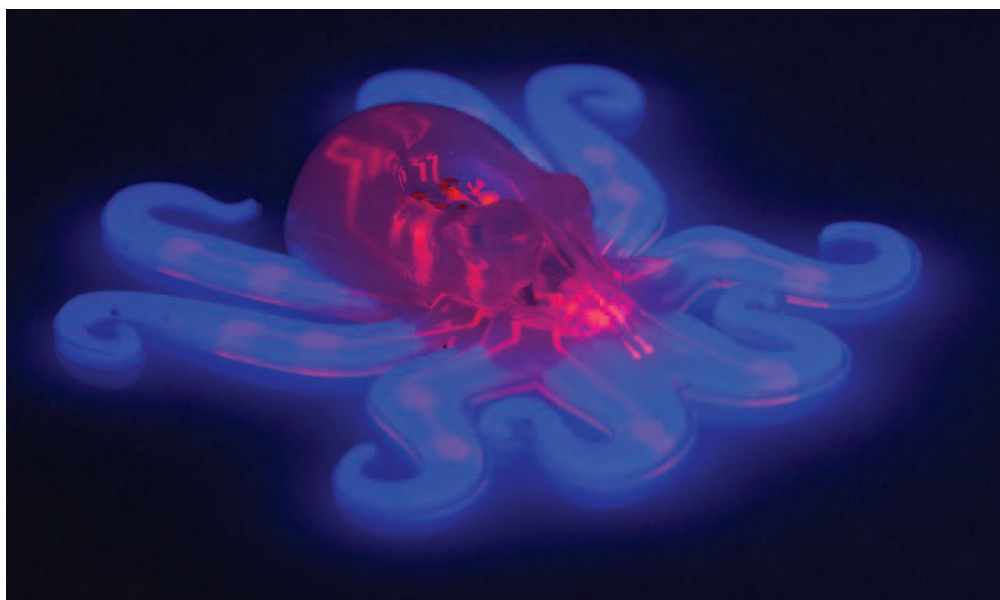
Soft robotics could help revolutionise how humans interact with machines. But researchers have struggled to build entirely compliant robots. Electric power and control systems – such as batteries and circuit boards – are rigid, and until now soft-bodied robots have been either tethered to an off-board system or rigged with hard components.

Robert Wood, the Charles River Professor of Engineering and Applied Sciences, and Jennifer A. Lewis, the Hansjorg Wyss Professor of Biologically Inspired Engineering at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS), led the research. Lewis and Wood are also core faculty members of the Wyss Institute for Biologically Inspired Engineering at Harvard University.

‘One longstanding vision for the field of soft robotics has been to create robots that are entirely soft, but the struggle has always been in replacing rigid components like batteries and electronic controls with analogous soft systems and then putting it all together,’ said Wood. ‘This research demonstrates that we can easily manufacture the key components of a simple, entirely soft robot, which lays the foundation for more complex designs.’

The research is described in *Nature* (doi: 10.1038/nature19100).

‘Through our hybrid assembly approach, we were able to 3D print each of the functional components required within the soft robot body, including the fuel storage, power and actuation, in a rapid manner,’ said Lewis. ‘The octobot is a simple embodiment designed to demonstrate our integrated design and additive fabrication strategy for



The octobot, here with fluorescently dyed fugitive inks (red) and hyperelastic actuator layers (blue), is fabricated by moulding and 3D printing. Lori Sanders/Harvard University

embedding autonomous functionality.’

Octopuses have long been a source of inspiration in soft robotics. These curious creatures can perform incredible feats of strength and dexterity with no internal skeleton.

Harvard’s octobot is pneumatic-based, and so is powered by gas under pressure. A reaction inside the bot transforms a small amount of liquid fuel (hydrogen peroxide) into a large amount of gas, which flows into the octobot’s arms and inflates them like balloons.

‘Fuel sources for soft robots have always relied on some type of rigid components,’ said Michael Wehner, a postdoctoral fellow in the Wood lab and co-first author of the paper. ‘The wonderful thing about hydrogen peroxide is that a simple reaction between the chemical and a catalyst – in this case platinum – allows us to replace rigid power sources.’

To control the reaction, the team used a microfluidic logic circuit based on pioneering work by co-author and chemist George Whitesides, the Woodford L. and Ann A. Flowers University Professor and a core faculty member of the Wyss. The circuit, a soft analogue of

a simple electronic oscillator, controls when hydrogen peroxide decomposes to gas in the octobot.

‘The entire system is simple to fabricate. By combining three fabrication methods – soft lithography, moulding and 3D printing – we can quickly manufacture these devices,’ said Ryan Truby, a graduate student in the Lewis lab and co-first author of the paper.

The simplicity of the assembly process paves the way for designs of greater complexity. Next, the Harvard team hopes to design an octobot that can crawl, swim and interact with its environment.

‘This research is a proof of concept,’ Truby said. ‘We hope that our approach for creating autonomous soft robots inspires roboticists, material scientists and researchers focused on advanced manufacturing.’

The paper was co-authored by Daniel Fitzgerald of the Wyss Institute and Bobak Mosadegh of Cornell University. The research was supported by the National Science Foundation through the Materials Research Science and Engineering Center at Harvard and by the Wyss Institute.

Leah Burrows, SEAS Communications

L'Oréal-UNESCO For Women in Science 2016 A&NZ Fellowships announced

Winners of the 2016 L'Oréal-UNESCO For Women in Science Australian & New Zealand Fellowships have been announced. The four researchers – including two chemistry researchers – are answering important questions surrounding male infertility, the evolution of pregnancy, pollution and its effect on our health and the environment, and the development of inorganic polymers to create new synthetic materials.

The \$25 000 Fellowships were presented by Rodrigo Pizarro, Managing Director, L'Oréal Australia & New Zealand, at the L'Oréal Australia headquarters in Melbourne in October.

Dr Jenny Fisher, University of Wollongong



Outdoor air pollution is a continual concern because it poses a serious risk to human health. With many different emissions from both human and natural activities, the ability to control air pollution relies on understanding how different emissions interact. This is where Fisher's work is key as she focuses on understanding the chemistry of these different emissions.

Over the next few years, Fisher plans to develop an Australian atmospheric chemistry model, similar to those already successfully used in North America and Europe. The information provided from the model will assist in predicting pollution amounts and their responses to future change. The information will help advance scientific understanding of the atmosphere on a global scale – while also providing new insights into what affects our local air quality.

Dr Erin Leitao, University of Auckland



Most synthetic chemistry is targeted at making molecules and materials containing predominantly carbon. Leitao wants to make use of other main-group elements such as silicon, phosphorus, nitrogen, oxygen and sulfur to synthesise polymers. These alternatives to carbon are not only in high abundance, they give the potential to produce materials with unexplored properties and reactivity.

Linking atoms to form polymers is possible by the use of catalysts. Currently the chemistry of linking main-group elements together is under-developed. Leitao plans on developing new, efficient synthetic routes, by focusing on promising catalytic reactions that will open doors to another next generation of functional polymers and materials.

Two other researchers received fellowships, for research into fertility and pregnancy. Dr Angela Crean of the University of Sydney received an Australian Fellowship for her work investigating the manipulation of environmental factors to boost sperm quality. Dr Camilla Whittington, also of the University of Sydney, received her Australian Fellowship for work investigating the evolution of pregnancy, and how the complex placenta has evolved independently in many different species to transport large quantities of nutrients to the foetus.

L'Oréal Australia

Business peak body calls for companies to give back to students



Peak industry association Ai Group has partnered with CSIRO to increase the number of industry professionals showcasing real-life science, technology, engineering and maths (STEM) skills and careers in Australian schools. The association, which represents more than 60 000 businesses, has called on industry to invest in the future workforce by getting their staff into Australian classrooms.

CSIRO's partnership with Ai Group is through the Scientists and Mathematicians in Schools (SMiS) program, which links practising scientists, mathematicians, engineers and IT professionals with students to generate interest and motivation in STEM through real-world exposure.

Of the 1972 active program partnerships across Australia, only 13% of STEM professionals come from industry and corporate businesses.

Cisco, an Ai Group member, is involved in the SMiS program as part of their organisational commitment to

tackle Australia's STEM skills shortage. Cisco Australia Vice President and SMiS mentor Sae Kwon said it was a real privilege to give back to the students who will be tomorrow's great innovators.

'It's great to be able to talk about the cool jobs available, the great people you get to meet, the many countries you can visit and all the fun you can have working in STEM.'

AiGroup Chief Executive Innes Willox explained that participation in STEM subjects is declining but industry can do more to support the Australian economy with a robust skills pipeline.

'Our relative decline of STEM skills is holding back our national economy and causing real frustration for employers,' Willox said.

According to the Ai Group and the Office of the Chief Scientist's STEM Skills Partnerships program, 75% of the fastest growing occupations require STEM knowledge and skills but the number of students coming out of university is not keeping up with this demand.

CSIRO Education Manager Mary Mulcahy said students' interest in STEM subjects is decreasing, and we need to solve this early on in schooling to ensure the future workforce pipeline can meet our future demand.

'Our evidence shows that bringing real-life, hands-on STEM into classrooms results in students being more engaged in these subjects,' Mulcahy said.

'Letting students know about the diversity of careers available to them is also important – jobs from accounting, construction, nursing to hairdressing all use STEM skills.'

Industry also tells us that people with STEM backgrounds are more flexible and innovative and are able to take advantage of opportunities and changes in the workplace.

This will be important in the future because it is predicted that up to 44% of current jobs will disappear within 20 years.

CSIRO

Australian experts provide star power to global fusion energy project



The ITER facility under construction in southern France. ITER

ANSTO's CEO has signed an agreement with the Director-General of the ITER International Fusion Energy Organisation to join an international consortium of countries that will lend expertise on the groundbreaking ITER fusion project in southern France.

Seven member entities, comprising 35 countries, are collaborating to build ITER – in the largest engineering project in the world.

Scheduled to begin operations in 2025, ITER will be the first fusion device to produce more energy than it consumes.

This is the first time a non-ITER member country has reached a technical cooperation agreement to work on the project, and connects the Australian community of fusion experts with those from the European Union, China, India, Japan, Russia, the US and South Korea.

Australian researchers and innovators will now work with international experts on this massive engineering project, determining the feasibility of fusion energy as a large-scale, greenhouse-gas-free energy source.

ANSTO's involvement allows all relevant Australian researchers to engage with ITER.

Speaking at the ITER facility in Saint-Paul-lez-Durance, during the signing ceremony with the ITER Director-General Bernard Bigot and accompanied by ANU Professor John Howard, ANSTO CEO Dr Adi Paterson said, 'Fusion is the Holy Grail for energy production and if achieved at a large-scale would answer some of the world's most pressing questions relating to sustainability, climate change and security.'

'This agreement is the mechanism through which Australians will be able to engage with ITER. In addition to ANSTO, Australian participants include the ANU, the University of Sydney, Curtin University, the University of Newcastle, the University of Wollongong and Macquarie University.'

The ITER project was established in 2006 and the first plasma is expected to be produced by December 2025.

ANSTO

Queensland sewer technology bound for international markets



USP general manager Tom Walkosak says that, according to the Water Infrastructure Network, the total annual cost of hydrogen sulfide corrosion in the US sewer network in 2000 was \$US13.75 billion. Greg L/CC BY-SA 3.0

A treatment developed at the University of Queensland to control sewer odour and corrosion is set for the international market. Researchers from the University of Queensland's Advanced Water Management Centre developed the technology, which uses free nitrous acid to remove biofilms that adhere to the inner surfaces of sewer mains.

University of Queensland commercialisation company UniQuest has negotiated an exclusive licence agreement with USP Technologies, an Atlanta-based provider of chemical treatment programs for water and wastewater applications.

Lead researcher and Advanced Water Management Centre Director Professor Zhiguo Yuan said the technology was developed with municipal wastewater collection systems in mind.

'Corrosion and odour problems in sewers are most often caused by sulfate-reducing bacteria in sewer biofilms that produce hydrogen sulfide,' Yuan said.

'Hydrogen sulfide is released into the atmosphere above the wastewater, causing odour problems, and is converted by sulfide-oxidising bacteria into sulfuric acid, which is corrosive to concrete sewer pipes.

'Most existing treatments for managing sulfide-related problems in sewers involve sewer pipe lining, sewer air ventilation with follow-on air treatment and round-the-clock chemical dosing, resulting in high operating costs.'

USP general manager Tom Walkosak said, 'This technology is different from existing treatments because it is delivered intermittently, provides longer duration control and effectively stops the production of hydrogen sulfide at its source.'

USP expects to market for the technology in North America, Australia, China and Europe.

University of Queensland

Automatic solvent extractors

With the option of three or six simultaneous determinations, the Velp SER158 series of fully automated solvent extractors offer state-of-the-art technology for fast high sample throughput, and precise, accurate fat determination in accordance with the Randall or Twisselmann techniques.

A smart User Interface, **Load & Go** allows easy operation. Simply prepare the sample and start with one-click. VELP extraction units are equipped with high-tech sensors allowing 24/7 analysis: the extractor automatically shuts down after the last analysis, without operator intervention.

The unique patent-pending titanium condensers use minimal cooling water (1 L/min) and combined with VELP technology, which enables more than 90% of solvent recovery, delivers unparalleled performance and makes these instruments cost-efficient and environmentally friendly.

