

chemistry

July 2015

in Australia

The way ahead for CSIRO: what are the options?



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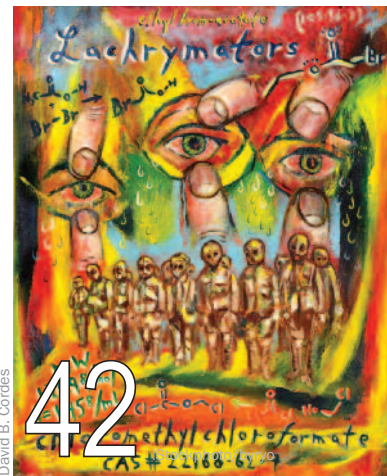
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David B. Cordes



cover story

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From the President

'Impact' is a word that is gaining prominence in all fields of research, including chemistry. Recently a report was published from the Office of the Chief Scientist and the Australian Academy of Science entitled 'The Importance of Advanced Physical and Mathematical Sciences to the Australian Economy'; the 'APM' sciences being chemistry, physics, earth sciences and mathematics. The report revealed that activity in the APM sciences contributes to about 22% ($\pm 6\%$) of the Australian economy (comprising direct and flow-on activity) so this is something that we can ill-afford to neglect.

Australian chemistry innovation has had significant impact on our lives. No doubt, many Australian discoveries have been made whose impact is yet to be felt as it can take 20 years or more for an idea to translate into a product. The polymer banknote, one of Australia's most successful chemistry-based inventions and exports, is an example of this time lag. I'm grateful for this invention each time I discover an intact note in the pocket of my clothing after going through the washing machine.

At the start of the supply chain is discovery, funded by Commonwealth-supported councils such as ARC and NHMRC or organisations such as CSIRO. Evidence of the 'impact' of research is becoming an increasingly important discriminator in the quest for competitive research funding, which is now more difficult than ever to obtain. However, given the time lag between discovery and application, it is difficult to demonstrate impact (on society) of chemistry research during the working lifetime of the researcher, particularly at the critical early stages where an idea needs exploration and testing.

The discovery must first be communicated and accepted by peers in the field, most commonly through publication in a refereed journal. If direct impact cannot be immediately demonstrated, a more realistic goal is to demonstrate its impact on peers, influencing the way they carry out their own fundamental research. This is evidenced by frequent citation of the original paper by others in the literature.

There are more than 500 chemistry journals, and opinions differ about their relative quality. Regardless of whether a 'score' for a research journal is appropriate, some four decades ago the 'impact factor' (IF) emerged as a tool for comparing journals on

the basis of citation volume. The IF of a journal (in that year) is the average number of citations (per paper) garnered by the journal over the preceding two years – a retrospective number that says nothing about the likely future impact of any paper published today or of any individual paper published over that preceding two years.

In spite of its original purpose, a culture has emerged where IF may influence where an author will publish their paper. The IF becomes an artificial esteem measure for authors to use in promoting the significance of their papers. As more people are drawn towards a high IF journal, the rejection rate rises and, paradoxically, the journal's reputation is enhanced. Quality papers are squeezed out due to editorial decisions on acceptance or rejection influenced by reviewers and projected citations of the paper in a competitive climate. Some high IF journals can even mandate that authors pay to publish because supply so greatly exceeds demand.

Papers that attract extremely high citations feed the journal's IF (and compensate for those that are never cited) yet there are some bizarre examples of heavily skewed statistics. In 2008, renowned crystallographer George Sheldrick published a 'methods' paper, 'A Short History of SHELX' in *Acta Crystallographica Section A* (vol. 64, pp. 112–22), which is cited in acknowledgement of a program from his group that is used by researchers worldwide. This paper has been cited more than 41 000 times and, singlehandedly, earned *Acta Cryst. Sect. A* its remarkable IF of 49.9 (2009) and 54.3 (2010) placing it at number 2 on the Thomson Reuters IF list (~12 000 journals) for those years. Inevitably, in 2011 the IF of *Acta Cryst. Sect. A* plummeted from 54.3 to 2.1 (from number 2 to 3011) when the Sheldrick paper disappeared from the IF calculation. Similar analyses of high IF journals lead to the same conclusion; IF on its own tells you nothing about the future impact of an individual paper.

Ultimately, the true impact of research will be established over a timeframe greater than the two-year window of a journal IF and regardless of the journal in which it is published.



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Reflections on the lives of worthy individuals

Reading of the passing of people we have known always brings sadness. Perhaps not quite the grief for family or those who were very close to the departed, but reflections nonetheless.

The recent passing of two University of Western Australia luminaries, as reported in this journal, certainly gave me reason to pause – Jack Cannon (February 2015) and Ian Ritchie (April 2015). As the obituaries attest, both were outstanding in their research fields and their respective visions for the future.

Both of these men were influential in my undergraduate years, and beyond. Perhaps readers of a similar age will forgive my indulgence in sharing a few recollections.

In my first year at university I had the good fortune to be in a tutorial class led by Jack Cannon. In the first week or so, Jack worked out that one of my classmates had an elder sibling who had recently been a member of his research group. Jack was quickly on the recruitment drive and suggested a tour of the research laboratory. I was lucky enough to be a good friend of my classmate and Jack graciously extended the invitation to those who had remained behind after the scheduled finishing time for the tutorial.

His joy in talking about his research group was obvious. The array of glassware, the hum of rotary evaporators, the squeal of water-aspirated vacuum pumps were all mesmerising to a first-year student.

Back in tutorials, Jack's gentle, patient and engaging style in working through basic mechanistic reactions still lives with me. At some point, the course moved on to more complex

subjects. Jack's face always lit up when the subject of vitamin B₁₂ came up. We were transported from our sunny tutorial room at the Crawley campus to Cambridge, working with A.R. Todd, a continental vacation and the virtue of patience. It was with considerable joy that I read his piece, 'Cooperation and luck during vitamin B₁₂ studies' (February 2013 issue, p. 5) and warmly recollected a personal account to a tutorial group in 1976.

The dynamic Ian Ritchie was quite a contrast and equally engaging. His lectures were always very different. He ardently engaged with students in the third-year laboratory program to build the next generation of research chemists.

Sometimes things may not have always turned out his way. I can still recall his good-natured indignation that I had gone to organic chemistry for my honours year rather than staying with his stream. But later, in one of life's twists, our research interests reconnected. We were both interested in oxidation. And so I came to briefly collaborate with his group on cyclic voltammetry, albeit on organic substances. As he said with that irrepressible and impish smile on his face, 'I always knew we would get you back in the end'.

Underlying that was an innate ability to establish a personal rapport with people. Without being overt, he took time to find out about the interests of others. For me that was a shared connection through the Scouting Movement. Though it had come up early in our acquaintance, I certainly didn't appreciate the full extent until some years later when I attended a Queen's Scout reunion at Government House in Perth. Out of the crowd, emerged the energetic and avuncular figure of Ian. Always keen to reconnect. Always interested in how your career was progressing.

Vale Jack Cannon and Ian Ritchie. No doubt it has been said before, but we are poorer for their passing.

Jeff Stewart MRACI CChem



As your RACI member magazine, *Chemistry in Australia* is the perfect place to voice your ideas and opinions, and to discuss chemistry issues and recently published articles.

Send your contributions (approx. 400 words) to the Editor at wools@westnet.com.au.

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'Your say' guidelines

We will consider letters of up to 400 words in response to material published in *Chemistry in Australia* or about novel or topical issues relevant to chemistry. Letters accepted for publication will be edited for clarity, space or legal reasons and published in print and online. Full name and RACI membership status will be published. Please supply a daytime contact telephone number (not for publication).

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Chemistry, topography and mechanics with one instrument

The probe of an atomic force microscope (AFM) scans a surface to reveal details at a resolution 1000 times greater than that of an optical microscope. That makes AFM the premier tool for analysing physical features, but it cannot tell scientists anything about chemistry. For that, they turn to the mass spectrometer.

Now, scientists at the Department of Energy's Oak Ridge National Laboratory have combined these cornerstone capabilities into one instrument that can probe a sample in three dimensions and overlay information about the topography of its surface, the atomic-scale mechanical behaviour near the surface, and the chemistry at and under the surface. This multimodal imaging will allow scientists to explore thin films of phase-separated polymers important for energy conversion and storage. Their results are published in *ACS Nano* (doi: 10.1021/acsnano.5b00659).

'Combining the two capabilities marries the best of both worlds,' said project leader Olga Ovchinnikova, who co-led the study with Gary Van Berkel, head of ORNL's Organic and Biological Mass Spectrometry Group. 'For the same location, you get not only precise location and physical characterisation, but also precise chemical information.'

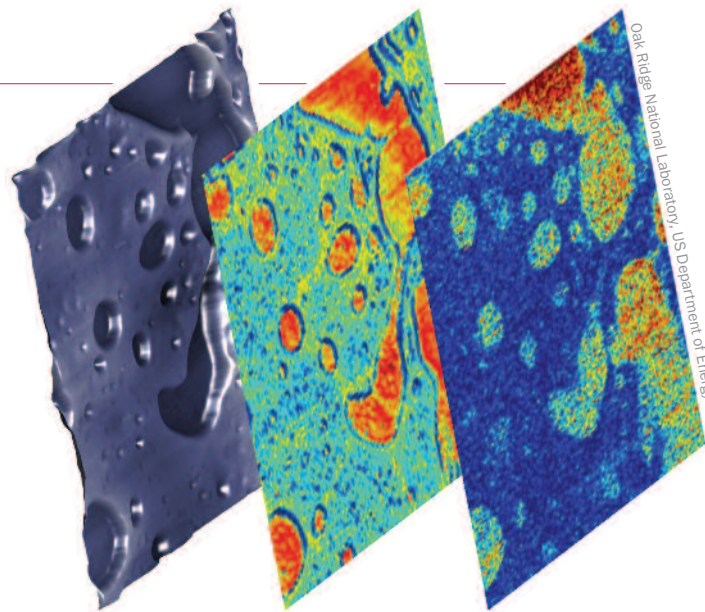
The new technique for functional imaging allows probing of regions in the order of nanometres, to characterise a sample's surface hills and valleys, its elasticity throughout deeper layers, and its chemical composition. Previously, AFM tips could penetrate only 20 nm to explore a substance's ability to expand and contract. Adding a thermal desorption probe to the mix allowed scientists to probe deeper, as the technique cooks matter off the surface and removes it as deep down as 140 nm. The mass spectrometer's precise chemical analysis of compounds gave the new technique unprecedented ability to characterise samples.

'We're now able to see subsurface structure that we were blind to before, using standard techniques,' Ovchinnikova said.

In the past, scientists measured physical and chemical properties on different instruments that displayed data on different resolution scales. The width of a pixel of AFM data might be 10 nm, whereas the width of a pixel of mass spectrometry data might be 10 μm – a thousand times larger.

'The resolution of the chemical identification was much poorer,' Ovchinnikova emphasised. 'You would take images from different techniques and try to line them up and create a melded image. Because the pixel sizes would be so different, alignment would be difficult.'

The ORNL innovation fixed that problem. 'Because we are now using one set-up, the pixel sizes are very similar to each other. You can pinpoint one pixel and correlate it to another pixel in the image,' Ovchinnikova said. Now scientists can



For a 500 nm deep polymeric thin film made of polystyrene (lighter) and poly-2-vinylpyridine (darker), one multimodal instrument imaged, from left, surface topography, elasticity of the bulk material and buried chemical behaviour.

perfectly overlay data, much like digital cameras faultlessly stitch together smaller pictures to create a panoramic image.

It took a team to characterise the topographies, nanomechanics and chemistry of phase-separated domains and the interfaces between them. The scientists tested their combined AFM/MS platform by probing a phase-separated polymer thin film. Vera Bocharova, of the Soft Materials Group, made a 500 nm thick film with polymers that separated into islands of poly-2-vinylpyridine in a sea of polystyrene. Vilmos Kertesz developed software to link analysis capabilities, and Van Berkel, Ovchinnikova and Tamin Tai set up the experiment and took and processed data. Mahmut Okatan, Alex Belianinov and Stephen Jesse of the Center for Nanophase Materials Sciences set up equipment to probe atom-scale mechanical properties.