The SER 158 provides reliable and accurate results via an improved extraction process compared to the traditional Soxhlet method (five times faster). The determination of extractable matter is performed with a solid-liquid extraction process. The SER 158 guarantees excellent reproducibility and compliance to the major standards.

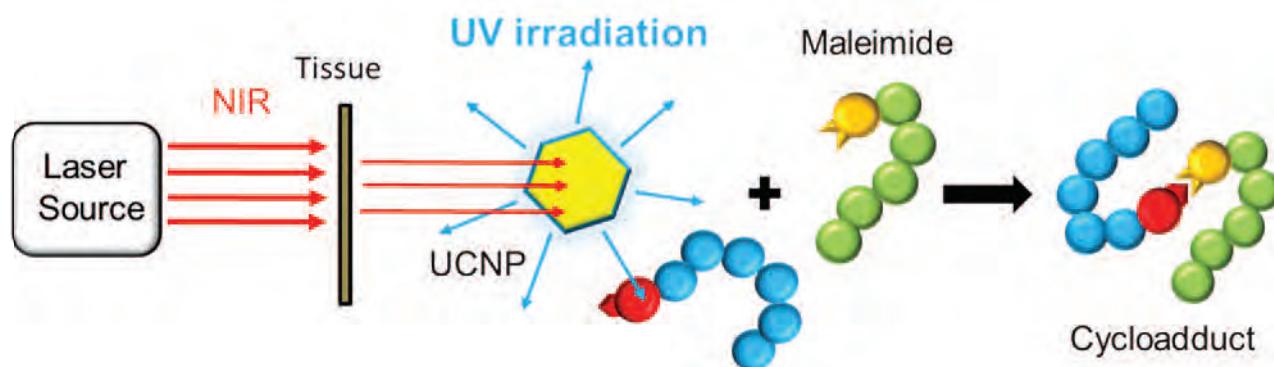


With a powerful new 7-inch display ControlPad, you can connect additional units, increasing capacity as your demands grow. A single ControlPad is able to connect four SER 158 units, giving you a maximum of 24 active positions processing up to 168 samples/day. The units have an intuitive User Interface for versatile data management and Ethernet connection, multi-lingual support and three USB ports.

The SER 158 safe **SolventXpress™** technology allows safe solvent dispensing, minimising operator exposure. The protective transparent cover seals the instrument and sensor control ensures a safe and reproducible analysis, time after time.

For more information, contact your local Rowe Scientific office or visit www.rowe.com.au.

A gentler approach to joining molecules



The ability to trigger the coupling of two molecules with light is an important tool in many scientific fields. A range of efficient light-induced ligation methods exists, but most coupling techniques to date have used UV light as a trigger. Such high-energy irradiation can cause decomposition or by-product formation in (bio)organic species. In addition, for in vivo applications, the depth penetration of UV light is limited as a result of absorption by tissue. Therefore, strategies that allow photo-coupling reactions to occur at longer wavelengths are desirable. The teams of James Blinco and Christopher Barner-Kowollik at the Queensland University of Technology and Karlsruhe Institute of Technology, Germany, and Si Wu at the Max Planck Institute for Polymer Research, Germany, have

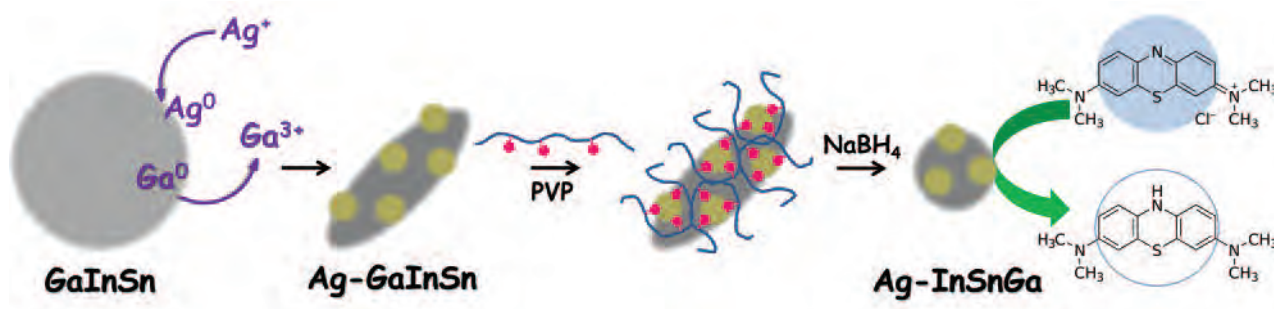
combined the chemistry of near-infrared (NIR) absorbing upconversion nanoparticles with the established nitrile imine-mediated tetrazole-ene cycloaddition reaction to yield a novel photoligation technique that can be activated at 980 nm (Lederhose P., Chen Z., Müller R., Blinco J.P., Wu S., Barner-Kowollik C. *Angew. Chem. Int. Ed.* 2016, **55**, 12 195–9). Full conversion of reagents and exclusive formation of the desired cycloadducts were observed. Enhanced penetration of the NIR light was also demonstrated with successful through-tissue reactions. Furthermore, carrying out ligation of a biologically active biotin moiety to full conversion resulted in no decrease in biotin bioactivity, demonstrating the potential of the technique for in vivo applications.

Plating liquid metal

The galvanic replacement reaction is a simple process in which a solid sacrificial template such as Ag is oxidised in the presence of ions of a different metal with a higher reduction potential, such as Au^{3+} . The latter are subsequently reduced to the metallic state at the template surface. This process has yielded a variety of nanostructured metals with many applications. Research by the O'Mullane group at the Queensland University of Technology has extended the concept

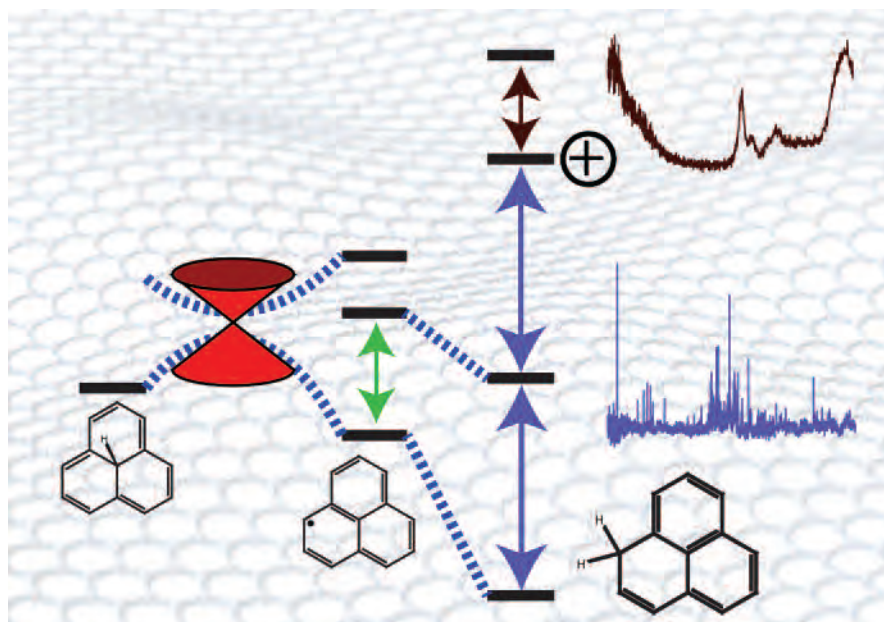
from solid particles to liquid metal (Hoshyargar F., Crawford J., O'Mullane A.P. *J. Am. Chem. Soc.* 2016, doi: 10.1021/jacs.6b05957). The researchers have shown that a droplet of liquid galinstan (70% Ga, 20% In and 10% Sn) can be galvanically replaced to create a liquid metal core surrounded by a solid metal shell whose shape depends on the type and concentration of the metal ion used. In addition, sonication of the liquid metal into microdroplets,

followed by galvanic replacement by silver or gold in the presence of the nanoparticle capping agent polyvinylpyrrolidone (PVP), creates galinstan-based nanorice-like structures decorated with silver or gold nanoparticles. This process could be used to recover precious metal salts from solution or its products could be employed as redox-active catalysts for reducing organic dyes.



Graphene in space?

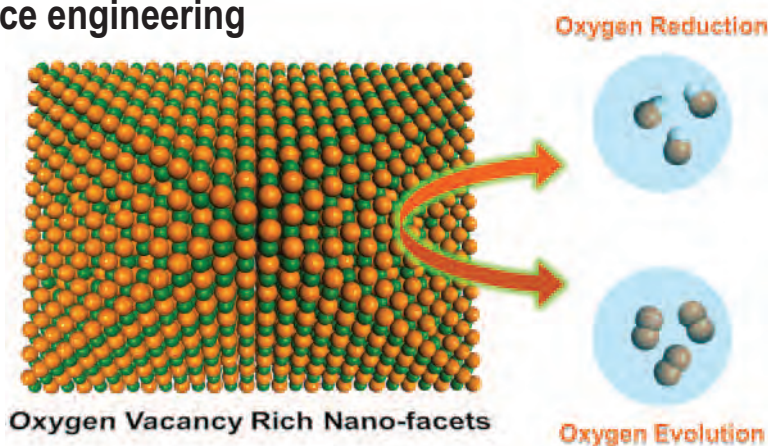
Addition of hydrogen to graphene alters the delocalised π -electron structure, altering graphene's electronic and magnetic properties. Chemisorption of hydrogen on graphene is also believed to catalyse the formation of interstellar H_2 . Because the size of graphene is beyond the reach of chemically accurate calculations, properties of hydrogenated and protonated graphene can only be determined through more approximate quantum-chemical methods. These methods can be benchmarked through the study of smaller model systems. A collaboration between the laboratories of University of New South Wales's Tim Schmidt, the University of Melbourne's Evan Bieske and the University of Sydney's Richard Payne and Leo Radom has examined the hydrogen-adduction and proton-adduction properties of the smallest polycyclic subunit of graphene, the phenalenyl radical (O'Connor G.D., Chan B., Sanelli J.A., Cergol K.M., Dryza V., Payne R.J., Bieske E.J., Radom L., Schmidt T.W. *Chem. Sci.* 2016, doi: 10.1039/C6SC03787A). Electronic spectra of two electronic states of 1H-phenalene and three electronic states of its cation, recorded in the gas phase through resonant-ionisation and resonant-dissociation techniques, have been examined and assigned by advanced quantum-chemical



methods. This has allowed properties such as the ionisation energy and the ground- and excited-state bond dissociation energies to be determined. This work sheds light on the chemical species responsible for interstellar absorption features (diffuse interstellar bands).

Better catalysts through atomic surface engineering

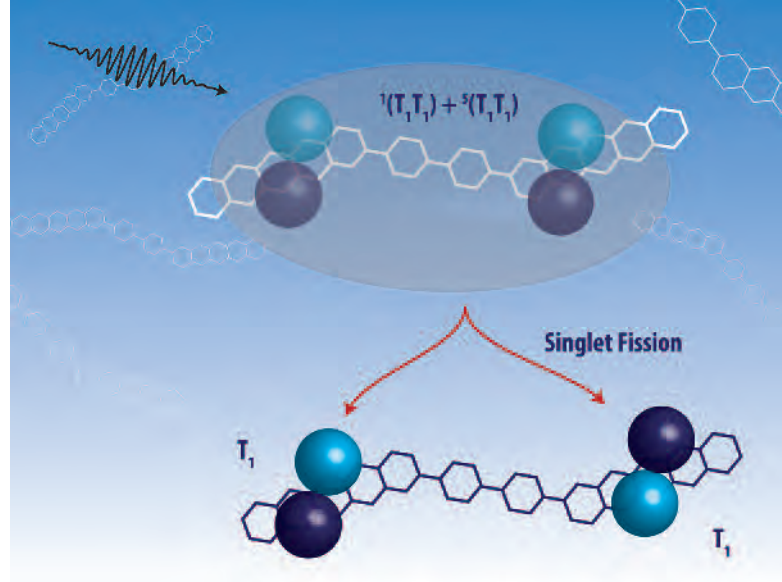
Electrocatalysts play crucial roles in sustainable energy production, for example in fuel cells, metal-air batteries and water splitting. At present, noble metals remain the most efficient electrocatalysts, but high cost, scarcity and unsatisfactory durability impede their widespread application. Although transition metal oxides have proved to be exceptionally promising for electrocatalysis, their activity and stability must be improved to fulfill the requirements of practical applications. The research team of Professor Shizhang Qiao at the University of Adelaide, in cooperation with Associate Professor Tao Ling at Tianjin University, China, has made significant steps towards this goal by developing single-crystal cobalt oxide nanorods with catalytically active nanofacets as highly effective and durable electrocatalysts (Ling T., Yan D.-Y., Jiao Y., Wang H., Zheng Y., Zheng X., Mao J., Du X.-W., Hu Z., Jaroniec M., Qiao S.Z. *Nat. Commun.* 2016, **7**, 12876). The team demonstrated that oxygen vacancies on the nanofacets favourably influence the electronic structure



of cobalt oxide, promoting rapid charge transfer and optimal adsorption energies for intermediates of the oxygen reduction and evolution reactions. This work holds promise for enhancing the electrocatalytic performance of transition metal oxide catalysts through surface atomic structure engineering.

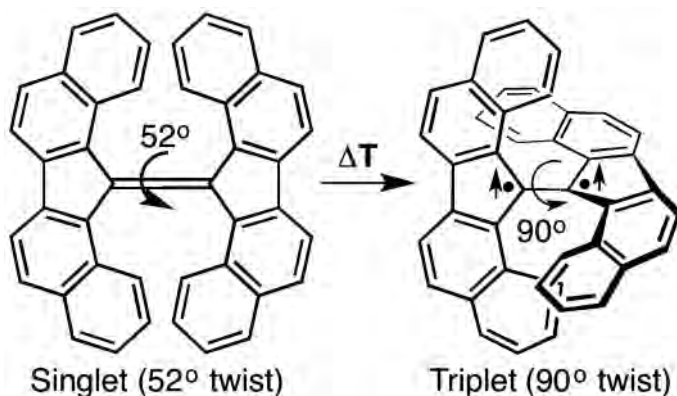
Singlet fission fate

Singlet fission is an electronic process wherein an excited singlet undergoes a spin-allowed transition to two triplets on neighbouring chromophores. The process, which is the reverse of triplet–triplet annihilation, was first observed in the 1960s but has only recently become the focus of intense research because of its potential application in photovoltaic technologies. While the initial and product states are well characterised in a wide range of molecular systems, considerable ambiguity remains as to the nature of intermediate states. Recently, scientists from the University of New South Wales, Columbia University and Brookhaven National Laboratory, USA, used laser spectroscopy and magnetic resonance techniques to study the spin properties of photogenerated states in covalently bridged pentacene dimers (Tayebjee M.J.Y., Sanders S.N., Kumarasamy E., Campos L.M., Sfeir M.Y., McCamey D.R. *Nat. Phys.* 2016, doi: 10.1038/nphys3909). They observed that a surprisingly long-lived quintet triplet–triplet pair state $^5(T_1T_1)$ is generated upon dephasing of the $^1(T_1T_1)$ state that is produced upon singlet fission. Moreover, they



showed that the population of coupled (T_1T_1) and localised decoupled triplets ($2 \times T_1$) can be engineered by modulating the length of the covalent bridge between pentacene moieties. In principle, control over these paramagnetic species has applications in fields ranging from organic optoelectronics to spintronics.

Alkene diradical with a twist



The rotational barrier of ethylenic C=C double bonds is known to be about 65 kcal/mol. The transition state of the rotation is formally a 90° twisted diradical, which, if it were allowed to exist in that form, would be a triplet excited state of the alkene. The group of Curt Wentrup at the University of Queensland, in collaboration with Peter Comba at the University of Heidelberg,

Germany, has recently observed a thermally populated, perpendicularly twisted, triplet alkene diradical arising from rotation about the central C=C bond in the sterically overcrowded bis-dibenzo[*a,i*]fluorenylidene (Wentrup C., Regimbald-Krnel M.J., Müller D., Comba P. *Angew. Chem. Int. Ed.* 2016, doi: 10.1002/anie.201607415). The ground state of this molecule is the

singlet, twisted at an angle of 52°, but even at room temperature the 90° twisted triplet state is observable by ESR spectroscopy, with the amount increasing with temperature. From the temperature dependence, a singlet–triplet (S–T) energy splitting of only 9.6 kcal/mol was determined, which arises from a combination of delocalisation in the π system and steric destabilisation of the ground state. The importance of the phenomenon is illustrated, for example, by Feringa's use of overcrowded ethylenes in the construction of molecular machines. At the other end of the spectrum, donor–acceptor substituted alkenes (push–pull alkenes) can have very low rotational barriers (less than 5 kcal/mol) but very large S–T gaps (75 kcal/mol) as a result of lowering of the ground-state energy by the push–pull effect, which increases the energy separation from the triplet state.

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

Celebrating RACI and Academy of Science awards

In 2013, the journal started a tradition of inviting the winners of RACI awards, prizes and medals to contribute papers on their work to a special issue of *Aust. J. Chem.* This has now become a yearly event, and this year we have also included chemistry-related prizes and medals awarded by the Australian Academy of Science. Thus, a total of 11 award papers are published in the December issue of *Aust. J. Chem.*

Joe Shapter (Flinders University) was the chief organiser of the very successful and smoothly run RACI Congress in Adelaide in 2014, which earned him a 2015 RACI Citation. He is contributing a research paper with co-workers Z. Alhalili, D. Figueroa, M.R. Johnston and B. Sanderson: 'Effect of modification protocols on the effectiveness of gold nanoparticles as drug delivery vehicles for killing of breast cancer cells'.

Ian Rae (Melbourne), winner of the 2015 Leighton Memorial Medal, writes a review on his involvement with the Montreal protocol, entitled 'Substance abuse: carbon tetrachloride and the ozone layer'.

David Jeffery (University of Adelaide), winner of the Analytical Chemistry Division's Peter Alexander Medal, contributes an account on the complex chemistry of wine aromas, entitled 'Spotlight on varietal thiols and precursors in grapes and wines'.

Anthony Weiss (University of Sydney) was the winner of the Applied Research Award. He is contributing a review on perspectives on the molecular and biological implications of tropoelastin in human tissue elasticity.

Colin Jackson (ANU), winner of the Organic Division's Rennie Memorial Award, presents a review with co-authors E. Sugrue, C. Hartley and C. Scott on the evolution of new catalytic mechanisms for xenobiotic hydrolysis in bacterial metalloenzymes.

Lara Malins, formerly a PhD student at the University of Sydney under Professor Richard Payne and now a postdoc at University of California, San Diego, won RACI's 2015 Cornforth

Award for the best PhD thesis and contributes a highlight on transition-metal promoted arylation: 'An emerging strategy for protein bioconjugation'.

Christopher Gordon Newton, the Organic Division's inaugural Mander awardee for the best PhD thesis in organic chemistry, then a student in Professor Sherburn's group and now a postdoc at the EPF Lausanne, is contributing a review together with E.G. Mackay on masked ketenes as dienophiles in the Diels-Alder reaction.

Jonathan George (University of Adelaide) was awarded the Organic Division's Beckwith Lectureship and contributes a research communication with co-workers K.K.W. Kuan and A.M.C. Hirschvogel: 'A biomimetic synthetic approach to the frondosins'.

Chengzhong (Michael) Yu (University of Queensland) won the Le Fèvre Memorial Prize (issued by the Academy and presented by the RACI). He contributes a research paper with co-workers C. Lei, L. Zhou, C. Xu, X. Sun and A. Nouwens on binder-free TiO_2 monolith packed pipette-tips for the enrichment of phosphorylated peptides.

Denis Evans (ANU) is the 2015 winner of the David Craig Medal of the Academy of Science and presents a research paper with co-workers Stephen Williams and Debra Bernhardt on a derivation of the Gibbs equation and the determination of change in Gibbs entropy from calorimetry.

Jeffrey Reimers (University of Technology Sydney and Shanghai University) is the 2016 winner of the David Craig Medal of the Academy of Science and presents an account entitled 'David Craig Medal 2016: putting Craig's legacy to work in nanotechnology and biotechnology'.



Planning has started for a special issue based on the 2016 Awards and Prizes. All research-oriented awardees are invited to contribute a paper, account or review by 1 June 2017 (www.publish.csiro.au/nid/54/aid/206.htm).

Curt Wentrup FAA, FRACI CChem

Errata

On page 18 of the October issue, the year of Clayton Lockett's execution should have been stated as 2014, rather than 2009.

On page 13 of the November issue, the reference to silicon should have been to selenium.

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The knowledge-oriented traveller



Yuriy Chaban/iStockphoto

There's no reason to leave your scientific curiosity at home when you take a holiday, says Terry Clayton.

Charles Darwin gave us more than *On the origin of species*. He invented science tourism. What else should we call a five-year voyage aboard a sailing ship with stops in over 20 ports of call? On shore, Darwin roamed the local countryside, collecting thousands of souvenirs. He called them 'specimens'. He even wrote a travel memoir that was hugely popular at the time and remains in print.

Today, we can do something similar. The Royal Geographical Society, PolarTREC and WiseOceans are just a few of a growing number of tour providers willing to help us realise our inner Indiana Jones.

To see what is on offer, I went exploring on the Earthwatch Institute website and quickly found an archeological expedition in Mongolia. If I signed up, I would be working

under the direction of expert archaeologists, helping them excavate artifacts left behind by the inhabitants of the Ikh Nart oasis as early as 9000 years ago. At the campsite, I would be staying in a traditional Mongolian yurt where a cook prepares meals and I could try traditional Mongolian baked goods and evening meals, including fermented mare's milk and a Mongolian barbecue.

For a growing number of people, this is a fun way to spend a few weeks. Mind you, these trips are not cheap. Two weeks on the Mongolia dig is US\$3000 – but it is a bargain compared to some of the more exotic tours and expeditions.

If getting your knees in the dirt and drinking mare's milk are impractical or a bit too extreme for your taste, there are more traditional tour formats with a strong scientific theme. In the coming year, Australian Geographic Travel With Us is offering expeditions to the Kimberley Coast, an Aboriginal Art Air Tour, a Southeast Asia Expedition and (my favourite) In Shackleton's Footsteps.

Shackleton's Antarctic expedition of 1914–17 was one of the more colourful episodes in a tradition that began in the 1700s with the explosive interest in science and reason we now call The Enlightenment. Along with trade and conquest, scientific curiosity became a new motive for exploration. Darwin's *Beagle* comes about halfway down a long list of scientific voyages aboard military vessels that begins with HMS *Dolphin* in 1764 and continues to this day. Take Australia's Department of the Environment and Energy and their ongoing program of scientific research under their Antarctic Division. Unfortunately, they don't offer tours, but they do have a terrific website, giving us all the opportunity to be armchair Shackletons.

Touring has its own long tradition. Part of the Enlightenment experience was the Grand Tour. Aristocratic young men were routinely packed off with a knowledgeable guide and tutor to absorb the classical roots of Western civilisation in the capitals of Europe and, no less importantly, to meet and greet their fellow aristocrats. Those with a genuine thirst for knowledge could network with the great minds of the day. The tradition declined with the growth of rail and steamship travel and when Thomas Cook introduced mass tourism with the Cook's Tour.

Whatever the month, if you are travelling to some distant shore, it makes sense to extend your trip a day or two to take in a bit of culture and a dash of science ...



A resources tour in the Pilbara, south of the Kimberley region in Western Australia, is a fascinating insight into Australia's iron ore mining industry. Stuart Woollett

Mass tourism today has become the mainstay of more than a few national economies and has splintered into scores of submarkets catering to every imaginable interest. You can pursue your interests in science through agri, atomic, eco, geo or nature tourism. Sadly, there is no chemical tourism.

Or is there?

Tourism doesn't have to mean 'holiday', not if you think of it as 'knowledge-oriented travel'. If you travel extensively for work, consider combining business and pleasure. Just check with your tax accountant what you can claim.

Few trips combine business and pleasure better than the professional conference. You may already know the website chemistry.conferenceseries.com, which lists upcoming conferences around the world by country and topic.

Just for fun, let's see what's on in France.

In 2017, there will be no less than 29 international chemistry conferences in Paris alone. The World Congress on Natural Products Chemistry and



A 1932 statue of Sir Ernest Shackleton stands outside the London headquarters of the Royal Geographical Society.

Michel Wal/CC BY-SA 3.0



Beginning in the mid-17th century, the developing idea of travelling for curiosity's sake was realised in the form of the Grand Tour of Europe (a typical route is shown). Scientific instruments were among the many souvenirs of these adventures. Szarka Gyula/CC BY-SA 3.0

Launching points

Try these search terms in your browser:

- Science museums in Australia
- Scienceworks Melbourne
- Questacon outreach travelling exhibitions
- World's best science centres
- World's best museums

Wiki Science Tourism has a good list of laboratories worldwide that host open days.

The Australian Nuclear Science and Technology Organisation offers tours, kids' school holiday workshops, science conferences and other public events.

CSIRO hosts an annual Science Bootcamp, offers tours and events, and has a discovery centre in Canberra.

Science- and nature-oriented tours:

- Royal Geographical Society
- PolarTREC
- WiseOceans
- Earthwatch Institute
- Australian Geographic Travel With Us

Research sounds like it has wide appeal. That's in October. It is a bit cool and wet in October, but it is off season, so you will get better prices and shorter queues anywhere you venture beyond the conference venue.

Whatever the month, if you are travelling to some distant shore, it makes sense to extend your trip a day or two to take in a bit of culture and a dash of science as I did when I once attended a conference in Townsville. I presented a paper, I learned a lot, and I met new colleagues with whom I stayed in contact for some time afterwards on a professional basis. It would have been a huge lost opportunity to travel all that way from Bangkok and not visit one of the wonders of the natural world, the Great Barrier Reef. I stayed on one more day for a snorkelling tour and consider it a great investment.

Years later, on my way through Paris to a science meeting in Montpellier, I arranged two extra days in Paris to visit the Louvre and the Jardin des Plantes,

France's main botanical gardens. That was November and the Louvre was practically deserted. At the Jardin des Plantes, there just happened to be a lecture on entomology that day I am not particularly interested in entomology, and I understood about every fifth word of the lecture, which was in French of course, but I do love history. The thrill was to be sitting in a lecture that was part of a series dating back to the time of Georges-Louis Leclerc, Comte de Buffon, the man who became curator of the gardens in 1739.