Ovchinnikova envisions companies using the technology to answer fundamental questions about product performance. If a polymer blend – in a rubber tyre or plastic bottle – is failing, why is it failing? In a stressed area, how are nanomechanical properties changing? What is the exact chemical composition at points of failure?

'This is something that AFM by itself could never see. It could just see differences in mechanics, but it could never really tell you precise chemistry in a location,' said Ovchinnikova.

The ORNL researchers are eager to explore scientific challenges that could not be addressed before the advent of high-resolution chemical mapping. For example, a better understanding of the structure and properties of solar-energy materials may speed improvements in their efficiency.

Next, to make multimodal imaging even more powerful, the researchers are considering coupling thermal desorption mass spectrometry – a destructive technique that cooks matter off a surface to enable its chemical analysis – with optical spectroscopy, a non-destructive technique.

BY DAWN LEVY, OAK RIDGE NATIONAL LABORATORY

Aerospace award for RACI student



A Queensland University of Technology PhD student and RACI student member has become the first woman to win a prestigious Aerospace Australia Limited Industry Innovation Award for her work on a project to improve the safety of aircraft and reduce maintenance costs.

Vanessa Lussini from QUT's School of Chemistry, Physics and Mechanical Engineering was awarded the 2015 \$10 000 Young Innovator Scholarship for Defence Industry earlier this year at Avalon 2015: The Australian International Airshow and Aerospace & Defence Exposition.

Lussini's project, being conducted for the Defence Materials Technology Centre, is focused on using organic compounds to develop sensors to alert maintenance crews when sections of an aircraft need repainting before mechanical strain, direct sunlight, varying temperatures, water, salt and other pressures cause dangerous corrosion, resulting in potentially catastrophic failure.

'Corrosion is like a cancer to metal, and paint acts like a sunscreen which needs to be re-applied before the structural integrity of an aircraft is compromised,' said Lussini.

'It's critical to know when to repaint an aircraft but we can also paint them too often simply because they are scheduled to be done, and every new coat adds weight.

'Often only certain sections need to be painted because they are more exposed and degrade faster. Or one plane is used every day and another sits in a hangar for long periods.

'Free radical oxidative degradation is the main route to coating failure and my project aims to create new, more resilient sensors to detect deterioration. A group of compounds called profluorescent nitroxides have been shown to be effective free radical sensors, utilising a fluorescent emission to monitor the chemical character of the protective outer coating of aircraft.

'Longer lasting sensors that can cope with harsh environmental conditions will make it easier to monitor and maintain aircraft coatings.

'The reapplication of these coatings is costly so utilising condition-based monitoring over basic periodic maintenance can maximise the potential lifetime of the product, optimise maintenance schedules and reduce costs.'

Lussini said that, while her research was focused on the defence and aviation industries, it could be equally applicable to other structures such as bridges.

QUEENSLAND UNIVERSITY OF TECHNOLOGY

Addressing capability and competency in the UK nuclear sector

Three leading players on the nuclear skills landscape have joined forces to sign a new collaborative agreement that promotes the highest standards of professionalism across the UK's nuclear industry.

Hinkley Point C in Somerset is on course to be the first nuclear power station in the UK since Sizewell B in Suffolk, which started generating electricity in 1995. Eleven more nuclear power stations are envisaged in a transformative development that has the potential to turn a legacy industry into one that could provide 16 gigawatts of new nuclear capacity by 2030.

The agreement, which is supported by the Nuclear Institute, the National Skills Academy Nuclear and the Institution of Chemical Engineers (IChemE), will facilitate closer alignment between the three organisations in a coordinated effort to encourage new entrants to the nuclear sector.

The Nuclear Energy Skills Alliance's Workforce Assessment Model reports that the total workforce is expected to grow from 70 000 to 98 000 by 2021. Direct supply chain support for Operations, Decommissioning, Engineering Construction and Defence is forecast to require recruitment for technical roles of 3000 and professional roles 3500 per year for current plans to be met. The Manufacturing workforce required is also expected to grow significantly to 8500 from 4000 reported in 2014.

A 2014 survey completed by the Nuclear Industry Association, of more than 1300 young people studying science, technology, engineering or maths subjects revealed that more than one-third of respondents did not believe they could work in the nuclear industry. Moreover, one in seven questioned had not heard anything about career opportunities in the nuclear sector.

The new collaboration will address this knowledge gap head-on and promote the nuclear industry as an exciting career.

The collaboration has been positively received. Mr John Clarke, CEO of the Nuclear Decommissioning Authority said: 'The highest standards of nuclear professionalism are required to ensure a safe and secure nuclear future – new build, existing operations, research and development and decommissioning – for the UK.'

Professor Geoff Maitland, IChemE president, said: 'Chemical engineering plays a crucial role in all parts of the nuclear fuel cycle and IChemE is fully committed to working with its partners to maximise the uptake of skills, training and professional development programs. Britain's nuclear future offers exciting opportunities for the next generation of chemical engineers.'

INSTITUTION OF CHEMICAL ENGINEERS

Medical Journal of Australia editor sacking stirs debate

Medical Journal of Australia (MJA) made news when it removed editor-in-chief Emeritus Professor Stephen Leeder after his disagreements with its plans to outsource production to Elsevier.

MJA's publisher AMPCo made the decision to cut subediting, production and administrative function by moving to an outsourced model in a move that Leeder estimates will cost approximately 14 people their jobs. The move, AMPCo said, was 'to ensure the continued success of the journal.'

However, Leeder clashed with management in the appointment of international publisher Elsevier as the journal's content provider, given its questionable history of editorial practices.

In 2009, Elsevier produced medical journal the *Australasian Journal of Bone and Joint Medicine*, which gave the impression of a peer-reviewed publication but in fact was sponsored by pharmaceutical company Merck.

MJA deputy editor Dr Tania Janusic resigned in support of Leeder's stance, and 19 members of the MJA's editorial board threatened to resign over the action.

In a statement to media, advisory board members Professors Michael Horowitz and Gary Wittert said: 'We consider that the MJA was extremely fortunate to have the services of an editor of this calibre and regard his stewardship of the MJA to have been exceptional.'

'The majority, if not all, board members, including ourselves, have indicated they will resign and believe that the Australian medical community, who we understand have not been consulted, will be appropriately outraged,' the statement said.

Guardian Australia has reported that 'remaining staff at the journal have been told they face dismissal if they speak to anyone about the Elsevier deal.'

However, the Australian Medical Association (AMA) stands with MJA and AMPCo's move to outsourcing, asking the editorial board to reconsider their resignations. Recognising Leeder's contribution to the publication and the medical community, the AMA stated the agreement with Elsevier was necessary in order to maintain the Australian publication.

Leeder's disappointment in leaving his post was clearly visible in quotes taken from across the media, in which he expressed his love of writing editorials, working with medical authors and production colleagues, and being part of the Australian medical scene. He has received hundreds of emails, phone calls and texts in support.

There is now question as to whether the MJA will be supported by medical researchers, given the controversy that has arisen between editorial ethics and business feasibility.

BY SHARON SMITH, FIRST PUBLISHED IN AUSTRALIAN HOSPITAL AND HEALTHCARE BULLETIN

ANU imaging system for fusion energy experiment

The world's largest fusion energy experiment, ITER, has turned to Australian physicists to supply a crucial imaging system for the multi-billion-euro experiment.

Nuclear fusion promises carbon-free clean power, by fusing hydrogen nuclei to form helium in high-temperature plasmas like the sun, and has none of the waste by-products associated with current uranium-based nuclear power.

The ITER project is under construction in the south of France and is expected to produce 500 megawatts of power in experiments by the end of the next decade.

Scientists at the Australian National University (ANU) have been contracted to undertake a design study for the installation of an advanced system that images plasma temperature and flow in ITER.

'It's effectively a Doppler speed gun for a fusion plasma,' said Director of the Australian Fusion Facility at ANU, Professor John Howard. 'These coherence imaging systems were pioneered at the ANU and are installed on fusion devices around the world.'

Head of Diagnostics at ITER Central Team, Michael Walsh, said the ITER project hoped to build stronger links to ANU and its technology.

The system developed by ANU focuses on the divertor – the floor of the fusion reactor.

'The centre of the plasma is over 200 million degrees. Where the edges touch the divertor it's like a welding arc,' Howard said.

'During unexpected turbulence, the fusion plasma can inflict power fluxes onto the walls comparable to those at the sun's surface.

'Figuring out how to manage the divertor heat flows is a major problem to solve. No other system can meet ITER's requirements for measuring and understanding the flows in this region of the experiment,' he said.

The ITER construction contracts are shared between the seven partner organisations: the European Union, the US, India, Japan, China, Korea and Russia.

Because Australia is not a member of ITER, the ANU group is fostering links with the US ITER partners, who have already installed a number of coherence imaging systems on their fusion experiment DIII-D, in San Diego. ITER USA will be responsible for the relevant observation ports on the ITER device.

AUSTRALIAN NATIONAL UNIVERSITY

Graphene key to faster DNA sequencing

Graphene, an unusual and very exciting form of carbon, looks to hold the key to real-time, high-throughput DNA sequencing, a technique that would revolutionise medical research and testing.

Led by Dr Jiri Cervenka and PhD candidate Nikolai Dontschuk from the University of Melbourne, the study also included scientists from the Australian Synchrotron and La Trobe University and is published in *Nature Communications* (doi: 10.1038/ncomms7563).

The Australian researchers have shown that graphene can detect the four nucleobases that make up DNA (cytosine, guanine, adenine and thymine).

A unique combination of the four nucleobases makes up the individual DNA sequence of a gene. Currently, DNA sequencing is a fundamental tool for medical diagnostics, forensic testing and medical and biological research.

The use of graphene to electrically sequence DNA promises to improve the speed, throughput, reliability and accuracy while reducing the price compared to current techniques, said Dontschuk.

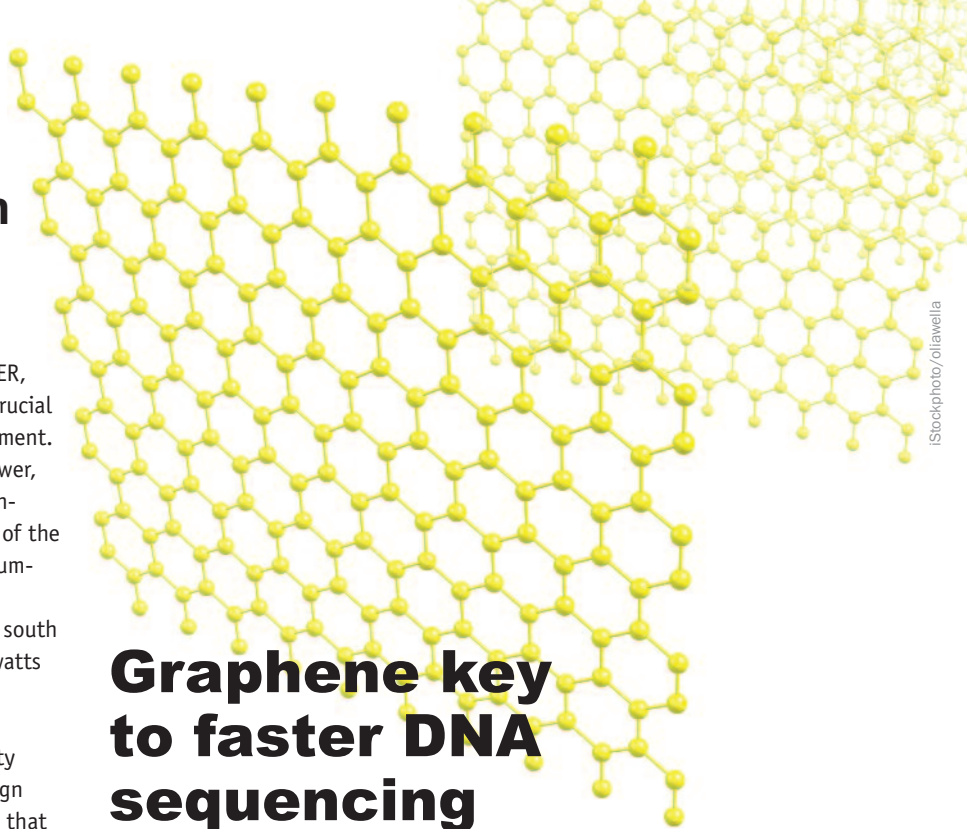
'We found that each nucleobase influenced the electronic structure of graphene in a measurably different way,' said Dontschuk.