These little layovers were well worth the extra personal expense – and no, you are not skiving off if you do them on your own time and at your own expense. You may even be able to claim a tax deduction for the cost of attending seminars, conferences or education workshops that are clearly connected to your work activities. This can include formal education courses provided by professional associations. Check the Government of Australia website for details.

Even if you can't add any time to your trip, it's not unusual to have the better part of a day waiting for your flight home. What better opportunity for a quick trip to some of the world's great science museums.

Science museums have been around for ages. The Natural History Museum in London was established in 1881 and the Academy of Natural Sciences in Philadelphia goes back to 1812. Closer to home is Te Papa Museum in Wellington. While not strictly a science museum, it has huge collections of fossils and archaeozoology, plant and bird specimens, not to mention the largest giant squid specimen in the world. Most major cities have a science or natural history museum. All you need to do is type 'science museums' in your browser, or go to the Wiki science tourism site, and that takes care of what to do before departure time.

Few of the museums or science centres I have visited in person or

Adding a 'knowledge' orientation to tourism would not only bring in a few extra dollars, it would help make tourism more sustainable.



The architects' impression of a Nobel Center exhibition space. © David Chipperfield Architects

virtually have displays or activities specifically about chemistry. I see a huge opportunity here for chemistry education. Many museums and science centres have travelling road shows and are looking to develop exciting displays.

Also on the lookout for exhibitions is the soon to be opened Nobel Center in Sweden. Museum directors from around the world, including the director of the Australian Centre for the Moving Image in Melbourne, met this year to discuss future exhibitions.

And, finally, there is the chemistry of tourism itself.

Tourism can be a great economic boon to a city, region or country, but there is growing concern about its social and environmental costs. In her recent book *Tourism and oil*, Susanne Becken, Director of the Griffith Institute for Tourism at Griffith University, discusses the impact of oil prices on tourism.

Becken's book looks mainly at economic implications, but it is a good jumping off point for chemistry. For example, any assessment of tourism-related environmental impacts on water, air, soil or waste products would benefit from inexpensive and easy-to-use rapid chemical test kits. UK tourism researcher Louise Twining-Ward teamed up with New Zealand Aid, Samoa Visitors Bureau and the South Pacific Regional Environment

Most popular science centres by number of visitors

1	Cité des Sciences et de l'Industrie, Paris	5 000 000
2	Science Museum, London	2 700 000
3	Shanghai Science and Technology Museum	2 500 000
4	National Science and Technology Museum, Taiwan	2 050 790
5	Museum of Science and Industry, Chicago	1 605 020
6	Pacific Science Center, Seattle	1 602 000
7	Museum of Science, Boston	1 600 000
8	Science City, Kolkata	1 522 726
9	Ontario Science Center, Toronto	1 509 912
10	Deutsches Museum, Munich	1 500 000

Facility to publish an *Indicator handbook* (bit.ly/2eiKVpt) that lists eight environmental concerns. Only one, water quality, comes with a chemical test.

For inspiration, we could look at mobile and web-based apps like iStream, a resource that predicts the concentration of chemicals used in 'down-the-drain' cleaning products, or the Good Fish mobile app you can use to guide your choice of sustainably harvested seafood. Imagine the impact of even a small percentage of travellers refusing to order the fish because it doesn't show up on the sustainably harvested list.

Australia is host to eight million visitor arrivals every year. About half come for holidays and the rest for business, education and visiting friends and relatives. In 2015, visitors

spent \$36 billion in Australia, an average of about \$4500 per visitor. Adding a 'knowledge' orientation to tourism would not only bring in a few extra dollars, it would help make tourism more sustainable.

The UN has declared 2017 to be the International Year of Sustainable Tourism for Development. Three of the Sustainable Development Goals (8, 12 and 14) explicitly address tourism. Conspicuous by its absence is chemistry. Now would be a good time to fix that and, in the process, raise awareness of the recently published Decadal Plan for Chemistry.

I can see it now: the Grand Australian Chemical Trail.

Terry Clayton is a freelance commercial writer, blogger and educator with a wide range of interests in the physical sciences and humanities. See more of Terry's work at www.terryerle.com.



Australia's biophysical chemistry tradition

iStockphoto/v_alex

Ronald J. Clarke
traces the
development of
biophysical
chemistry and its
emergence in
Australia.

It appears that Australian universities and funding bodies are increasingly coming to appreciate interdisciplinary research. This is reflected in part by the number of interdisciplinary centres established in recent years; for example, the Bio21 Institute (Melbourne), the ARC Centre of Excellence for Nanoscale BioPhotonics (Adelaide) and the Australian Institute for Nanoscale Science and Technology (Sydney).

However, interdisciplinary research in Australia isn't new. For more than 60 years, Australia has had a tradition of research in biophysical chemistry, a truly interdisciplinary field, overlapping biology, physics and chemistry. At its centre is the solving of biological problems, and striving for deep understanding based on mathematical theories and principles from the physical sciences.

Significant advances must still be made within areas of pure physics, chemistry or biology, and experts for specific fields will always be essential. However, many research problems, particularly those related to living systems, cannot be solved by approaches limited to one discipline. Physics, chemistry and biology each have their own languages, but to solve an interdisciplinary research problem, communication across disciplines is required and scientists able to speak the languages of other disciplines play a crucial role.

Consider the major developments that have occurred in science over the past 100 years. The first half of the 20th century can be said to belong to physics, through the development of quantum theory and the revolutionary change in our view of matter and energy that it introduced. Over the second half of the 20th century,

biology was dominant, with the discovery of how genetic information is stored within DNA and the development of gene technology. This broad generalisation appears to leave out chemistry altogether, but this isn't actually so. Nowadays it is impossible to imagine any first-year university chemistry course without quantum theory. It represents a fundamental foundation of chemistry, providing an explanation for structure and bonding and ultimately chemical reactivity.

Modern biology is in fact molecular biology. From the word 'molecular', the core role of chemistry is clear. To understand the development of biophysical chemistry, let's reflect on the origins of molecular biology and how the shift in emphasis between physics and biology occurred in the mid-20th century.

Physicists played a large part in the founding of molecular biology. In 1932, the Danish physicist Niels Bohr gave a lecture entitled 'Light and Life' at a conference in Copenhagen. There, Bohr expressed the opinion that the new idea of the complementary wave-particle nature of matter might be mirrored by a complementary relationship in biology, and, analogous to Heisenberg's uncertainty principle, there could be a limit on our understanding of life itself.

At this lecture was a young German physicist, Max Delbrück (Nobel Prize in Physiology or Medicine, 1969). Delbrück was so influenced by Bohr's lecture that he devoted the rest of his career to biology and the search for the theoretical limit in our understanding of life. In 1935, he published his first biological research paper, in which he and his collaborators showed that genetic information could be mutated or destroyed by X-ray damage, leading to the conclusion that the information was somehow encoded within a molecule present within each living cell.

Although Bohr's influence on Delbrück was certainly decisive for the origins of molecular biology, an

even more pivotal character in the drift from physics to biology was Erwin Schrödinger, the founder of wave mechanics. After Schrödinger fled the Nazi government of Austria, he took up a professorship in Dublin, where in 1943 he held a series of lectures (subsequently published) entitled 'What is Life?'. Schrödinger expressed his views on how genetic information might be encoded within living organisms. First, Schrödinger publicised the work of Delbrück, which hadn't yet received much attention. Second, he suggested that genetic information might be stored within an aperiodic molecular crystal, surprisingly close to the mark considering that a gene was then still an abstract term.

Although Bohr's influence on Delbrück was certainly decisive for the origins of molecular biology, an even more pivotal character in the drift from physics to biology was Erwin Schrödinger, the founder of wave mechanics.

The effect of Schrödinger's book on the development of molecular biology was profound. In their biographies, both Watson and Crick acknowledge its influence on their careers. The fact that it was written by a founder of quantum theory held in such high esteem in the scientific community

contributed greatly to its impact. The timing of the book could also hardly have been better. As World War II ended and scientists everywhere saw where atomic physics had led (i.e. to the atom bomb), many lost interest in physics and were looking for other fields of research. Schrödinger's book gave legitimacy for hordes of physical scientists to move into biology, which led to the burgeoning of the fields of biophysics and biophysical chemistry. To mention one example, Walter Moore, who held the Chair of Physical Chemistry at the University of Sydney from 1974 to 1983, actually worked on the Manhattan Project, but turned his attention to biological molecules (e.g. myelin) after the war.

Another who was profoundly influenced by the atom bomb was Linus Pauling, who became a powerful peace activist. Pauling made significant contributions to molecular biology through discovering the α -helical and β -pleated sheet conformations of protein structures. His earlier work was in X-ray diffraction, quantum chemistry and the nature of chemical bonding. In his case, one couldn't say his move into biology was influenced by the war, for he'd started researching proteins in the mid-1930s. Nor could one say he was influenced by another scientist. For Pauling and for many others, then and since, the motivation to tackle biological questions was most likely the innate drive to search for greater challenges, or the flight from boredom or monotony Pauling had been studying small molecules since the 1920s. For him, it was a natural progression to turn his attentions to the more complex molecules of nature.

Another significant physicist in the development of molecular biology whose motivation parallels Pauling's is the Australian-born Lawrence Bragg. Together with his father, William Bragg, he studied X-ray diffraction of crystals and discovered the relationship between diffraction patterns and the atomic spacing within a crystal lattice.



Denis Oswald 'Doj' Jordan.
Courtesy University of Adelaide Archives

It is well documented that Lawrence Bragg had a lifelong interest in biology, in particular shells, which he collected as a boy on Adelaide's beaches.

In light of his childhood experiences, it seems natural that Bragg would eventually grow tired of studying X-ray diffraction patterns of mineral crystals and would wish to turn to biological macromolecules. As Director of the Cavendish Laboratory, University of Cambridge, 1938–53, he played a crucial role in providing the scientific environment that enabled his team of outstanding scientists to solve both the first three-dimensional protein structures (Perutz and Kendrew) and the double-helical structure of DNA (Watson and Crick). Their successes attracted many others to tackle the complexities of biological molecules, including Hans Freeman at the University of Sydney, whose team in 1977 solved the structure of the protein plastocyanin.

So physicists, both intentionally and unintentionally, contributed greatly to the rise of biology in the middle of the 20th century. Partly due to the impact of Schrödinger's book, the mechanism by which genetic information is stored and transmitted was one of the hottest topics of the time. However, Schrödinger was of the opinion that physics alone could not provide the solution, as is clear from the following quote from *What is life?*: 'Indeed, I do not expect that any detailed information on this question is likely to come from physics in the near future. The advance is proceeding and will, I am sure, continue to do so, from biochemistry under the guidance of physiology and genetics.' As Schrödinger predicted, chemical investigations proved crucial.

Denis Oswald 'Doj' Jordan can be considered the founder of Australia's tradition in biophysical chemistry. Jordan was in the thick of research on DNA in the late 1940s and early 1950s. In 1939, he was appointed as assistant lecturer at University College Nottingham. There he gained his PhD based on research, totally unsupervised, of electrokinetic phenomena, and came into contact with Professor J. Masson Gulland, an organic chemist with a special interest in biological molecules and the application of physical methods. Since 1931, Gulland had been researching the structure of nucleic acids. No doubt keen to have a collaborator with a physicochemical background, Gulland suggested that Jordan investigate the physical chemistry of nucleic acids. This wasn't an easy task because of the difficulty in obtaining pure samples. Eventually, in 1947, they succeeded in developing a preparation of pure DNA from calf thymus. What followed was a series of three ground-breaking studies in which they concluded that DNA was a highly polymeric molecule stabilised by hydrogen bonds between the bases, probably on adjacent chains.

... Lawrence Bragg had a lifelong interest in biology, in particular shells, which he collected as a boy on Adelaide's beaches.

Tragedy struck the same year when Gulland was killed in a train derailment. There's no way of knowing whether Gulland and Jordan would have solved the double helical structure before Watson and Crick if their collaboration could have continued. What is certain is that the work they did accomplish together had a significant impact. In his book *The double helix* Watson wrote: 'But a recent rereading of J.M. Gulland's and D.O. Jordan's papers on the acid and base titrations of DNA made me finally appreciate the strength of their conclusion that a large fraction, if not all, of the bases formed hydrogen bonds to other bases. Even more important, these hydrogen bonds were present at very low DNA concentrations, strongly hinting that the bonds linked bases in the same molecule.'

Following the death of Gulland, Jordan continued his studies on nucleic acids. After a year at Princeton University in 1948, he returned to Nottingham and in 1953 was promoted to reader. By that time John Coates* had started as a PhD student under Jordan's supervision. In his own biographical memoir of Jordan, John reminisced: 'In the late autumn of 1953 Doj announced to his assembled research students that he had been appointed to a chair and after a short pause added "in Adelaide, South Australia"'. The appointment caused no surprise but its location was quite

*John Coates, who was the author's PhD supervisor, died in June. His obituary appears on p. 34.



The Johnson laboratories, where Jordan worked at the University of Adelaide. Courtesy University of Adelaide Archives

unexpected; indeed some, not Test cricket enthusiasts, had no idea where Adelaide was!'

What motivated Jordan's acceptance of the position as professor of physical chemistry at the University of Adelaide is unclear. Jordan may have remembered that Gulland's PhD supervisor, Sir Robert Robinson, was Professor of Pure and Applied Organic Chemistry at the University of Sydney from 1912 to 1915. That a stint in Australia didn't do his career any harm was clear, because in 1947 Robinson was awarded the Nobel Prize for investigations on plant alkaloids. Jordan's stint would last for the rest of his life.