'When used in conjunction with a nanopore, a single DNA molecule would pass through the graphene-based electrical sensor – like a single string of beads passing through one section of tiny chicken wire – enabling real-time, high-throughput sequencing of a single DNA molecule.'

The research team conducted the first experiments to combine in situ electrical measurements of graphene-based field effect transistors with photoemission spectroscopy at the soft X-ray spectroscopy beamline at the Synchrotron.

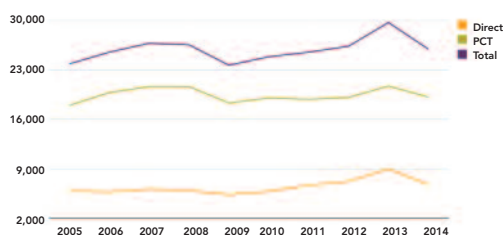
After comparing the experimental and synchrotron results, the team predicted that single-molecule sensing of guanine, cytosine and thymine by bulk graphene devices could be achieved.

AUSTRALIAN SYNCHROTRON



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Report details Australian intellectual property trends



Standard patent applications 2005–14. (PCT, Patent Cooperation Treaty)

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Parliamentary Secretary for Industry and Science Karen Andrews has released the Australian Intellectual Property Report 2015, a detailed breakdown of the latest intellectual property (IP) trends in Australia.

‘Intellectual property is a powerful tool for Australia’s economic development and national prosperity, it is a key part of each business’s suite of assets,’ Andrews said at the Institute of Patent and Trade Mark Attorneys of Australia annual conference in Adelaide.

‘A well functioning and effective IP system is important to support the major structural adjustment in Australia’s economy as we transition to a knowledge economy that is innovation intensive, high value add and export oriented.

‘As global markets continue to expand, the role of IP rights is becoming increasingly important because IP underpins our innovation, trade and investment efforts.’

Andrews said the latest Australian Intellectual Property Report showed marked variations across the four registered IP streams, with demand for trademarks and plant breeder’s rights growing and demand for patents and designs easing.

‘These trends reflect a range of factors, both domestic and international, which are explored throughout the report,’ Andrews said.

The Australian IP Report is an annual publication that promotes awareness of IP rights and developments and is released by IP Australia, the Australian Government agency that administers IP rights and legislation relating to patent trademarks, designs and plant breeder’s rights.

Andrews also announced the second release of the IP Government Open Data, which is now available.

‘The data includes information about IP rights applications going back to the early 1900s. It is matched to individual firms, along with information about their size, their technology and their geographic location,’ Andrews said.

The Australian IP Report 2015 is available from www.ipaustralia.gov.au.

DEPARTMENT OF INDUSTRY AND SCIENCE

New hub for sustainable chemistry



In April, the Parliamentary Secretary to the Minister for Education and Training, Senator Scott Ryan, opened Monash’s new Green Chemical Futures building.

Green Chemical Futures is a multidisciplinary innovation hub dedicated to supporting researchers and industries innovating within the chemicals manufacturing sector. It also offers exceptional learning spaces for students.

The new building acts as a catalyst for new ideas, providing a stimulating environment where industry and academia collaborate. The design of the building is intended to stimulate innovation with features such as a spiralling staircase and inspiring wall art.

Opening the building, President and Vice-Chancellor Professor Margaret Gardner AO said the building is a dynamic area connecting industry with researchers and students.

‘As part of the second largest manufacturing sector that employs more than 60 000 people in highly skilled jobs, chemistry is central to the country’s societal, environmental and economic well-being,’ Gardner said.

‘The opening of the Green Chemical Futures hub signifies Monash’s position as a world leader in sustainable chemistry research and teaching. It provides an engaging and high-tech environment in which students, academics and industry professionals teach, learn and collaborate to help make the world a better place.’

The first two levels of the building house innovative teaching and collaborative learning spaces, encouraging active learning and creative problem solving. The building also includes top-class research laboratories and facilities on the upper levels.

Also in the building is the Victorian Centre for Sustainable Chemical Manufacturing, the Graduate Research Interdisciplinary Program, and the Training and Innovation hub of the Chemicals and Plastics Innovation Network.

MONASH UNIVERSITY

We can measure research engagement, says ATSE

The Australian Academy of Technological Sciences and Engineering (ATSE) is spearheading a campaign to change the way Australia values research.

There is growing acknowledgement in government and industry that the Excellence in Research for Australia (ERA) model – currently the only accepted measure of research ‘quality’ – cannot adequately encourage research commercialisation or other translation into community benefit.

This is against a background where Australian universities, publicly funded research institutes and industry are far less engaged in research collaboration than their counterparts in other countries, which is concerning, given that such collaborations are the engine room behind the advanced manufacturing industries of the future.

To drive policy thinking towards a better-balanced approach, ATSE has produced a major report, “Research Engagement for Australia” (REA), which proposes to reward research engagement, under the REA banner, alongside research excellence (ERA).

The key principle is to use the amount of revenue from industry and other research end-users as a measure of research engagement.

ATSE argues that this would impose negligible costs because it would use data already submitted by universities in annual returns and as part of the ERA process.

ATSE believes that use of the REA metrics will help to increase the return on the public investment in research in science, technology, engineering and maths (STEM) and humanities and social sciences (HASS) alike. Importantly, the metrics are calculated for disciplines within universities (by Field of Research code), so that comparisons are made between universities, not between disciplines.

ATSE President Dr Alan Finkel AO FTSE said it is vital to reward activities by researchers directed at innovation.

‘The ERA recognises and rewards scholastic achievement but in some cases, without intention, it deters engagement by researchers with industry, or with key communities such as

hospitals,’ he said.

‘REA will foster collaboration and knowledge exchange – and encourage research translation and impact.

‘Researchers are too often forced to choose between research and commercial careers, rather than being able to nurture their discoveries and innovations to market successfully.’

Finkel acknowledged the value of the ERA, which he described as a robust quality measure of research excellence.

‘We don’t question that at all, but because it’s the only measure out there, researchers and their managers at universities are focused on doing well in that measure.

‘It’s intended to encourage researchers to elevate themselves in research excellence but,

inadvertently, it can dissuade researchers from engaging with industry and nurturing the fruits of their research into the market because they are under pressure to publish and be cited.

‘We think it’s important that the Australian community and the Australian Government receive a measurable return on investment in research beyond just the research itself. It must be translated into community and commercial benefit.’

ATSE Vice-President Professor Peter Gray FTSE, who chaired the Steering Committee that produced the Research Engagement for Australia (REA) report, commented:

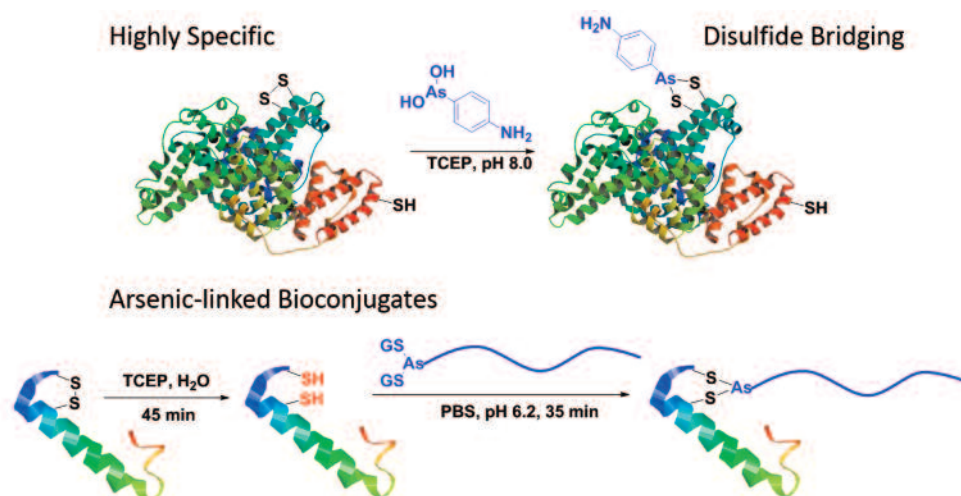
‘Initial trials show that the resulting REA metric is a simple, robust measure of research engagement, based on data already collected by the university sector, which can be applied within the various research disciplines

‘It would be a relatively simple exercise to determine the REA metric, and the exercise of determining such a metric would modify behaviour within the university sector and encourage research collaboration and uptake by industry and other end users.’

The report, funded by the Australian Government Department of Education and Training, is on the ATSE website (atse.org.au).
AUSTRALIAN ACADEMY OF TECHNOLOGY SCIENCES AND ENGINEERING



Linking polymers and peptides selectively and efficiently



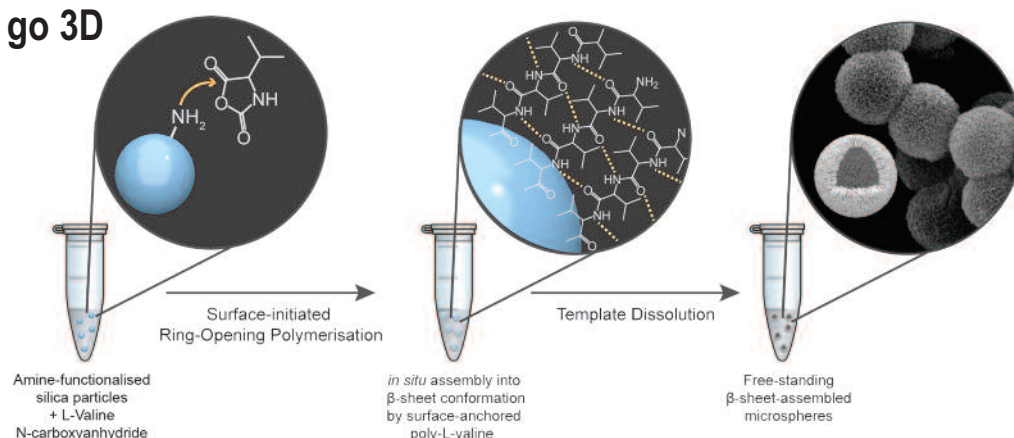
Researchers from Monash University and the University of Warwick have developed a new way to make peptide/protein-polymer conjugates that exploits the affinity of trivalent arsenic (As^{III}) for proximal dithiols (Wilson P., Anastasaki A., Owen M.R., Kempe K., Haddleton D.M., Mann S.K.,

Johnston A.P.R., Quinn J.F., Whittaker M.R., Hogg P.J., Davis T.P. *J. Am. Chem. Soc.* 2015, **137**, 4215–22). As a proof-of-principle, an organic arsenical was used to bridge the disulfide present in a therapeutic peptide (salmon calcitonin, sCT) and in a model protein (bovine serum albumin, BSA).

Conjugation was stoichiometric in sCT with efficiencies equal to those reported for established disulfide targeted conjugation strategies. Arsenicals were found to be much more specific than existing maleimide-derived reagents in reacting with disulfide-derived dithiols in the presence of monothiol residues in native and partially reduced BSA, invoking the potential for thiol-based orthogonality. Peptide-polymer conjugates were formed by reacting reduced sCT with a polymeric arsenical synthesised via aqueous single-electron-transfer living radical polymerisation using an arsenic-functional initiator. Finally, it was shown that the arsenical-linked conjugates could be thermodynamically dismantled in the presence of stronger chelating reagents such as 1,2-ethanedithiol or lipoic acid.

Peptide β -sheets go 3D

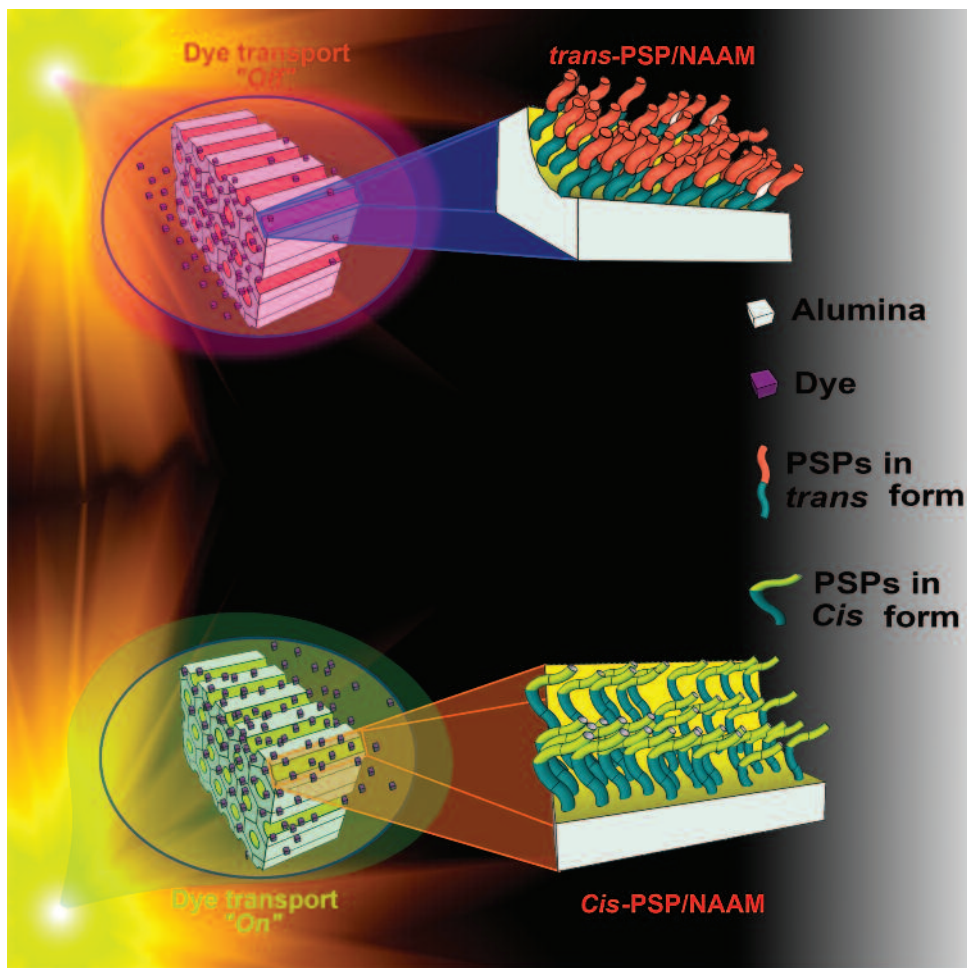
Polypeptides have attracted widespread interest as renewable building blocks of nanomaterials due to their innate ability to form higher order structures such as β -sheets. But controlled assembly of β -sheet peptides is challenging as they tend to form unprocessable aggregates. Until now, β -sheet assembly has only successfully been achieved using specialised instruments such as automated peptide synthesisers and/or meticulously controlled self-assembly conditions to yield fibre-like architectures, with limited control over dimensions or aspect ratio. Researchers led by Professor Greg Qiao at the University of Melbourne (Wibowo S.H., Sulistio A., Wong E.H.H., Blencowe A., Qiao G.G. *Adv. Funct. Mater.* 2015, doi: 10.1002/adfm.201404091)



have demonstrated the ability to control the shape and dimensions of β -sheet assembled architectures by employing a rapid and robust strategy involving surface-initiated ring-opening polymerisation. Peptides remain 'anchored' to the surface of a template during polymerisation, which forces in situ assembly into a parallel β -sheet conformation. Consequently, the hydrogen-bonded peptide grafts adopt

the 3D shape of the template and retain this shape after template dissolution. Given the broad range of possible templates, the sizes and shapes of the architectures can be easily tailored. The assembled structures exhibit a remarkable ability to non-covalently entrap a broad range of materials, opening the door to potential applications in therapeutic delivery and organic catalysis.

Photoswitchable membrane for on-demand molecular transport



PSP: photoswitchable peptide NAAM: nanoporous anodic alumina membrane

Researchers in the School of Chemical Engineering and Department of Chemistry at the University of Adelaide and ARC Centre of Excellence for Nanoscale Biophotonics have developed an artificial membrane that mimics controlled molecular transport across a cell membrane (Kumeria T., Yu J., Alsawat M., Kurkuri M.D., Santos A., Abell A.D., Losic D. *Adv. Mater.* 2015, **27**, 3019–24). The system employs a peptide-based azobenzene photoswitch attached to the pores of a nanoporous anodic alumina membrane to control the passage of Rose Bengal across the structure. The azobenzene component can be reversibly switched between *cis* and *trans* photostationary states on irradiation with specific wavelengths of light (namely 440 and 364 nm). This reversibly controls the diameter and surface chemistry of the pores in the membrane. The researchers showed that transport across the membrane could be controlled and manipulated on demand over multiple cycles of irradiation.

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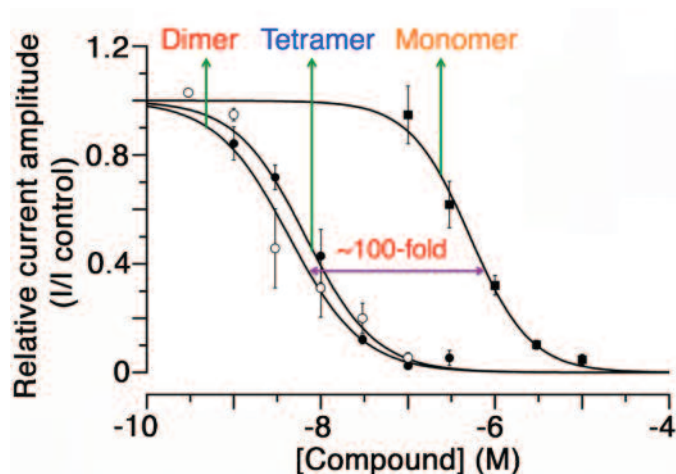
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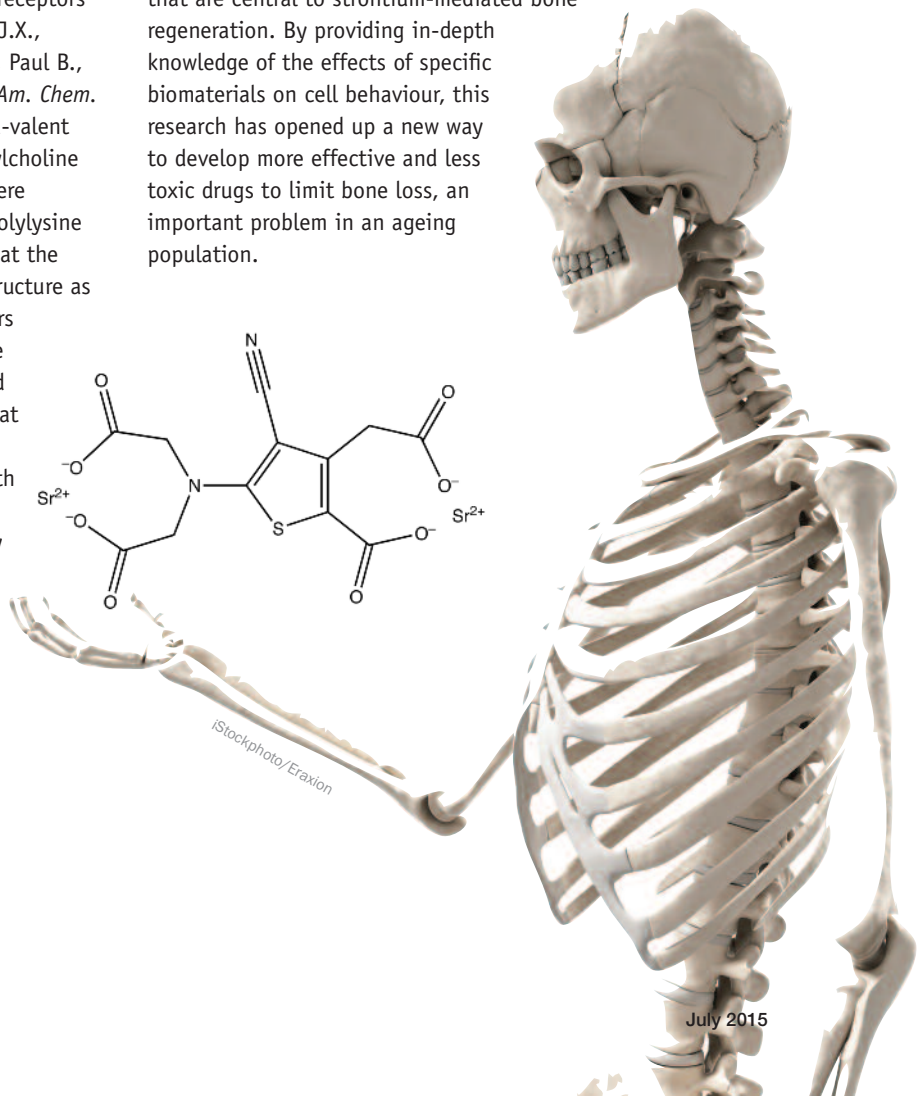
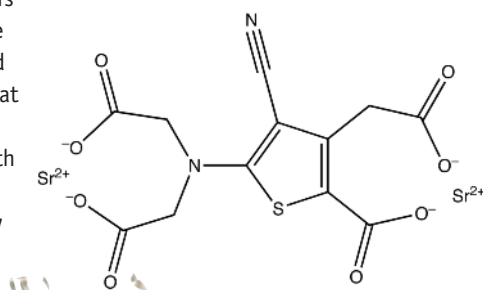
Enhanced potency of receptor ligands using dendrimers



An Australian team led by Professor Paul Alewood from the University of Queensland has described the synthesis of the first conotoxin dendrimers and demonstrated dramatically enhanced potency of the dendrimers to the neuronal receptors targeted by the peptide α -conotoxin (Wan J., Huang J.X., Vetter I., Mobli M., Lawson J., Tae H.-S., Abraham N., Paul B., Cooper M.A., Adams D.J., Lewis R.J., Alewood P.F. *J. Am. Chem. Soc.* 2015, **137**, 3209–12). Homogenous di- and tetra-valent dendrimers incorporating the small $\alpha 7$ nicotinic acetylcholine receptor (nAChR) blocker α -conotoxin ImI (α -ImI) were attached via 'click chemistry' to an alkyne-modified polylysine dendron. NMR and CD structural analysis confirmed that the α -ImI moiety in both dendrimers had the same 3D structure as native α -ImI. Binding affinity of the α -ImI dendrimers to the protein Ac-AChBP, which is a homologue of the ligand-binding domains of nAChRs, revealed enhanced affinity and quantitative electrophysiology showed that the α -ImI dendrimers had an approximately 100-fold enhanced potency at human $\alpha 7$ nAChRs compared with native α -ImI. These multivalent peptide constructs represent a promising approach to enhancing potency and selectivity of ligands for homomeric ion channels such as nicotonic acetylcholine receptors and for developing drugs that target these receptors.