In Adelaide, Jordan broadened his research to encompass synthetic

polymers as well as natural polymers, but the overall themes of his research remained, i.e. to understand the stability of the DNA structure and determine how the solution chemistry of polymers depends on their structure and stereochemistry. With time, Jordan built up his new Department of Physical and Inorganic Chemistry into one of the strongest and most active in Australia. In 1963, he succeeded in finding funding for a new building, which in 1981 was named the Jordan Laboratories in his honour. He was very active within the Australian chemical community, particularly the RACI. He organised the first national polymer chemistry conference in Adelaide in 1957, which led to the founding of the RACI Polymer Division. The Division's highest award for

outstanding work in polymer chemistry is named the Batteard–Jordan Medal in recognition of his contributions to the polymer field in Australia.

Through the PhD students Jordan supervised and their own subsequent students who continued to work in the field and established their own personal areas of expertise, biophysical chemistry has spread throughout Australia, with members of academic staff at the ANU, University of Technology Sydney, and the Universities of Melbourne, Sydney, Queensland, Adelaide and South Australia able to trace their academic ancestry back directly to D.O. Jordan.

Ronald J. Clarke MRACI CChem is at the School of Chemistry, University of Sydney. The author thanks Jenny Turner and Philip Kuchel for helpful discussions.

Celebrating chemistry 2016

fotojog/iStockphoto

Dave Sammut takes a light-hearted look at some of this year's chemistry highlights.

Periodicity

The biggest chemistry news so far this year has been the proposed naming of the four newest elements. The names nihonium, moscovium, tennessine and oganesson have entered our lexicon, for elements 113 (Nh), 115 (Mc), 117 (Ts) and 118 (Og). These were proposed by their attributed discoverers, and by the time of publication should have been ratified (or rejected) by IUPAC.

Nihonium, named for Japan, was proposed by the RIKEN Nishina Center for Accelerator-based Science in Wako, near Tokyo.

Moscovium and tennessine, for Moscow and Tennessee respectively, were jointly proposed by the collaboration of the Joint Institute for Nuclear Research in Dubna, Russia, and the Lawrence Livermore National Laboratory in California, USA. The same collaboration proposed the naming of oganesson in honour of Yuri Oganessian 'for his pioneering

contributions to transactinoid elements research'.

Coffee mug manufacturers worldwide have expressed disappointment that elements don't better lend themselves to spelling words. 'We need more element vowels,' said Joe Caffeine, spokesperson for the Coffee Mug Association, 'The caffeine molecule can only take us so far.'

In an effort to stay relevant, mathematicians announced the discovery of a new prime number, the biggest so far: 'We took the biggest number that we could think of, and added one.' But at just 22 million digits, chemists laughed off the 'discovery' with the witty retort 'Avagadro, ya mug'.

Meanwhile, chemists are celebrating having reached the end of our laboratory days. The periodic table is complete, everyone. We can all go home now, maybe go out and get a little sun (wearing sunblock... which we invented).

113 Nh Nihonium (286) <small>Rdsmith4/CC-BY-SA 2.5</small>	114 Fl Flerovium (289)	115 Mc Moscovium (288) <small>A. Savin/CC-BY-SA 3.0</small>	116 Lv Livermorium (293)	117 Ts Tennessee (294) <small>Kremlin.ru/CC-BY 4.0</small>	118 Og Oganesson (294)
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In space, no one can smell your steam

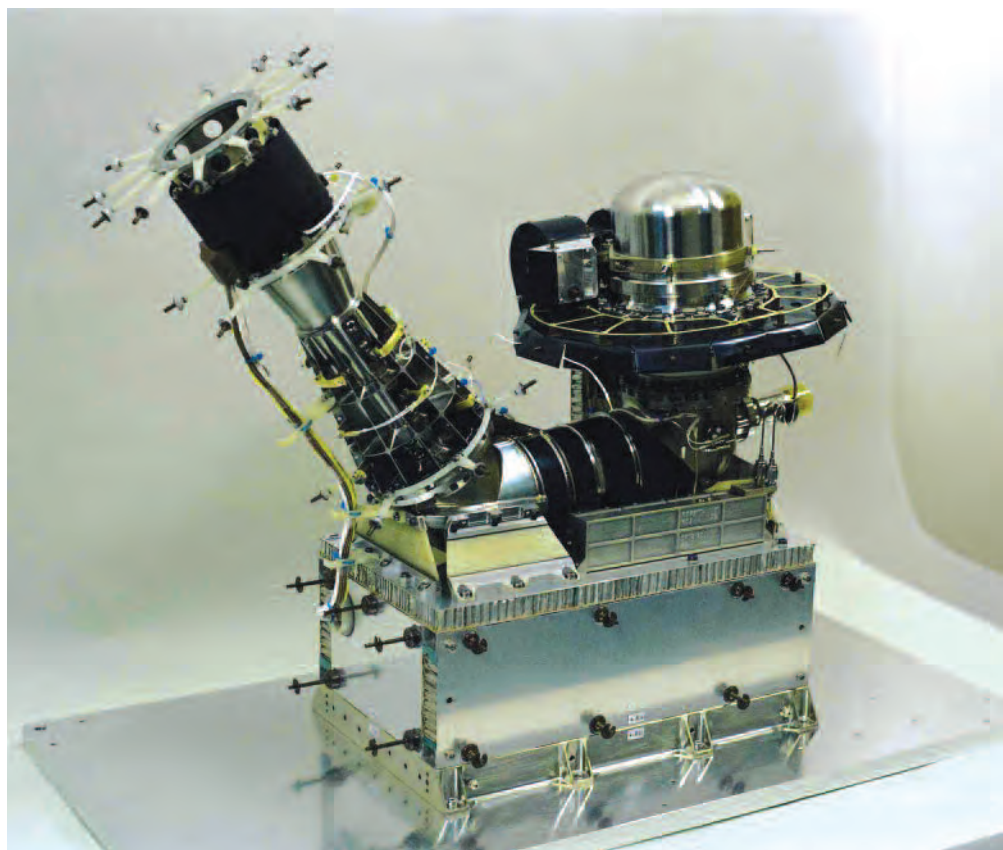
Since the Rosetta probe came close enough to comet 67P/Churyumov-Gerasimenko, ongoing analysis using double-focusing mass spectrometry and reflection time-of-flight mass spectrometry has detected the expected water, carbon monoxide and carbon dioxide, but also key life ingredients such as glycine and its precursors, and phosphorus, and key life-ending compounds such as hydrogen cyanide.

With krypton and xenon also detected in 2016, some might say the possibility of fugitive interstellar superbeing refugees has not been absolutely ruled out. I can just imagine a Federal Minister for Alien Affairs (yet to be appointed) responding: 'I don't care if they can fly; no unauthorised superbeing will ever be allowed on this country's soil. They can just stay airborne.'

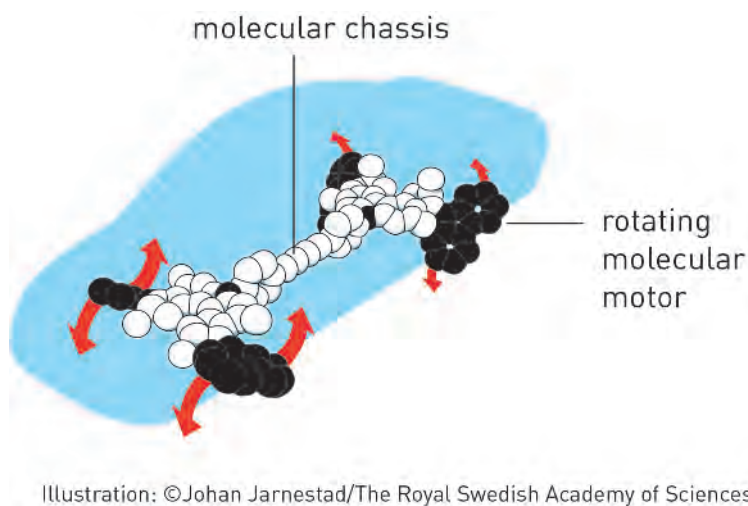
Collectively, comet 67P has been described as smelling of 'rotten eggs, cat pee and bitter almonds'.

UK perfumers The Aroma Company, in collaboration with Open University scientist Dr Colin Snodgrass, have reproduced the comet's aroma in 2016, coming soon to a counter near you. Professional chemists have been observed carefully wafting the Aroma Company's scent-imprinted cards within the safe confines of their fume cupboards.

... comet 67P has been described as smelling of 'rotten eggs, cat pee and bitter almonds'.



For the European Space Agency's Rosetta mission, NASA provided part of the electronics package for the double-focusing mass spectrometer (pictured), which is part of the Swiss-built Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) instrument. ROSINA is the first instrument with the resolution to separate two molecules that have approximately the same mass: molecular nitrogen and carbon monoxide. Clear identification of nitrogen will help scientists understand conditions at the time the solar system was born. University of Bern/Lockheed Martin



Nobel endeavours

On the basis of the parental advice 'good things come in small packages', the 2016 Nobel Prize in Chemistry has been jointly awarded to Jean-Pierre Sauvage, Sir J. Fraser Stoddart and Bernard L. Feringa 'for the design and synthesis of molecular machines' (see p. 7). Given that the most sophisticated molecular machine developed so far has been a ring and axle, pundits have observed that it seems overkill to be handing out prizes for literally reinventing the wheel.

In March, it was reported that global average temperatures had briefly spiked 2°C above the pre-industrial average.



Feeling hot, hot, hot

This year has been a big one for climate science. In March, it was reported that global average temperatures had briefly spiked 2°C above the pre-industrial average. The University of Massachusetts Amherst reported that sea-level rises could nearly double over earlier estimates in the next 100 years. And the Max Planck Institute for Chemistry reported that in future decades, the Middle East and North Africa could become so hot that human habitability is compromised. The more sarcastic residents of Dubai might well respond: 'Have you *been* to the Middle East lately?'

In related news, reports of the first successful gene therapy to lengthen telomeres and thereby delay ageing has caused some conservative politicians to sit up and take notice. With the possibility that they might live long enough to be affected by climate change, they are suddenly much less keen to debunk the scientific consensus.



The water of the Rio Olympic diving pool turned green after 80 litres of hydrogen peroxide was mistakenly added to the pool during cleaning. The hydrogen peroxide neutralised the chlorine and allowed algae to bloom. Fernando Frazão/Agência Brasil/CC-BY-2.0

Faster, stronger, greener

Chemistry is of course fundamental to every aspect of daily life, but this fact was brought to the world stage at the 2016 Rio Olympics diving pool. Billed as the 'Greenest Olympics ever', the organisers took the marketing hype to extreme levels.

The diving pool was slammed by German diver Stephan Feck as smelling like a 'fart'. Australia's swimmers were more sympathetic, combining the bleaching of the excess chlorine added in response to the crises with the residual algae to put on a truly patriotic display of green and gold.

RACI National Award winners

RACI congratulates all the RACI National Award winners who are celebrating winning prizes for 2016. Full details will be published in the February edition.

I would like to thank the RACI for allowing me to write for *Chemistry in Australia*, and most particularly Sally Woollett (Editor) and Catherine Greenwood (Production Editor) for all of their hard work, guidance and patience throughout the year.

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.



Richard Payne wins Malcolm McIntosh Prize for Physical Scientist of the Year

For his revolutionary drug development technologies, Professor Richard Payne MRACI CChem from the University of Sydney has been awarded the 2016 Malcolm McIntosh Prize for Physical Scientist of the Year.

Drugs based on proteins found in nature have huge medicinal potential. Take stroke for example – the leading cause of disability in Australians. Blood-sucking leeches, ticks and mosquitoes all produce powerful anticlotting proteins to ensure they get a good feed from their victims. But turning these proteins into drugs is difficult and usually involves making the proteins in mammalian or insect cells, then harvesting and trying to purify the protein.

Payne's technologies bypass those challenges. Instead, he recreates the protein in the chemistry laboratory, building it one amino acid at a time. Along the way, he can tweak the pure protein to fine-tune its performance.

He has recreated the anticlotting agents found in ticks and modified them to make them into potent anticlotting drugs that cause less bleeding than currently used anticoagulant therapies. These drugs are expected to enter pre-clinical assessment in the next year.

The complications and cost of conventional drug discovery has meant that new drugs that are desperately needed to treat TB and malaria – two enormous global health problems – have been slow to emerge.

Following support from the Bill and Melinda Gates Foundation for his PhD at Cambridge, Payne is prioritising the use of his new technologies to tackle global health issues. For malaria, he's developing modified versions of gallinamide A, a peptide-based natural product found in marine bacteria in the West Indies, that have shown excellent results at clearing a malarial infection in vivo. He's also working with compounds from soil bacteria that show strong antibiotic effects and kill drug-resistant strains of TB.



Prime Minister's Prizes for Science/WildBear

One-third of the world's population (about two billion people) are thought to be infected with TB. It kills more than 1.5 million people per year and is becoming resistant to most of the drugs used to treat it. Payne hopes that his TB drug candidates will lead to new and effective drugs within the decade.

Payne and his team have also developed the first fully synthetic cancer vaccine candidates possessing all the components required to stimulate an immune response for the eradication of tumours.