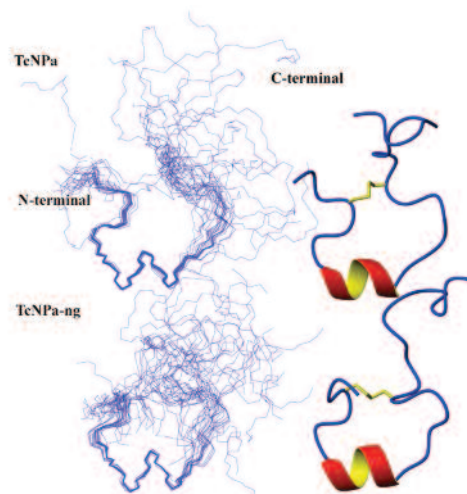
Making no bones about role of strontium

The biomaterial Stronbone™ was developed to treat osteoporosis and other diseases or injuries that involve bone loss. The active ingredient is strontium ranelate, a strontium(II) salt of ranelic acid. By stimulating the body's mesenchymal stem cells to differentiate into bone, grafts containing strontium ranelate coax the body's own cells to regenerate lost or damaged bone. But until now little was known about the biological pathways responsible. In collaboration with Stronbone's inventor, Professor Molly Stevens of Imperial College London, an Australian research team at CSIRO's Manufacturing Flagship led by Professor Dave Winkler analysed the gene response of mesenchymal stem cells donated by three patients treated with Stronbone (Autefage H., Gentleman E., Littmann E., Hedegaard M.A.B., Von Erlach T., O'Donnell M., Burden F.R., Winkler D.A., Stevens M.M. *Proc. Natl Acad. Sci. USA* 2015, **112**, 4280–5). Using a novel statistical method called sparse feature selection, they were able to identify 11 genes from over 35 000 candidates that were most important in stimulating the growth of bone. These genes revealed previously unknown biochemical pathways involved in sterol and fatty acid biosynthesis that are central to strontium-mediated bone regeneration. By providing in-depth knowledge of the effects of specific biomaterials on cell behaviour, this research has opened up a new way to develop more effective and less toxic drugs to limit bone loss, an important problem in an ageing population.



Synthesised snake venom peptide potential heart drug lead

Natriuretic peptides regulate sodium levels in the body and play important roles in the physiology of the heart. A team led by Professor Paul Alewood from the University of Queensland and including researchers from the University of Sydney, Macquarie University and University of Singapore have discovered and synthesised a 31-residue natriuretic peptide from the venom of the Australian snake *Tropidechis carinatus* (Reeks T., Jones A., Brust A., Sridharan S., Corcilus L., Wilkinson B.L., Thaysen-Andersen M., Payne R.J., Kini R.M., Daly N.L., Alewood P.F. *Angew. Chem. Int. Ed.* 2015, **54**, 4828–31). This peptide is the first O-linked glycosylated natriuretic peptide to be discovered and the first natriuretic peptide to show secondary structure (helical structures in the image shown of the glycosylated (TcNP_a) and non-glycosylated (TcNP_a-ng) peptides). It is also the first 'natural' natriuretic peptide to show bifunctionality at natriuretic peptide receptors NPR-A and NPR-B, thus increasing its potential as a drug lead molecule. This work will underpin the future development of bifunctional natriuretic peptide mimetics.



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



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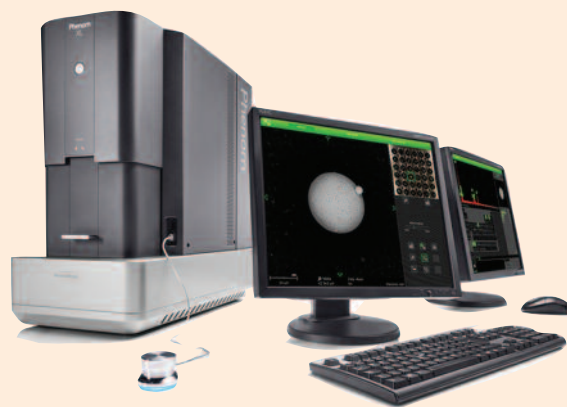
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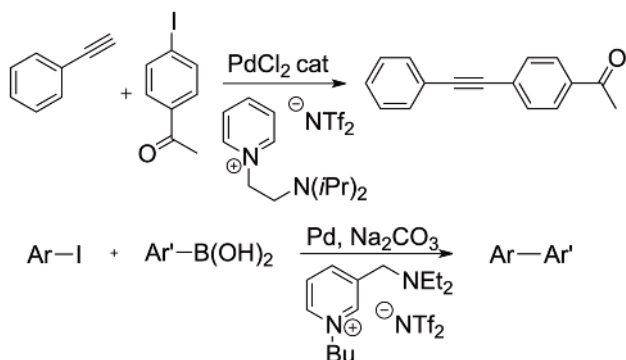
Aust J Chem

In the June issue, Al-Zoubi and co-workers (Jordan and Canada) describe a method for the 1,2,3-tri-iodoation of aromatics. Several 1,2,3-triiodoaryl derivatives are known to be biologically active, so general synthetic methods for this class of compounds are desirable.



The triiodo-compounds obtained here in good yields from benzoic acids can be further transformed by electrophilic *ipso*-substitution to form 1-substituted 2,6-diiodo derivatives (NIS = *N*-iodosuccinimide; E = H, CH₃, HC=O, SiMe₃, alkyl).

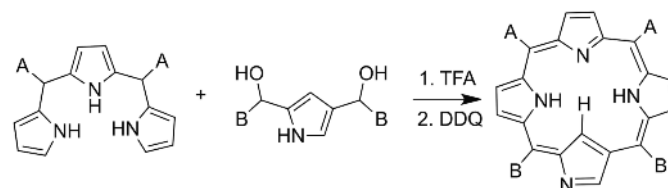
Peter Scammells (Monash University), with co-workers in Canada and Spain, describes the preparation of several nitrogen-containing ionic liquids (two examples shown) and their use in organic syntheses, including the Sonogashira and Suzuki–Miyaura reactions shown in the scheme, as well as Knoevenagel and Morita–Baylis–Hilman reactions.



Denping Hu et al. (Nanjing University) have synthesised carbon-supported non-noble metal oxide catalysts, in particular MnCo₂O₄/C, and used it as a cathodic catalyst in a microbial fuel cell. The maximum power density obtained was 545 mW/m², which is far higher than for a plain cathode ($P_{\text{max}} = 214 \text{ mW/m}^2$), and only slightly lower than that obtained with a widely used commercial Pt/C catalyst. This study implies that the MnCo₂O₄/C nanocomposite may be used as cost-effective cathodic catalyst for practical fuel cell applications.

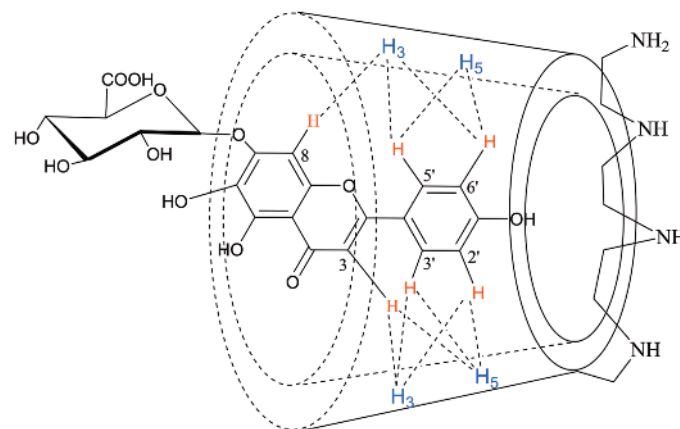
N-confused porphyrins (NCPs), also known as carbaporphyrins or inverted porphyrins are isomers of normal porphyrin, in which three pyrrole rings have α – α linkages, and the fourth, 'confused' pyrrole has α – β linkage. The inner C–H moiety in these compounds can complex with metal ions, often forming complexes with metals in unusual oxidation states, such as Ag^{III}, Cu^{III} and Rh^{IV}. NCPs are less aromatic than normal porphyrin, and this property makes them better chromophores

for light-harvesting antenna systems. Iti Gupta (Indian Institute of Technology Gandhinagar) and associates now report a synthesis of NCPs as shown here, where A = substituted aryl, and B = C₆F₅.



These compounds show fluorescence maxima in the 700–740 nm region.

Bo Yang et al. (Kunming University, China) describe the Chinese herbal drug Scutellarin (SCU), which is a 4',5,6-trihydroxyflavone-7-*O*-glucuronide extracted from the Chinese herb *Erigeron breviscapus* (Vant.) Hand.-Mazz. It is not only important in Chinese medicine, but is also a major constituent of skullcap, which is a popular Western herb. Since the 1970s, SCU has been shown to be effective in dilating blood vessels, improving microcirculation, increasing cerebral blood flow, and inhibiting platelet aggregation. In addition, it has been clinically used to treat acute cerebral haemorrhage in China since 1984. It can also induce cell death in human colon cancer cells and inhibit HIV-1 reverse transcriptional activity, HIV-1 particle attachment and cell fusion, all of which are essential activities for viral transmission and replication.



However, a limiting factor has been the low solubility of SCU, which is partially overcome by incorporating the compound in cyclodextrin. The Chinese group has decorated β -cyclodextrin with a number of amino acid residues and report that the resulting materials are able to solubilise SCU to levels up to 50 mg/mL compared to 9.0 mg/mL for the unmodified β -cyclodextrin. Consequently, the antitumour activity of SCU was significantly increased by using these new and readily synthesised inclusion complexes.

Larry and the science factory

Larry Marshall is an old colleague of mine from the world of start-ups and venture capital. Along with others who know Larry and have had dealings with CSIRO, I was quite surprised late last year when Larry was announced as the new CEO of CSIRO. However, not unpleasantly surprised.

CSIRO has a history of unusual CEO appointments. For example, the three prior appointments were Megan Clark, previously Vice President, Health, Safety, Environment, Community and Sustainability at BHP; Geoff Garrett, who was head of the South African CSIR, the South African equivalent to CSIRO; and Colin Adam, who was head of commercialisation in CSIRO prior to becoming CEO, but before that had been in the corporate sector.

These are 'unusual' appointments because none was an internal appointment of a candidate with a long history within CSIRO. An organisation that is performing strongly tends to have processes to identify and groom internal CEO candidates. Often a candidate who does become CEO has been employed in the organisation for

decades, in many different roles. Some current well-known examples are Tim Cook of Apple, who has been there since 1998, and Jeffrey Immelt of GE, who has been at the company since 1982. These internal CEO candidates carry the culture and vision of the organisation with them into their CEO roles in a way that external candidates cannot. The very choice of an external CEO candidate is often a tacit recognition that the organisation needs a new culture and vision.

'Shaping the future' in a shifting economy

From an outsider's perspective, it appears that CSIRO has struggled to find relevance after the deregulation of the Australian economy in the 1980s and the subsequent changes therein. Since this period, there has been a dramatic shift in our economy towards the (science-agnostic) services sector, which now generates 68% of our GDP. CSIRO, with its main focus on science, is primarily left serving the resources and agricultural sectors, plus some other sectors at the fringes of economic importance in Australia.

Another change that we saw in the late 1980s was the deregulation of the Australian university sector, which led to these organisations becoming willing and able to work with the Australian private sector. Before this, they had, for various reasons, been less interested in doing so. In fact, the federal government, through the Linkage grant scheme, the CRC program and other schemes, actively encouraged university and 'industry' engagement. The expanding university sector effectively began to compete with CSIRO in what was a shrinking market for outsourced scientific services in Australia.

Any perusal of CSIRO's website, or any article written by CSIRO strategists, quickly reveals that CSIRO sees itself as a purveyor of scientific services and science-derived outcomes. That is, the 'S' and 'R' in CSIRO dominate their thinking. For example, at the CSIRO website the 'About us' by-line reads: 'At CSIRO we shape the future. We do this by using science to solve real issues.'

This focus on science is at a time when the global high-growth technology business sectors (in which

After meeting with new CEO Larry Marshall, Ian Maxwell looks at CSIRO's place among public and private interests, and the options from here.

Australia is seriously lagging) are increasingly being driven by engineering and IT technologies, and less so by science. With CSIRO's focus on 'scientific services and outcomes' in Australia, their TAM (total available market) is even further reduced compared to a scenario in which they also had a serious focus on IT and engineering.

Little wonder that with a reliance on over \$0.75 billion in federal funding per annum, the CSIRO leadership has been desperate to find a role that either is more profitable or at least generates enough positive publicity so that government funding is secure. However, despite over two decades of restructuring and unusual CEO appointments, it could be plausibly argued that the organisation is no closer to finding a secure place in the Australian economy.

The organisation has had decades of constant organisational restructures, a matrix management structure that few believe in, and an oversupply of 'managerialism' emanating from head office. Recent cuts have culled \$111 million off the CSIRO budget over four years and resulted in the loss of



Changing of the guard at CSIRO

The appointment of Dr Larry Marshall as the new Chief Executive of CSIRO was announced in October 2014 by the Chairman of the CSIRO Board, Simon McKeon.

‘Dr Marshall has an impeccable record as a scientist, a technology innovator and business leader,’ McKeon said.

‘The Chief Executive of CSIRO is probably the most important position in national science administration, so we conducted an extensive global search for an innovative scientist with strong business leadership qualities, and more

than 70 candidates were considered.

‘The Board is confident that Dr Marshall will lead CSIRO in a manner which ensures that it continues to provide advice of the highest quality to Government as well as provide best practice collaboration with the private sector.’

McKeon also thanked current Chief Executive Dr Megan Clark for her leadership of CSIRO for the past six years.

Marshall joined CSIRO in January. He was previously Managing Director of Southern Cross Venture Partners, an

early-stage venture capital firm specialising in creating Australian technology companies and growing them globally in Asia and the US.

Marshall was educated at Macquarie University (Sydney) where he took a doctorate in physics. He began his career in the Defence Science and Technology Organisation and has 25 years experience as an international technology entrepreneur and holds 20 patents protecting commercial products. He has founded six successful US



companies in biotechnology, photonics, telecommunications and semiconductors. CSIRO

around 700 jobs. In 1996, CSIRO employed 7400 people; by 2015 the number is closer to 5000.

CSIRO, rather confusingly, variably focuses on nine National Flagships, Science Excellence and Preparedness, Deep Collaboration and Connection, and being an Innovation Organisation and a Trusted Advisor. CSIRO also operates three lines of business – the ‘National Facilities and Collections’, CSIRO services, and the aforementioned nine National Flagships, which are Agriculture, Biosecurity, Digital Productivity, Energy, Food and Nutrition, Land and Water, Manufacturing, Mineral Resources, and Oceans and Atmosphere. It is arguable whether all of these activities are world class, but more importantly it is also arguable whether a local capability deep in the science of all these areas has relevance to Australia in 2015.

Repurposing science

It is worthwhile considering what happened way back when the management of CSIRO announced these nine Flagships for the first time.

Every scientist in the organisation simply chose which Flagship they were in, or the choice was made for them or against them. However, scientists cannot simply adopt a new discipline at the drop of a hat; whatever choices were made, they remained as chemists, physicists or mathematicians with a primary focus in a very specific sub-field within their discipline. In the modern era, it takes a scientist decades to build up a portfolio of publications and a reputation within a specific and tight field of activity. It can be very inconvenient to have an employer like CSIRO suggest to the chemist that she abandons, say, a life-long focus on a specific new type of radical chemistry, in which she is a world expert, in order to chase some unrelated agricultural chemistry challenge that will likely be a victim of the next restructure.

The point I am making is that an organisation with science as its primary focus is the single most unlikely candidate for successful repurposing. Efforts to do so, as have been seen at CSIRO since the 1980s,

just make the scientists unnecessarily stressed and sometimes also passively uncooperative, and as a result the organisation is even less likely to be successful in an innovative or entrepreneurial sense.

The new CEO

Enter Dr Larry R. Marshall. Larry is a serial entrepreneur credited with many successful start-ups in areas as diverse as biotechnology, photonics and semiconductors. Some of these companies have been successfully sold to larger operating companies and one went onto an Initial Public Offering. Larry has also been a venture capitalist and a private investor. He has had significant business dealings in China and the US, and in both countries he is extraordinarily well connected to leaders in the tech sectors. He is a serial inventor named on around 20 patent families and has somehow managed to find the time to be an author on over 100 research publications. This is a non-trivial set of polymath achievements, quite rare in its breadth and depth. However, none

of it speaks directly to the skills needed to turn around a large and unprofitable organisation that is in need of something dramatic just to survive.

CSIRO generally has five-year plans and it is due for a new one right now. I suspect that this federal government, or any federal government, would like to define success for CSIRO as zero federal funding requirements. I find it quite remarkable that CSIRO already attracts about one-third of its operating costs from commercial activities; they should be applauded for this achievement. However, given the size of the market for 'scientific services and outcomes' in Australia I would suggest that any attempts to grow this market with today's pricing structure may be up against the Pareto rule, i.e. the cost of acquiring new customers will become higher and higher, to the

point of unprofitability, as its market share becomes even more dominant.

In this context, and assuming continued pressure on its public funding, CSIRO has two stark options – to reduce in size, commensurate with its genuine market revenues, or to find entirely new sources of revenues.

Larry's entrepreneurial background would suggest that he would rather attempt to achieve great success at CSIRO than oversee a transition to a much smaller and more secure scientific services provider.

Larry himself has signalled that the sources of new revenue might involve a more entrepreneurial focus: '... I can't promise that change is now over ... We've got to focus our efforts ... We've got to be more entrepreneurial and agile ... We've got to get our overheads down ... we've got to create some more headroom for exploration

... I have learned a lot about lean innovation and focusing on where we are unique.'

It was in this context that Larry and I shared a beer in mid-March of this year. He told me that he is still in the process of formulating his thinking on his role as CEO of CSIRO. His big priority is to oversee the new five-year strategic plan that is due this year. Rather than report on our discussion, which would be a little unfair to Larry given the early stage of his engagement, I've adopted more of an opinion piece. Commentary on the options ahead for CSIRO can be found in the rest of this article, at chemaust.raci.org.au.

Ian A. Maxwell is a serial (and sometimes parallel) entrepreneur, venture capitalist and Adjunct Professor in Electrical and Computer Engineering at RMIT University, who started out his career as a physical polymer chemist.



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Girls studying chemistry

Comparing secondary school performance

BY **ROBERT MACLAGAN**

More girls are studying secondary school chemistry, but specific trends in Australasia and further afield are linked to examining authorities.

In New Zealand in 1975, less than a third of students studying chemistry in the final year of secondary school were female. In that year, only about one in ten of the girls who started secondary school in 1971 was still at school. The situation has changed. In 2014, more than half of the final-year chemistry class in New Zealand was female. Almost nine in ten girls who started secondary school in 2010 remained to the 2014 final year (Year 13).

Enrolment trends are something I have been interested in for some time. I have previously reported trends since 1975 (published in *Chemistry in*

*New Zealand and ANZ Physicist**) in the number of New Zealand students studying science.

Each year since 1975, I have updated my database, and this time I decided to see whether the trends in secondary school chemistry in New Zealand are the same as they are elsewhere. As you will see, they are not. I have compared the enrolment and performance of girls studying final-year secondary school chemistry in 2001–13 in New Zealand and five Australian states, and in various examination systems in the UK and Ireland. I leave it to readers and others to try to explain what has been observed.

Rates of change for chemistry enrolments

The number of girls studying final-year secondary chemistry has increased. The table opposite shows that in New Zealand and Queensland, the increase in numbers is significantly greater for girls. (Data in all tables and figures has been sourced from the websites of the relevant examining authorities). For the UK AS and A levels, the increases are similar for both sexes, while elsewhere they are greater for boys.

The different rates of increases are reflected in the change over the period 2001–13 in the percentage of girls in final-year secondary chemistry (%F). The changes in %F are shown in

*Visit chemaust.raci.org.au for reference information.



the graph on page 24. The %F in Ireland has remained greater than 50%, while in South Australia and Western Australia it has remained less than 50%. In New Zealand and Queensland, the percentage of girls in

final-year secondary chemistry has increased markedly to greater than 50%. The increase in %F in Queensland is due to very little change in the number of boys in final-year secondary chemistry, with a

linear fit actually giving a decrease of 3.4 male students per year compared with an increase of 80.3 female students per year. By contrast, the larger increase in the number of boys studying final-year chemistry compared with girls in Victoria has led to the %F dropping from 54.5% in 2001 (the largest Australasian %F in 2001) to 49.3% in 2013. In Victoria, it is the girls' number that has not changed greatly, with a linear fit

giving an increase of only 1.4 students per year while the fit to the boys' data gives an increase of 105.7 students per year. The trends for UK AS levels were the same as for the UK A levels. This is also true for the Scottish Advanced Highers when compared with the Highers. The Scottish Higher was introduced in 2000 and the number taking the Advanced Higher exam was only 592 in 2001 compared with 1769 the following year. With increased competition for places in top universities, I suspect more students are taking AS courses in addition to those they are taking for A levels, since the AS results are sometimes used to determine who receives offers of places. Straight A's in A levels do not guarantee a place in Medicine

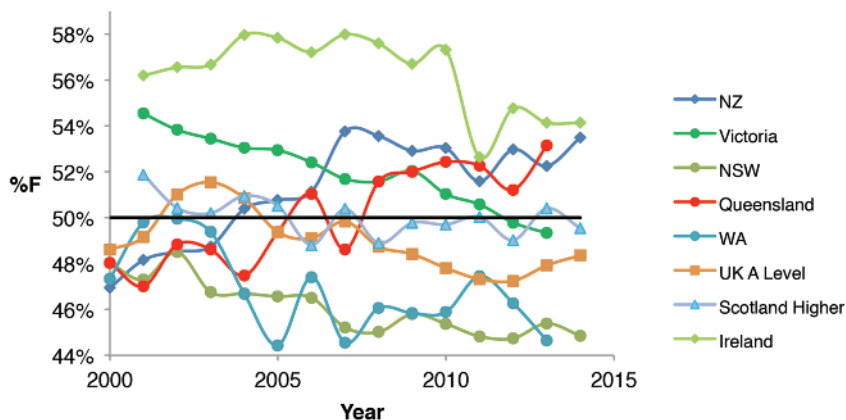
New Zealand and Victoria had similar percentage increases in the number of boys studying chemistry in their final secondary school year but very different percentage increases for girls. The different rates of increase for

Percentage change in chemistry enrolments in New Zealand, Australia (some states), Ireland and the UK 2001–2013

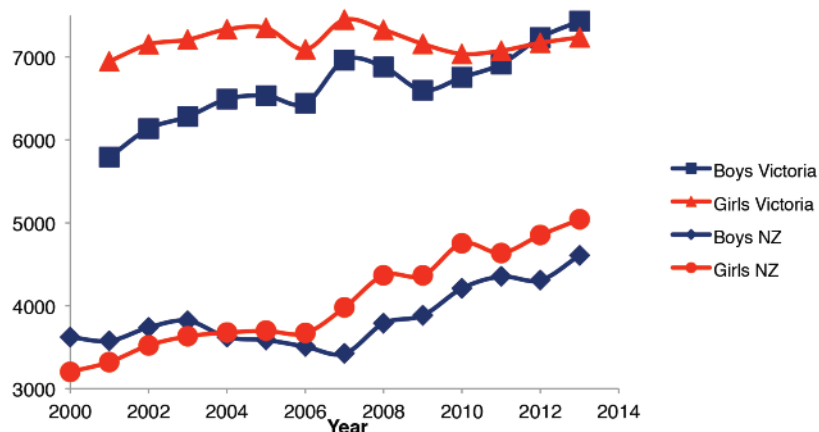
State/country	Percentage change	
	Boys	Girls
New Zealand	28.8	51.8
New South Wales	25.1	15.8
Queensland	−0.7	22.4
South Australia	−13.8	−12.1
Victoria*	28.4	4.2
Western Australia	54.2	25.4
Ireland Leaving Certificate	35.7	24.8
Scotland Higher	10.9	4.5
Scotland Advanced Higher	45.0	57.0†
UK A Level	39.6	32.8
UK AS Level	122.8	102.5

*Average of two externally assessed units.

†Data for 2002–13; see text.



Percentage of female students in final-year secondary chemistry.



Numbers of girls and boys studying final-year chemistry in New Zealand and Victoria 2001–13.