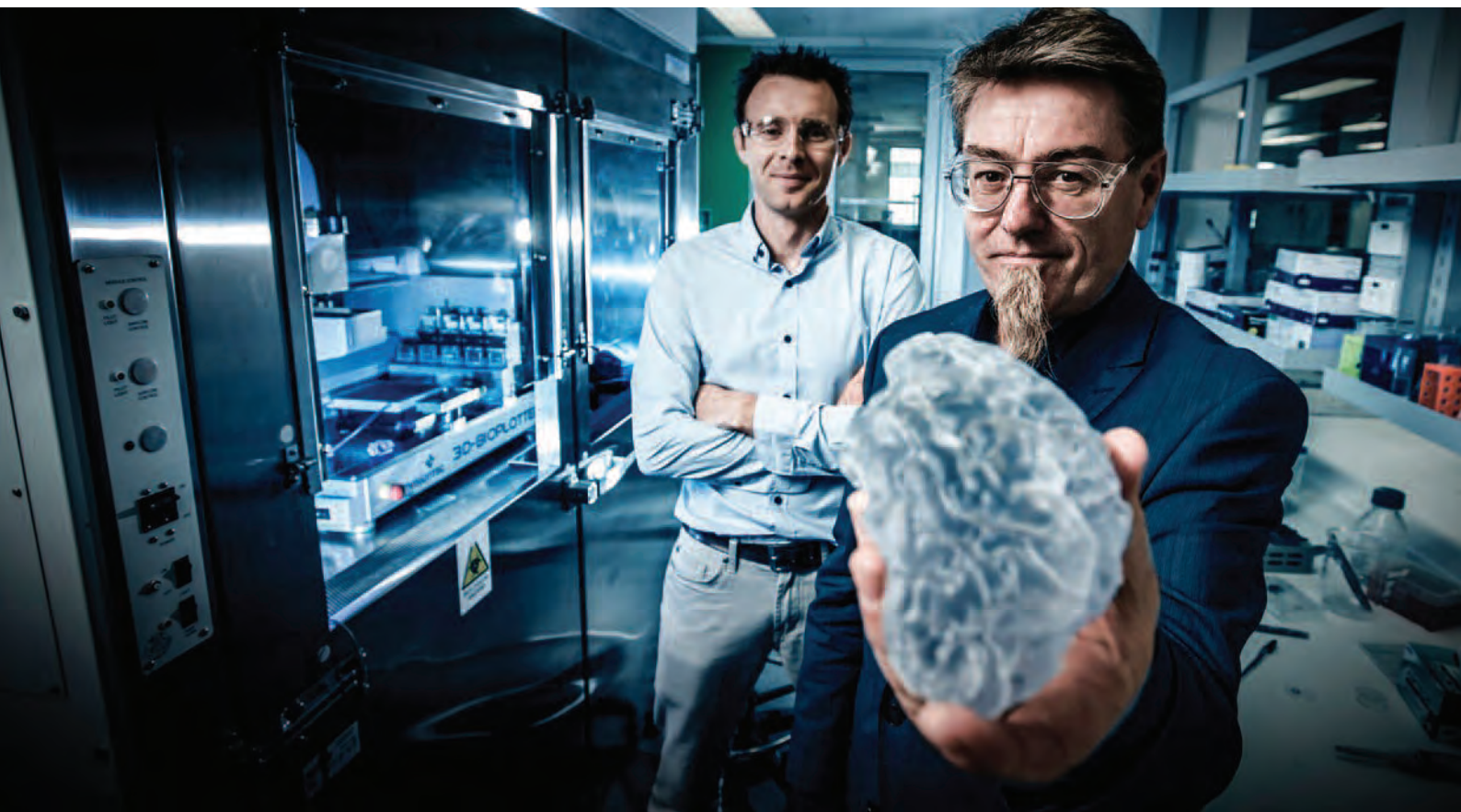
Certain proteins on cell surfaces are decorated with sugar molecules. Payne

has shown that cancer cells produce more of these sugar molecules and that they have different chemical structures from the molecules on normal cells. He's made segments of these sugar-derived proteins and shown that they can generate antibodies that attack cancer cells selectively. Work is underway to test these potential vaccines in models of pancreatic cancer and breast cancer.

Richard Payne is Professor of Organic Chemistry and Chemical Biology at the University of Sydney. He is an Australian Research Council Future Fellow.

Science in Public

Smart materials pioneer wins Eureka prize



Professor Gordon Wallace and a 3D printing polymer model of a brain, with colleague Dr Stephen Beirne. University of Wollongong

Professor Gordon Wallace FRACI CChem has won the CSIRO Eureka Prize for Leadership in Innovation and Science.

Recognised for his work as an internationally renowned researcher at the University of Wollongong's ARC Centre of Excellence for Electromaterials Science (ACES), Wallace was commended at the Eureka Prize gala dinner in Sydney, for his cultivation of a research vision in the area of 'intelligent polymers'.

The Eureka Prizes are Australia's most comprehensive national science awards, presented annually by the Australian Museum to reward outstanding achievements in Australian science.

Wallace said his Eureka Prize acknowledged the pioneering work undertaken by his collaborative team, in the use of nanotechnology and additive fabrication in renewable energy and medical science.

'This award acknowledges the ability of ACES and its partners to take fundamental discovery to real applications,' Wallace said.

'It takes an integrated, cohesive and committed team to achieve this.'

'A great team can make most people look like a good captain.'

In his acceptance speech, Wallace thanked the people he has worked with over his 30 years at the University of Wollongong.

'Thank you to the hundreds of people I've worked with around this country, especially those at ACES and the Australian National Fabrication Facility,' Wallace said.

'Thank you also to the community we work for. You can be assured that you have around this country, research scientists totally committed not only to discoveries in the lab, but to translating those discoveries to practical outcomes in the most effective and efficient way possible, so that we can all lead better lives.'

Natalie Foxon Phillips, University of Wollongong Media

John Hewlett Coates, 1932–2016

Biophysical chemist

John Coates died on 10 June 2016 at the age of 83. He had a distinguished career in the Department of Physical and Inorganic Chemistry at the University of Adelaide. John's contributions to science were mainly in biophysical chemistry, a field in which he was a pioneer in Australia.

John was born in Ringstead in Northamptonshire, UK. He studied chemistry at Nottingham University and began his PhD work in the early 1950s on the chemistry of DNA with the physical chemist Denis Oswald 'Doj' Jordan, who together with J. Masson Gulland, an organic chemist, had begun carrying out research on DNA a few years earlier.

When Jordan was appointed to a professorship in physical chemistry at the University of Adelaide, John had to choose between emigration to Australia or changing his PhD topic and completing his studies under a different supervisor. John chose Australia. He arrived in Adelaide in 1954 after a long sea journey as a ten-pound passenger. In fact, John arrived a few weeks before Jordan, and, because of this, at the University of Adelaide he was jokingly referred to as 'John the Baptist'. The aptness of this name was reinforced by an earthquake in Adelaide in the night of 1 March 1954. John woke up, realised it was an earthquake, but, since he'd only just arrived, he thought this must be a regular occurrence, and so turned over and went back to sleep.

The only piece of equipment Jordan brought with him to Adelaide was a new analytical ultracentrifuge. John was a heavy user of this instrument and became an expert in the application of analytical ultracentrifugation to biological systems. Together with Jordan, John researched the effect of heat on the stability of DNA and the retardation of its chain melting by electrolytes. Such fundamental work provided a basis on which modern molecular biology could be built, in particular the current application of the polymerase chain reaction.

On his arrival in Adelaide, Jordan immediately gained two honours students, Tom Kurcsev and Ted Treloar, who chose him as their supervisor purely on his reputation. Tom, Ted and John became good friends, and remained in contact for the rest of their lives. Ted later moved to Melbourne and became a member of the academic staff in the Department of Physical Chemistry at the University of Melbourne, whereas John and Tom stayed in Adelaide and gained appointments in the Department of Physical and Inorganic Chemistry. In the 1980s, Tom and John served successive terms as chairman of the department. From 1968 to 1980, John also held the position of Foundation Master of Kathleen Lumley College, one of the University of Adelaide's residential colleges, which provides a home for mostly overseas postgraduate students.

In the 1970s, John switched the emphasis of his research from ultracentrifugation to rapid reaction kinetics. John had several stopped-flow systems, a temperature-jump spectrometer



Courtesy Discipline of Chemistry, University of Adelaide

and a pressure-jump apparatus built in the department's excellent workshops from designs he supplied. From the mid-1970s, he had a long and fruitful collaboration with the inorganic chemist Stephen Lincoln, an expert in NMR spectroscopy, in particular the kinetic application of lineshape analysis. Together, they published a series of papers on the kinetics of ligand substitution reactions of metal complexes. At the beginning of the 1980s they switched their attention to the chemistry of cyclodextrins and their inclusion complex formation. Their collaboration on the cyclodextrins continued until John's retirement in 1993.

John's published research was always of the highest quality, and included two *Nature* papers. He had a strong belief in the value of good solid science. Simply being first past the post was not his top priority. He was a real gentleman and it was a joy to work with him or under his supervision.

In the year before he retired, John's first wife Claudia sadly died after a long illness. Soon after her death he re-connected with Aileen, former wife of his friend Ted Treloar, who herself had been widowed for 13 years. They married shortly after and, together with Aileen, John was able to enjoy a long and happy retirement. John is survived by Aileen, his three children, Anna, Toby and Nick, and six grandchildren. He will be sorely missed by all who knew him.

Ronald J. Clarke MRACI CChem

The author thanks Associate Professor Toby Coates, Professor Stephen Lincoln and Associate Professor Tak Kee of the University of Adelaide for providing valuable information.

RACI NSW initiatives for young chemists

When I joined the RACI a few years ago, I did so with the express intention of giving something back to the next generation of young scientists. So it has been my very great pleasure to work with other members, and most particularly the New South Wales Young Chemists Group (YCG) on a range of initiatives to maximise the value of membership for student and early career members.

Here are some of the ideas that we have been working on in NSW.

NSW mentoring program

Starting in 2015, we have been developing and growing the NSW RACI mentoring program. Through one-on-one mentoring relationships, the aim is to develop the mentees' skills and preparedness for the job search, as well as to help them develop their networks.

According to Graduate Careers surveys (www.graduatecareers.com.au), personal networks are already the greatest source for locating career opportunities, even at the graduate level (and building from there).

In the 2015 pilot, both mentees not only graduated with jobs, but they graduated with their dream jobs. Most of the mentees in the 2016 program already have their jobs lined up, and the program is being expanded in 2017 with the aim of having student members from each of the five main Sydney universities, and hopefully the University of Newcastle as well.

Places will have already been allocated by the time this goes to print, but if you know of any student member who is particularly keen, then they should still contact the NSW Branch office. We'll find some way to be of help.

Lecture series: understanding the job market

Over the course of 2016, I have had the privilege of presenting variations on the 'Understanding the Job Market' lecture series, singly or as part of careers events, at most of the major universities in Sydney and Newcastle, and to an RACI careers event in Brisbane. The lecture series focuses on understanding *how* the job market works, and the specific tips and techniques that a young chemist can employ to distinguish themselves from the crowd.

Finding a good job takes effort, but it is eminently achievable. If you understand the process, you can shave months off your job search.

The full lecture series is freely available on the RACI website, and I invite RACI members from any institution to get in touch with me if you would like me to present (at no charge, of course) to your students. This can be particularly useful towards the beginning of the year, when the students still have months ahead of them to take advantage of the advice on networking.

Networking events

During 2016, the NSW Analytical and Environmental Group arranged a very successful event in conjunction with the YCG. By simply adding a 90-minute networking session to the end of a symposium, we were able to bring together 80 students, researchers and commercial/industrial representatives for a highly successful networking event.

I urge each and every RACI group across Australia to give the idea some consideration. The incremental time and cost in the event organisation was minimal. The incremental value to RACI's young members was outstanding. This should be a regular component of our event preparation.

By simply adding a 90-minute networking session to the end of a symposium, we were able to bring together 80 students, researchers and commercial/industrial representatives ...

These are just three of the initiatives that we have been working on. However, most of these are focused on student members, and we should also be devoting time to encouraging, supporting and engaging early career members. I encourage everyone reading this article to get in contact with your local YCG or me (through the NSW Branch office). We want to hear from you with your ideas, if you want to get involved, and/or if you know of young chemists who could benefit from taking part in the programs.

Dave Sammut FRACI CChem is a member of the NSW Branch committee and the NSW Analytical and Environmental Group committee. His business, DCS Technical, has a dedicated pro bono budget set aside for initiatives to help and support young RACI members.

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New Fellow



Anthony W. (Tony) Addison was born in Sydney in 1946. With him always curious about the behaviour of stuff, his interest in chemistry was possibly sparked by the mysterious jars in his older brother's rather neglected chemistry set, which contained prettily crystalline and coloured substances, some of which had strange odours or tastes (lead acetate!). At Manly Boys' High School, he had two skilled Chemistry teachers, Don Johnson and Andy Watson. Remarkably, Watson had been a geologist with Mawson's 1911

Australasian Antarctic Expedition.