Percentage of final year candidates studying chemistry in New Zealand, Australia (some states), Ireland and the UK in 2013

State/country	Boys (%)	Girls (%)
New Zealand	19.0	19.3
New South Wales	16.6	13.2
Queensland	18.9	20.8
South Australia	9.7	10.3
Victoria	19.8	17.4
Western Australia	23.3	19.5
Ireland Leaving Certificate	11.6	14.0
Scotland Higher	18.0	18.7
Scotland Advanced Higher	22.6	17.7
UK A Level	6.9	5.4
UK AS Level	7.0	5.7

Girls in the Chemistry Olympiad

My involvement with New Zealand's participation in the International Chemistry Olympiad revealed how few girls were meeting the standard to be invited to the selection camp. We have had to resort to establishing quotas to ensure some girls attend the camp.

In 2015, only four of the 31 students in the New Zealand Chemistry Olympiad Selection camp were girls, yet more than 50% of the final-year chemistry class are girls. One girl did make the team. It is worth observing that in the period 2001 to 2013 only seven girls (13%) have been in the New Zealand International Chemistry Olympiad Team. Both Australia and UK had fewer girls in their teams over this period. Does there exist a peer culture discouraging top girls from reaching the team selection standard or is it the Olympiad curriculum?

girls and boys in Victoria and New Zealand are shown in the graph. In New Zealand, the rates of increase have been almost the same since 2006.

Percentages of final-year students studying chemistry

Another measure worth examining is the percentage of students in their final year who are studying chemistry (see following table). In New Zealand, Queensland, Scotland (for the Higher) and Ireland, where the %F was greater than 50%, the percentage of females is

greater than the percentage of males. An exception to this pattern is in South Australia where there is a greater percentage of females in the final year studying chemistry but the %F is less than 50%.

Exam performance

The table on page 25 shows data for the relative performance of girls and boys in final year secondary chemistry in 2013. Each state or country has a different grading scheme, with the number of points varying from the New Zealand NCEA's E(xcellent), M(erit) and A(chieved) to South Australia's

nine-point A⁺ to C⁻. In columns 3 and 4 are the percentages achieving the highest grade (or in South Australia's and Ireland's cases, the highest two grades). In columns 6 and 7 are the percentages achieving grades that include up to about 50% of candidates. In Victoria, the UK at both A and AS levels, and Ireland, a higher proportion of girls have higher grades in chemistry than boys. In Scotland, the performance of girls and boys is essentially the same in the Higher exam, but the boys perform better in the Advanced Higher. New Zealand boys perform better than girls in the standard 'Demonstrate understanding of equilibrium principles in aqueous systems', which involves some more quantitative questions.

Why the difference in performance? Is it the syllabus, especially its relevance, or the type of examination questions or their difficulty? Peer expectations and different levels of confidence may also play a part. It is unlikely to be a difference in teacher quality between different states or countries, although that could be a factor between different schools.

Examining authority makes a difference

With the exception of South Australia, the number of girls studying chemistry in their final secondary school year is increasing in all of the places for which data was collected. The percentage of girls in the final secondary year studying chemistry has increased for some places/examining authorities but decreased in others. This percentage varies significantly from examining authority to examining authority for reasons that are not obvious. If the goal is to have equal numbers of boys and girls, then there is some comfort in the situation being better for chemistry

Comparison of percentages of males and females achieving high grades in 2013 chemistry examinations

	Grade(s)	Male (%)	Female (%)	Grade(s)	Male (%)	Female (%)
New Zealand NCEA Level 3†‡	E	7.7	8.4	E+M	34.1	35.3
Queensland§	VHA	15.1	15.9	VHA + HA	46.1	53.5
South Australia	A ⁺ /A	12.8	13.9	A ⁺ -B ⁺	42.1	48.0
Victoria	A ⁺	9.7	8.4	A ⁺ -B	48.8	46.0
Western Australia	A	26.0	26.3	A + B	48.2	51.3
Ireland Leaving Certificate	A1/A2	21.7	19.5	A1-B3	49.7	47.3
Scotland Higher	A	31.7	31.7	A-B	55.4	55.3
Scotland Advanced Higher	A	35.0	30.4	A-B	62.8	57.6
UK A Level	A [*]	9.1	7.4	A [*] + A	34.0	33.1
UK AS Level	A	20.9	20.8	A-B	41.4	41.9

†Average of three externally assessed standards.

‡In New Zealand, the grades are (E)xcellence, (M)erit and (A)chieved.

§In Queensland, the achievement levels are (V)ery (H)igh (A)chievement, (H)igh (A)chievement, Sound Achievement, Limited Achievement, Very Limited Achievement.

Trends in biology and physics

The number of girls studying final-year secondary biology in the period 2001–13 has increased across the board, but the %F has decreased in Victoria, New South Wales and the UK, mainly due to a larger proportional increase in the number of boys studying the subject, probably a result of the increasing appeal of biochemistry and biotechnology. There were drops in the number of girls studying final-year secondary physics in the period except in New Zealand, the UK for A levels but not for UK AS levels, and Ireland. There was a resultant drop in the %F in physics classes except in New Zealand where the percentage was unchanged. This has serious implications for occupations such as engineering where women are under-represented.

In biology and physics, girls perform better in most examination systems. The exceptions are in Victoria for both subjects and in Scotland for the Advanced Higher. Boys in Victoria perform better in the cumulative statistics until B grades are included. New Zealand boys perform better in the physics standard 'Demonstrate understanding of mechanical systems' but in the other two externally assessed standards girls perform better.

than physics or biology. In some examining systems, girls perform better than boys and in others the reverse is true. Plenty of questions remain begging to be answered.

Robert G.A.R. MacLagan MRACI CChem (robert.maclagan@canterbury.ac.nz) is retired and is an Adjunct Associate Professor in the Department of Chemistry, University of Canterbury, New Zealand.



Pursuing other professions

PhD supply
and demand

BY **BRITTANY HOWARD**

Many young scientists, armed with PhD qualifications, are opting out of the laboratory to pursue other, more stable, professions.

The number of students graduating from Australian universities with a science-based PhD is increasing, yet the Australian Government's expenditure on science, research and development plummeted to a historic low in 2014. It is a matter of oversupply and underdemand, and students are acting accordingly.

Oversupply

Wilhelm University in Berlin, Germany, is credited as being the first university to award a modern PhD degree. The degree involved the completion of coursework, the undertaking of original research compiled into a substantial dissertation, and the subsequent successful defence of that dissertation. The model proved successful and was shortly thereafter adopted by the US, with Yale University awarding its first PhD in 1861. However, it took many years for the qualification to become available in Australia, with the University of Melbourne awarding the first PhDs in 1948.

The German PhD model was not adopted in Australia. Instead, we follow the practice of the UK, with the student undertaking a research apprenticeship under the direction of a nominated supervisor. Australian PhD students are not formally required to complete coursework, nor are they usually required to defend their resultant thesis. As a result, PhD degrees are awarded on the basis of an examination of the thesis, and not a direct assessment of the student. The model is appealing to many seeking

their PhD qualification; even more so given the degree is generally completed in just three to four years (compared to six to seven years in the US). Despite the substantial differences in PhD models, Australian PhD graduates continue to hold their own at an international level.

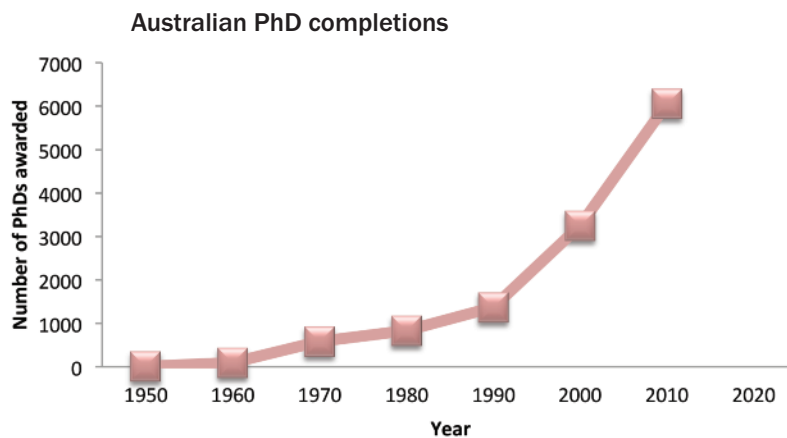
The Australian PhD is so appealing that the number of PhDs awarded annually has been increasing exponentially. Particularly in recent times, where during the period of 2000–2010, the number of doctoral enrolments at Australian universities rapidly propagated from 27 966 to 47 066 – a 68% increase. Accordingly, the number of students awarded a PhD by an Australian university rose to 6780 in 2011 (last available data).

Even more staggering is that there are 118 396 PhD-qualified individuals residing in Australia, according to the most recent Census of Population and Housing conducted by the Australian

Bureau of Statistics. More than 30% of these PhDs are in the natural and physical science disciplines.

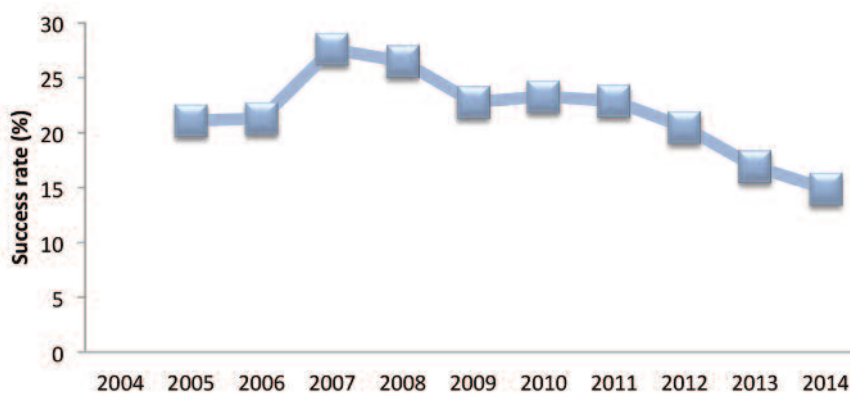
Underdemand

The Australian Government has estimated a contribution of \$9.192 billion to science, research and innovation in 2014–15. This value is \$386 million less than that contributed in the 2013–14 period. In practice, this \$386 million amounts to a significant reduction in the number of scientific jobs for budding young scientists. This \$9.192 billion contribution equates to just 0.56% of GDP in 2014, a historic low that hasn't been witnessed since 1979–80. To put this into perspective, Iceland sits atop the table, contributing more than 1.1% of its GDP to research and development. The figures are bleak and, consequently, Australia's investment in research and development is falling well behind several other countries.



Data compiled from *The changing PhD: discussion paper*, Group of Eight, March 2013.

NHMRC grant success



Data compiled from NHMRC website, www.nhmrc.gov.au/grants-funding/research-funding-statistics-and-data/nhmrc-project-grants-success-rate-broad-research

With so few scientific jobs available in Australia, ... It's all too frequently a matter of not what you know, but who you know. Herein lies the Catch-22. After being forced to undertake postdoctoral positions abroad, many young scientists often lose these connections.

The Australian Government's 2014–2015 Science, Research and Innovation Budget Tables reveal that research institutes were allocated 20% of the overall budget, while the higher education sector was allotted 31%. In addition, the Government contributes directly to the country's main granting body, the National Health and Medical Research Council (NHMRC). However, the NHMRC was allocated just 10% of the Government's overall science, research and innovation budget in 2014. Consequently, the NHMRC was able to fund only 14.9% of total grant applications for the year, which equated to the lowest level of success for research scientists since grant funding commenced in 2006.

The result

Government expenditure on science, research and innovation is failing to reflect the number of PhD graduates produced annually by Australian universities. It's just not keeping up, meaning there is a relative oversupply of PhD graduates and an undersupply of scientific positions. This 'oversupply and underdemand' issue is forcing many young scientists to make critical decisions during the early stages of their career.