Addison received his BSc(Hons-I) in Applied Chemistry in 1968 from the University of New South Wales, publishing his first research article under the tutelage of Associate Professor D.P. Graddon. His PhD program was at the University of Kent at Canterbury, where he worked with Professor R.D. Gillard on rhodium compounds, further developing his interests in transition metal chemistry. In 1970, he went to Northwestern University in Evanston to work with Professor I.M. Klotz on an NIH-funded postdoctoral fellowship (1970–2). This was where he learned about the physical biochemistry of metalloproteins. At Northwestern, he and his wife Barbara met and they married in 1972. He then took up an assistant professor position at the University of British Columbia (1972–8). In 1978, Drexel University Chemistry Head Professor J.G. Kay made Addison an offer he couldn't refuse and he assumed his position in the Chemistry Department at Drexel in Philadelphia. Now a professor in the department for over 20 years, he previously served as assistant and associate head and also as head of the department.

Addison's research endeavours reflect his curiosity and wide interests. He and his co-workers have produced about 120 research articles encompassing bioinorganic, organic and transition metal chemistry, several of which are quite highly cited. They have also produced several articles on educational topics and experiments and 130 conference presentations. Addison has been co-author/co-editor of two books.

The Drexel undergraduates note his infectious enthusiasm for chemistry and he was a Christian and Mary Lindback Distinguished Teaching Awardee in 1987. Other honours include the John van Geuns Fonds Lectureship at the University of Amsterdam (1985) and the American Chemical Society's Ulliot Service Award. He is a Fellow of the Royal Society of Chemistry and of the American Chemical Society. He is also a member of the Canadian Society for Chemistry and the International EPR/ESR Society. Addison has been actively involved with the ACS for almost 20 years.

Tony and Barbara, parents of two sons, are now empty-nesters, residing in Swarthmore, Pennsylvania. They have been active advocates for people with autism. Addison's hobbies are reading, classical music, photography, wine and woodworking.

Big fat myths

Meerman R., Penguin Random House, 2016, paperback, ISBN 9781925324273, 304 pp., \$34.99

In *Big fat myths*, self-professed 'physics nerd' Ruben Meerman reveals an ancient, secret formula for weight loss. Eat less, move more. Yes folks, it is that simple. The diet gurus are going to hate this book.

Meerman began with one of those deceptively simple questions that so often lead to great insights: what happens to the fat we lose? Turns out we don't 'burn it off'; we breathe it out in the form of good old H₂O and carbon. We actually lose weight in our sleep at the rate of about nine milligrams of carbon per breath. Just how that happens is fascinating and some of the most engaging chemistry I have ever read.

Meerman busts just about every 'rule' of dieting. Sugar is not poison and it doesn't matter what you eat as long as you expel more carbon than you ingest. People have gone on McDonald's-only diets, Twinkie diets and potato diets and they all lost weight. And their blood tests all showed improvements as well. I did say the diet gurus would hate this book.

Meerman begins 'to get chemical' in the chapter on fat science. We start with Santorio Sanctorius of Padua, the 'father' of metabolic balance studies. Santorio suspended himself from a balance beam to measure his weight before and after eating. A century later, the natural philosophers (Boyle, Hooke, Black, Lavoisier, Priestley and others) figured out the basics of respiration and metabolism, unwittingly setting the stage for a billion-dollar-a-year diet industry.

Here is the real secret. Fat, like everything else in our physical universe, is made of atoms. Sounds obvious, but not recognising this simple fact is the basis for much of the controversy in the ongoing weight-loss debate. There are differences between saturated, unsaturated and polyunsaturated fats, but those differences don't matter one iota if weight loss is your goal. As Meerman says in his final chapter: '... all their diets will work, but only on one condition: weight loss occurs if and only if less atoms go into the body than out.' Call it the 'atomic diet'.

Meerman writes with vigour and wit and has a deft hand with a metaphor, which means those of us with little or no chemistry can follow the plot and professional chemists can enjoy the science.

Unfortunately, what should be an informative and highly entertaining read is tragically marred by errors too numerous to count. Typos, missing and wrong words, subject-verb disagreements – this looks very like a draft manuscript. For the average reader, this is the verbal version of an obstacle course that quickly becomes annoying to the point where most readers will, I fear, simply give up in exasperation. This is truly unfortunate because *Big fat myths* is the most sensible thing I have yet read on the subject of dieting and weight loss.

Terry Erle Clayton



Grunt, the curious science of humans at war

Roach M., W.W. Norton and Co., 2016, hard cover, ISBN 9781780749778, 288 pp., \$22

Even if you normally have a dislike of military science books, don't be tempted to leave this book on the shelves. *Grunt, the curious science of humans at war* is not focused on areas many may associate with military science, such as weapons development or perhaps the latest advances in military vehicles, manned or unmanned. Nor is the book focused on the science identified while the author, Mary Roach, was embedded with a military unit, trailing troops into combat zones such as Iraq or Afghanistan. Most of the book instead takes a light-hearted look at the individuals (the science boffins) behind the scenes in military research institutions throughout the US, and how the science they have a passion for helps to improve the conditions for military service men and woman.

A scientific education is not mandatory to enjoy this book, as its intent is to inform and entertain the reader rather than to educate. Humour, including the self-deprecating form, is frequent throughout the book as Roach reminds us that she is just an everyday person experiencing the largely hidden world of military science. Roach's writing style is fantastic at setting the scene, allowing the reader to experience her observations and thoughts, and can make even the most boring facility, military officer or white-lab-coat-wearing scientist appear interesting. However, don't think that all involved in military research are the stereotypical pocket-protector-wearing scientist. Just as the areas of science or medical research detailed in Roach's book can be unusual or unexpected, so can the background of those undertaking the work. So you may be surprised, for instance, to know that former swimwear and bridal gown designers are part of the team helping to improve military uniforms.

Significant work has been undertaken to improve military uniforms as they have developed from just a mere outfit to a crucial system also required to hold countless gizmos and the batteries used to power them. Refreshingly, the book does not get bogged down in boring details such as the 22 pages of the US Government button specifications, focusing instead on both the people and their work. Some of the more unusual parts of 'Second Skin', the chapter devoted to the military uniform, include the impact clothing design can have on military snipers and the research underway to develop explosion-proof underwear (spoiler alert: they aren't really explosion proof).

While interesting, this book covers much more than just military clothing. The book comprises 14 chapters covering a diverse range of topics, both historical and current. Preventing diarrhoea for army troops, tackling fatigue in navy submariners and the development of shark repellents for airforce pilots forced to ditch over the sea are examples of topics discussed. However, the author devotes most attention to IEDs (improvised explosive devices). There are chapters that focus on

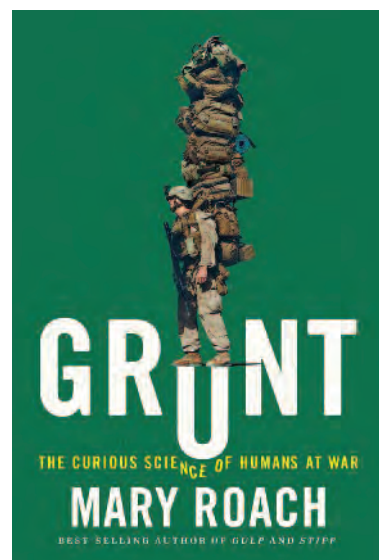
improving vehicle designs to withstand IEDs, as well as the development of a test dummy to use in place of cadavers to examine the impact of IEDs on the human body. Efforts underway to repair the injuries sustained by troops as a result of IEDs, such as penis reconstruction and testicular transplants, are also discussed. The latter topic is not only interesting due to the medical challenges but also because of the politics.

Previously, military command has focused only on getting troops home alive and for a long time this appears to have been incorrectly deemed sufficient. Roach's ability to set the scene, including the politics, makes each chapter feel more like issues and challenges that could be discussed with colleagues over morning tea, rather than a lecture or military propaganda.

While the researchers and their work are the basis of Roach's observations, her interactions also include those with military personnel. These interactions are interesting given they highlight the sometimes less-than-perfect relationship that can exist between military personnel and the scientist, unflatteringly referred to as 'Chairborne Rangers'. While the scientist's aim is to always assist, their lack of deployment experience can sometimes result in solutions that create other issues. For example, while minimising hearing loss, hearing protection can reduce a soldier's ability to have a clear understanding of their surrounds, potentially placing soldiers' lives in increased danger. And electronic gadgets, while providing a technological advantage, often have the side effect of increasing the weight soldiers must lug around in addition to the batteries, weapons and ammunition they already carry.

There are many standout features of the book, including a behind-the-scenes look at military science from the researcher's point of view and the courage to discuss the less glamorous military topics that will never be part of the next Hollywood blockbuster. Perhaps most pleasing is the fact that Roach's writing style renders the discussion of science entertaining and appealing to a wide audience, including those typically uninterested in science.

Michael Leist MRACI CChem



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Navigating the R&D Tax Incentive program – are my activities compliant?

Kate Mahady, Director, and Cleode la Harpe, Senior Manager, FB Rice

The R&D Tax Incentive program is designed to help Australian companies offset the cost of undertaking their research and development (R&D) activities and provide much needed cash flow.

The incentive is a broad, industry-based program applied as a tax offset, which can help decrease your tax liability and can be refundable. It is available to companies incorporated in Australia and is well applied across Australia's chemical science industry sector.

Currently, applicants to the program are facing increased compliance scrutiny from both AusIndustry and the ATO, highlighting the need for companies undertaking R&D to develop strong tax compliance processes.

What are the changes to the R&D Tax Incentive rates?

In August 2016, the government announced a reduction in the R&D tax incentive benefit rates by 1.5%. The new rates, which apply from 1 July 2016, are:

- 43.5% refundable tax offset for eligible entities with an aggregated turnover of less than \$20 million
- 38.5% non-refundable tax offset for eligible entities with an aggregated turnover of equal to or more than \$20 million.

Eligible companies with R&D expenditure in excess of \$100 million are limited to a benefit of 30% for any R&D expenditure in excess of the \$100 million cap.

Are my activities eligible?

R&D activities are defined as being experimental in nature and the outcomes of the activities must not be known in advance. R&D

activities follow a systematic progression of work from hypothesis to experimentation to a logical conclusion. The activities must also result in the creation of new knowledge in the form of new or improved materials, products, devices, processes or services. These activities are referred to as core R&D activities. Any other activities undertaken directly in support of such activities are also eligible R&D activities, and are referred to as supporting R&D activities.

What documentation do I need to be compliant?

The program is a self-assessed program. However, as with any claim for a tax benefit, the onus to establish the entitlement to the claim rests with the taxpayer. That means that all expenditures and technical activities must be substantiated with documentary proof that they actually took place as described in the registration document. Recently, a number of claimants for the R&D tax incentive have failed in their claims when audited because they could not adequately provide evidence of their activities or the associated costs, highlighting the importance of maintaining documentation.

How do I register the R&D activities?

All R&D activities must be registered with AusIndustry within 10 months of the end of the financial year in which they were undertaken. It is important for companies to describe the activities accurately and concisely in these registration forms and understand the eligibility definitions.

For more information on how FB Rice Consulting can help with lodging your R&D Tax Incentive, please email Kate Mahady, kmahady@fbrice.com.au, or Cleo de la Harpe, cdelaharpe@fbrice.com.au.

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Italian bubbles for summer

Our summer season is a good opportunity to explore some of the sparkling wines from Italy.

Prosecco has had great success in the Australian market place. It has spawned a range of Australian styles, especially in regions that have an Italian community, such as the King Valley in Victoria. In Italy, Prosecco comes from the Veneto and Friuli Venezia Giulia regions. The grape is Glera, a white grape native cultivar from the Prosecco region that is claimed to date back to Roman times. For many years, the cultivar was known also as Prosecco, a name that it is still used in Australia as there appears to be some reluctance to change to Glera.

The bubbles in Prosecco result from a secondary fermentation. While the traditional method is used to some extent (i.e. secondary fermentation in the bottle followed by disgorging of the yeast, topping up and re-sealing), the more common production method is secondary fermentation in a pressure tank (the Charmat or Italian method), followed by pressure filtration to remove the spent yeast and then pressure bottling. The wines show a balance of acidity and sugar, with a good foam, but some less expensive examples tend to be over-sweet.

Spumante is an Italian term for sparkling wine in general, although it is commonly regarded as synonymous with the sparkling wines from Asti in Piedmont. The production of these sparkling wines is by primary fermentation only. At some stage during the primary fermentation, the wine is transferred to a pressure tank, allowing the bubbles to be trapped. When the desired balance of alcohol production and residual sugar is reached, the fermentation is stopped by chilling the wine to stop yeast activity. The use of refrigeration and other technological advantages has improved the overall quality of this wine style, although to my palate the acid/sugar balance is not quite harmonious enough.

A variation on this approach is the Moscato d'Asti, a lovely, 'gently fizzy' dessert wine. The pressed grape juice is kept cold until required for fermentation, which is carried out in a pressure vessel until 5% alcohol is produced with slightly less than two atmospheres CO₂ pressure. The wine is chilled to stop the fermentation and prepared for bottling, sometimes under crown seal. This process is continued throughout the year, thereby ensuring that fresh product is always available. Alcohol labelling is intriguing because one can find 'actual [sometimes effective] alcohol content' of 5%, 'potential alcohol content', which represents what would be obtained if all residual sugar were fermented, and 'total alcohol content', which is the sum of the two. Moscato Bianco is the cultivar used, which is also known as Muscat Blanc à Petits Grains, a white cultivar that is related to 'Brown Muscat', the cultivar that makes the famed Muscat wines from Rutherglen.

What to try

I prefer the Brut style of Prosecco that has a maximum of 12 g/L residual sugar. The Valdobbiadene Superiore Brut is a good way to go. For summer, a variation is Aperol spritz, a mix of three parts of Prosecco, two parts Aperol and one part of soda water with lots of ice.

Recently, I tried the Moscato d'Asti La Caliera 2015 from Borgo Maragliano. The aroma is dominated by musk, reinforced with a floral violet character. The palate is lingering and sweet, but not cloying. A great way to spend a summer's afternoon is with La Caliera in one ice bucket and fresh fruit in another.

The Bellavista Franciacorta 'Alma' Cuvée NV Brut and the Reserve 2010 Vintage Brut are two impressive wines with a good acid structure and palate length, delightful both as an aperitif and food wine.

The Trentino wines from Rotari, particularly the 2010 vintage and the AlpeRegis 2009 are very exciting. Ferrari makes a very pleasant, complex non-vintage style while the vintage wines are outstanding. The *Giulio Ferrari* vintage 1999 is quite mind-blowing.

The Trentino and Franciacorta regions of northern Italy produce sparkling wines that, in many cases, rival those from Champagne at similar price points. Trentino wines are based on Chardonnay, while those from Franciacorta are commonly blends of Chardonnay, Pinot Nero and Pinot Bianco. The two regions are close to the southern slopes of the Alps and relatively far north in latitude at around 45.5–46°N. Production of the sparkling wines is generally by the traditional method of bottle fermentation, followed by disgorging and topping up. Ageing the wines on lees post the secondary fermentation is a critical component of the character of these wines with 4–10 years ageing for some wine styles. This, of course, is reflected in the price. At a recent tasting at University House at the University of Melbourne, wines from these two regions and similar style wines from Champagne were tasted blind. In several brackets, one of the Italian wines was picked as the preferred wine, with most participants being surprised with their choice when the wines were revealed.



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

Happy birthday, Alfred

J.S. Anderson (1908–90) was professor of inorganic and physical chemistry at the University of Melbourne (1954–9). He showed the world, including his colleagues, a rather austere countenance that mellowed only late in life. He was always referred to as 'J.S.', even by the authors of the biographical memoir published by the Royal Society of London.

Anderson is best known for his research on the chemistry of the solid state, but for us undergraduates he gave a series of wonderful lectures on coordination chemistry. He concentrated on the work of Alfred Werner and almost left us with the impression that he'd been at Werner's right hand while the great discoveries were being made in Zurich.

Backing up the lectures, I had a copy of *Modern aspects of inorganic chemistry* by H.J. Emeléus and J.S. Anderson. When the first edition was published in 1938, the authors were both junior staff members at the Royal College of Science in London, but by the time of the second edition, 1952 (the one I had bought), they were professors respectively at Cambridge and Melbourne. They divided 'the contents between them according to their separate interests', and since Anderson had published on coordination compounds and Emeléus hadn't, I am pretty sure that it was J.S. who wrote the 100 pages or so on 'Coordination compounds and inorganic stereochemistry'. He began with a description of the ammoniates of trivalent cobalt, such as $\text{Co}(\text{NH}_3)_6\text{Cl}_3$ (I later made some in my home laboratory), then complex cyanides such as $\text{K}_4\text{Fe}(\text{CN})_6$ and double salts, including alums such as $\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$.

Anderson's lectures (nobody ever read the textbook until years later!) were my introduction to the idea that some of groups associated with the metal were tightly bound, while others like the 'water of crystallisation' were in an 'outer sphere'. Werner had laid it all out in his 1893 paper 'Beitrag zur Konstitution anorganischer Verbindungen', *Z. anorg. Chem.* 1893, vol. 3, 267–330. He adopted the coordination number to describe bonding between metal ions and species such as

amines, dividing the metal-ammines into two classes, those with coordination number six (for which he proposed octahedral configuration) and those with coordination number four (square planar or tetrahedral). According to George Kauffman's 1966 biography of Werner, the idea came to him in a flash of genius at 2 a.m. one night in 1892. Werner 'proved' it was an octahedron by preparation of two isomers of cobalt complexes MA_3B_3 , whereas hexagonal planar and trigonal prismatic configurations would have generated three isomers. It's not a conclusive proof, but a later one was sound.

J.S. drew our attention to the consequences of bidentate ligands occupying *cis* positions, in which case complexes $\text{M}(\text{A-A})_3$ and others should be resolvable. Werner achieved this in 1911 with *cis*-chloro- and -bromo-amminebis(ethylenediamine) cobalt(III) salts. 'After many abortive attempts, he succeeded at last' according to John Read, who did his PhD with Werner, working on coumarin and graduating in 1907. Read (1884–1963), who was professor of organic chemistry at Sydney (1916–22), had quite a bit to say about Werner in his book, *Humour and humanism in chemistry* (1961), pp. 262–84. Werner was thus first to demonstrate that stereochemistry was not limited to carbon compounds and for his groundbreaking work he was awarded the Nobel Prize in Chemistry for 1913. Werner's laboratory was enormously productive: it is estimated that there are more than 8000 samples (Werner complexes) in the Werner collection at the Chemisches Institut der Universität Zürich.

Alfred Werner was born at midnight on 12 December 1866 in Mulhouse. Although of German nationality, on account of the German annexation of Alsace after the Franco-Prussian war of 1870, Werner always felt that he was French but he took Swiss citizenship when he made his career in that country. He had studied at the ETH in Zurich (PhD 1891) and for the next few years worked mainly on organic chemistry, including a year in the laboratory of Marcel Berthelot (1827–1907) in Paris. Returning, he took up a junior appointment at the University of Zurich where he was appointed to a chair in 1893 (*extra-ordinarius*) in succession to organic chemist Viktor Merz (1839–1904). By 1895, Werner was full professor and his career in inorganic chemistry was under way.

From the turn of the century, Werner's health was failing – too much alcohol, too many cigars, and not enough sleep/rest, according to Kauffman – but he kept up the pace through the war years (Switzerland being neutral) until he died in Zurich on 15 November 1919.

Since coordination compounds were the mainstay of Australian inorganic chemists through most of the 20th century, I'm sure that several generations will join me in saying happy 150th, Alfred.



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.

Werner ... adopted the coordination number to describe bonding between metal ions and species such as amines, dividing the metal-ammines into two classes, those with coordination number six (for which he proposed octahedral configuration) and those with coordination number four (square planar or tetrahedral).

Difficulty rating: hard

The symbols for the nine elements most abundant in the Earth's crust are used. Your challenge is to complete the grid so that each 3×3 box as well as each column and each row contains all nine of these elements.

Na		Si		O	K			
		K	Na	H				
O				Ca		Si		
				Al	O	Fe	H	
		H			Mg			
K	Na	O	H					
	Mg		Ca					Al
			Fe	Mg	Si			
		Al	Si		Fe		Mg	

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

events

Australian Society of Cosmetic Chemists (ASCC 2017)

3–5 May 2017, Sunshine Coast, Queensland
<http://ascc.com.au>

2nd European Organic Chemistry Congress

2–3 March 2017, Amsterdam, Netherlands
<http://organicchemistry.conferenceseries.com/europe>

Solutions for Drug Resistant Infections

3–5 April 2017, Brisbane, Queensland
www.sdiri2017.org

International Conference and Exhibition on Pharmaceutical Nanotechnology

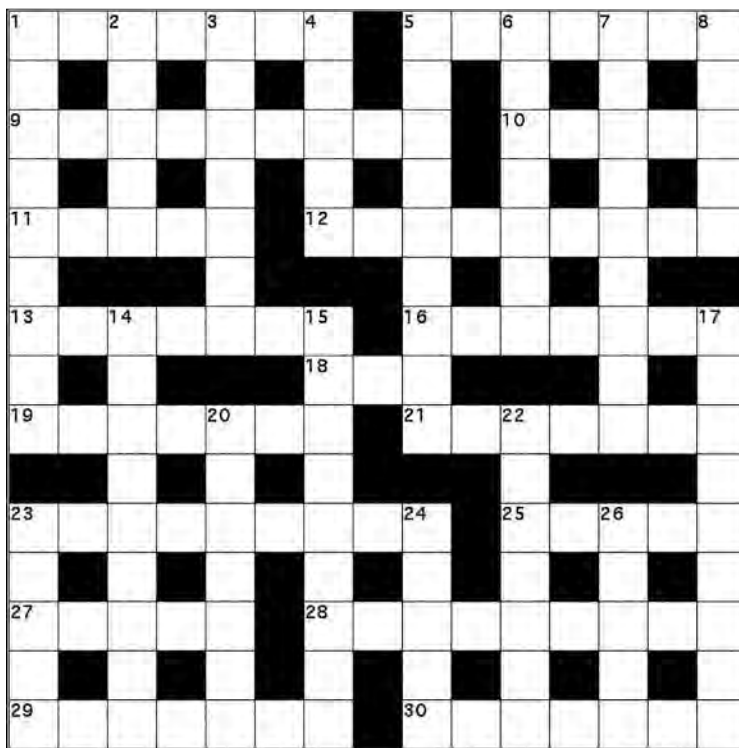
27–29 October 2017, Rome, Italy
<http://nanotechnology.pharmaceuticalconferences.com>

10th Australasian Organometallics Meeting (OZOM10)

10–13 January 2017, Dunedin, New Zealand
www.otago.ac.nz/ozom10/index.html

8th International Conference on Advanced Materials and Nanotechnology (AMN8)

12–16 February 2017, Queenstown, New Zealand
www.amn8.co.nz



Across

- 1 Turned and spoke loudly. (7)
- 5 Postures points of view. (7)
- 9 It will not make a homogeneous system. Baffling! (9)
- 10 Best 40 Roman sounds. (5)
- 11 Singular 19 Across organised germanium. (5)
- 12 A crystalline overlayer composed of lithium iodide with tantalum, protactinium and xenon. (9)
- 13 Art meme review gives a current measure. (7)
- 16 Rather in another's place. (7)
- 18 The first lady after dark. (3)
- 19 Once canvas ranges . . . (7)
- 21 . . . over spoiled molecules in which the centres of positive charge do not coincide with the centres of negative charge . . . (7)
- 23 . . . astonished users drip instability. (9)
- 25 Sulfur combined with calcium-containing inorganic material to make a mucilaginous substance. (5)
- 27 Shortly under 10@1. (5)
- 28 Process time charge after Orlando, for example. (9)
- 29 Take up sulfur estimates. (7)
- 30 Mailed sulfur parcel to give the wrong idea. (7)

Down

- 1 As_3H_5 is near art work. (9)
- 2 Greek pitch, sir, on toss. (5)
- 3 Most awful guest with lithium battery. (7)
- 4 Unit of Spooner's base scan. (5)
- 5 Iodine, fluorine and sulfur pieced together and set. (9)
- 6 Compounds having the structure $\text{R}_2\text{C}(\text{OR}')_2$ champion salt manipulation. (7)
- 7 Fuel holds fabric dye. (9)
- 8 H_3Si -radical is absurd if you switch the last two. (5)
- 14 Friends hang around back den for elements. (9)
- 15 Reduce current stir re SOS turmoil. (9)
- 17 Grasped saw. (9)
- 20 Moth ran around a town in WA. (7)
- 22 Units of four or five elements. (7)
- 23 Presents man over at sodium seminar introduction. (5)
- 24 Conjure up scenario of armed assault. (5)
- 26 $\text{RN}=\text{CR}_2/\text{I}$ belongs to me. (5)

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

7th Heron Island Conference on Reactive Intermediates and Unusual Molecules



The 7th Heron Island Conference on Reactive Intermediates and Unusual Molecules was held on 9–15 July 2016 in the tradition of the now iconic conference series, which started on Heron Island (Great Barrier Reef, off Gladstone) in 1991. However, these events are part of a global series of conferences on reactive intermediates, which started in Geneva in 1978.

The Heron Island Conferences enjoy an excellent international reputation as high-level scientific events bringing together people from a wide range of areas such as reaction mechanism,

synthesis, computational chemistry, spectroscopy and catalysis. This variety of fields, the provision of ample opportunities for interaction and the fact that all delegates have all meals together have fostered extensive discussion and new international collaborations across chemistry disciplines.

The seventh conference had some 80 delegates from all over the world, and the plenary lectures – traditionally given in the after-dinner sessions – were presented by Herbert Mayr, Munich (ambident reactivity: a revision of the Klopman-Salem approach), Anna

Gudmundsdottir, Cincinnati (vinylnitrenes), Peter Schreiner, Giessen (tunnelling control of chemical reactions), Michelle Coote, ANU (chemical-free catalysts), and Huw Davies, Emory (site selective and enantioselective C–H functionalisation of *n*-alkanes and terminally substituted *n*-alkanes). In addition, some 60 invited and contributed papers were presented, and, as always, the vibrant poster sessions attracted all participants and fostered further, intense discussion.

In spite of the intense and high-level science, it is noteworthy that these conferences are very family friendly, and many speakers brought their families along, including children of all ages. This is fairly unique among international conferences, creating a very special atmosphere and showing that it is possible to combine good science with good family life. For many people coming from abroad, this would have been their first and unforgettable exposure to Australia. For the dozen Australian PhD students present, it was a fantastic exposure to a high concentration of top-level international scientists.

The conference was organised by Curt Wentrup and Craig Williams, University of Queensland, who are now planning the eighth conference for July 2019. Further information about dates, venue etc. will be announced in due course.

Curt Wentrup FRACI CChem



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Season's greetings