For many PhD graduates, this decision leads them to undertake an international postdoctoral position. Previously, working abroad was considered beneficial to a scientist's training, transforming them into a more

experienced and well-rounded professional. Australian scientists who undertook an international postdoc were at an advantage compared to those who elected to complete a postdoc at home, and were consequently more sought after by employers upon returning to Australia.

However, the paradigm has shifted recently. While a postdoctoral position is still considered beneficial to a scientist's training, their paucity in Australia is forcing more and more PhD graduates to relocate overseas. An example of this is Dr Fiona McRobb,* who relocated to the US to commence her first postdoctoral position following the completion of her PhD in medicinal chemistry. Following her postdoctoral work, she was hired as an applications scientist at Schrödinger, and, while she misses home, Dr McRobb concedes: 'I cannot have this job in Australia and so to advance my career, I have to live overseas'.

From my own experience, securing a postdoctoral research position abroad was not all that difficult. Postdoctoral researchers are highly attractive employees – they are highly qualified, yet very affordable. Also, it is a critical time for young scientists to bolster their publication record, and they are therefore willing to work around the clock to accrue as many high-impact, peer-reviewed publications as possible. Of course, the number of publications accrued by a postdoc is also directly beneficial for their employer, particularly when the time for submitting grant applications inevitably rolls around. I have previously discussed (February issue, p. 36) that government grants may perhaps be too heavily dependent on the number of publications produced by scientists, but the reality remains,

*Each of the cited individuals, including the author, graduated with a PhD in Medicinal Chemistry from the Monash Institute of Pharmaceutical Sciences between 2009 and 2012.

NHMRC grants are heavily dependent on a researcher's publication record.

The issue then becomes one of re-entering the scientific field upon return to Australia. It is yet another hurdle for young scientists. In such a situation is Dr Brad Doak, who remains abroad as a postdoctoral researcher at Uppsala University. Dr Doak has plans to return to Australia to undertake a second postdoctoral position, though is aware of the challenges involved in doing so. With so few scientific jobs available in Australia, many positions are filled through personal networks. It's all too frequently a matter of not what you know, but who you know. Herein lies the Catch-22. After being forced to undertake postdoctoral positions abroad, many young scientists often lose these connections.

After graduation with her PhD, Dr Jessica Holien made the decision to undertake a postdoctoral position at home. The position was solidified through a personal network established during her PhD research, and she currently holds the position of postdoctoral research fellow at St Vincent's Institute of Medical Research. Dr Holien has been successful in taking advantage of the early career research grants available to scientists within a five-year period of graduating with a PhD. She now faces the challenge of taking the next step and finding avenues that are going to support her scientific research in the long term. The prospect is daunting.

The prospect is so daunting that many young scientists make an alternative decision during the early stages of their career – many choose to pursue other, more stable, professions. On the one hand, by this stage, many years have been invested into acquiring the skill and knowledge necessary to excel in science. It is counterintuitive to seemingly cast that aside. On the other hand, in many cases, it is simply not financially

feasible to continue in such an unpredictable and unstable field.

At an early stage in my career, I considered these factors, as well as many others, and made the difficult decision to pursue a career outside of scientific research. I made this decision during my first, and last, postdoctoral position at the National Institutes of Health, Maryland, US. Ultimately, it was the right decision for me. I am now employed as a Trainee Patent and Trade Marks Attorney at Melbourne's longest running intellectual property firm.

The prospect is so daunting that many young scientists make an alternative decision during the early stages of their career – many choose to pursue other, more stable, professions.

For me, the benefit of pursuing a career in the intellectual property field was the ability to utilise my PhD qualification. I was hired first and foremost for my scientific knowledge, and I would not have been eligible for the position without it. However, PhD graduates, like me, are attractive to a number of employers not only for their scientific expertise. A PhD instils fundamental qualities that are transferrable to most professions. Most notable is a PhD graduate's ability to critically think and problem-solve, and

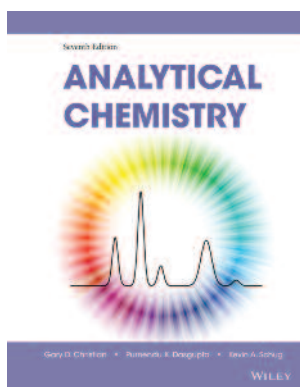
this sets them above other candidates. Consequently, PhD graduates are becoming increasingly in demand in a broadening scope of professions. For example, applicants with a scientific PhD qualification are now highly regarded in the business and finance industries.

A key consideration in my moving to the intellectual property profession was that my PhD qualification was not going to waste. Quite the opposite, as I simply would not have been considered for the position without it. While I will continue to utilise the scientific knowledge acquired during my PhD, the intrinsic skills developed during my PhD are an asset. Most significantly, I now have stability, certainty. I can make plans because I have mitigated the risk.

Finding the balance

The number of PhDs awarded annually by Australian universities continues to increase, yet the Government's contribution to science, research and innovation is failing to reflect this. Budgetary cuts have seen research and development expenditure per %GDP plummet to a historic low in 2014. The ultimate consequence is a lack of research positions for PhD graduates, with many forced to either relocate overseas or shift into an alternative profession. Encouragingly, for those who make the decision to pursue an alternative career path, the fundamental qualities instilled by a PhD qualification hold us in good stead in a broad range of professions. It is for this reason that the number of candidates enrolling in a PhD at an Australian university will continue to exponentially increase.

Dr Brittany Howard MRACI completed her PhD in medicinal chemistry at the Monash Institute of Pharmaceutical Sciences before undertaking a postdoctoral position with the National Institutes of Health (US), and has since commenced as a trainee attorney with Watermark Patent and Trade Marks Attorneys.



Analytical chemistry (7th edn)

Christian G.D., Dasgupta P.K., Schug K.A., Wiley, 2014, hardback, ISBN 9780470887578, 830 pp. approx., \$185.99

Analytical chemistry first appeared in 1971. This seventh edition reflects major developments in the scope and complexity of analytical chemistry, together with changes in pedagogical approaches that have

occurred since. The early editions of 'Christian' were characterised by a friendly, encouraging style providing gentle guidance for students. I am very happy to report this is still the case. The book is an excellent student text for university courses in analytical chemistry and a reference of enduring value. That is just as well. The book is not cheap, although not out of kilter with similar alternatives.

Christian has taken on two new co-authors for this edition, which has facilitated some revision of the chapters on classical analytical chemistry as well as enlargement to include additional areas of instrumental chemistry. Each chapter begins with a statement of learning objectives. Additional sections, 'Professor's Favourite Problems' and 'Professor's Favourite Examples' (garnered from the authors' global appeal for submissions from a broad scientific community), pose intriguing (extra) problems and explore valuable insights.

Sidenotes summarise or illustrate the main message of the adjacent text and contain photographs of famous chemists and their brief biographies. The latter are mainly 'men of a certain age', frequently bearded and generally a pretty dour looking lot. As a male of 'a certain age' and bearded (but not admitting to dour!), I greatly enjoyed these vignettes. However, it would be interesting to explore their appeal to the 18–21-year-old target audience, particularly the females who are not likely to derive a lot of inspiration from them.

The use of Excel spreadsheets for data processing and plotting is strongly advocated throughout the book and there

are extra spreadsheets on the associated website for various calculations. Excel is certainly a very powerful tool, capable of performing very elegant data analyses and producing very professional-looking outputs. Christian et al. thoroughly explore this. My key enjoinders to students are that the output ought to take some cognizance of the laws of chemistry and statistical outputs must pass both a reality test and a comprehension test. Fine presentation doesn't necessarily mean it is right! After all, GIGO! (Garbage in, garbage out!)

Purchase of the book qualifies the buyer for the 'steak knives' and what a wonderful assortment they are. Indeed, some of the extras are available without any purchase. There are companion websites ('student' and 'instructor', accessible via www.wiley.com/college/christian), where there is an array of supplemental material expanding on the text via videos, URLs, a variety of text, PowerPoint and Excel files and JPEGs. All figures and tables from the text are online as PowerPoint slides, with notes for the presenter. Solutions to all the problems and answers to all the questions posed in the text are available in a Solutions Manual. There are some 200 websites referred to in the text to allow readers to access supplementary materials. These are replicated on the website, which means you don't even have to type out URLs to access them!

But wait, there's more! QR codes* throughout the text allow you to get supplementary material via your smartphone or iPad. While this is all great stuff, may I humbly say that if students just *read* the text it would be a damned fine start! Bells and whistles are an adjunct rather than an alternative to hard slog.

All up, this is a great student text. It is well presented, well illustrated, well backed-up and user-friendly. The authors admit there is more material in the book than could reasonably fit into a one-semester course. Too right there is ... about 600 pages worth! This is a three-year proposition (which amortises the price), a valuable addition to the bookshelf for university students and their lecturers, and a useful reference for practising analytical chemists.

R. John Casey FRACI CChem

*For the benefit of people who, like me, have enough trouble with a 'dumbphone', QR codes are those black and white pixellated patterns, roughly 25 mm², that 'talk' to electronica.



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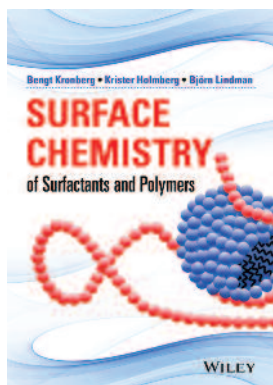
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Surface chemistry of surfactants and polymers

Kronberg B., Holmberg K., Lindman B.,
Wiley, 2014, hardback,
ISBN 9781119961246, 496 pp., \$167.95

Perhaps it is easiest to start by saying what *Surface chemistry of surfactants and polymers* is not. It is not a pleasant, light Sunday read to brush up on polymer chemistry or satisfy your curiosity about what you don't know

about surfactants. At 465 pages (excluding the index), it is not for the faint of heart.

Now to what it is . . .

The world of polymers and surfactants is immense. The authors have tackled an ocean of information, sectioning it into 25 manageable chapters on specific areas. The subject breadth and depth is such that even after deep dives, the reader may still 'surface' with a feeling of just how much there's still to know about polymer surface chemistry. The book examines a huge range of theory; I felt as if each chapter was a challenge on its own.

In my view, this book would most suit a professional already involved with surfactants or polymers, along with researchers in the field. It would also serve as a comprehensive reference book on your shelf, but, be warned, there is no short way to expound any questions you might have! The book's explanations are often interlinked with theory from earlier chapters, which often precipitates more substantive reading rather than simply a 'quick look'.

The authors have gone to great lengths to explain why certain reactions proceed while others do not, with for the most part easy to understand, practical explanations (some of which may take a little work to fathom but are nonetheless well elucidated). The authors display and deliver an enormous understanding of the chemistry underpinning interactions in solution, at interfaces and at surfaces between surfactants, polymers and surfactant polymer mixes and all manner of molecule and particle.

My only suggestion to the authors is that the text's second edition contain practical examples of experiments one could perform to help crystallise (or 'gel') the knowledge. It really was a challenge to retain each chapter's message, especially by number 20! While enthused by what I read, as a non-polymer chemist I could not apply the knowledge immediately and thus fear it will quickly evaporate.

Overall, this is an ambitious, commendable text – hard going at times but rich with theory based on real-world results. It is definitely of great value to practitioners in the surface chemistry field.

Scott Burov

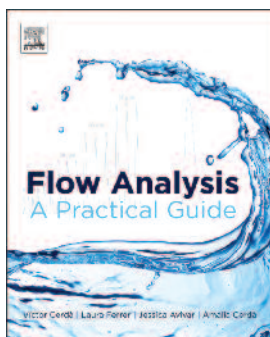
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June 25 - Oct. 15	Early registration
October 16	Standard registration begins
November 13	Housing closes
December 20	Registration closes



Flow analysis – a practical guide

Cerda V., Ferrer L., Avivar J., Cerda A., Elsevier, 2014, hardback, ISBN 9780444595969, 288 pp., \$295.94

Within the first few pages of *Flow analysis – a practical guide*, readers will discover that the book spends little time reflecting on historical milestones that have occurred in the development of flow analysis techniques. The

authors instead focus on the practical necessities of the science, thereby encouraging the reader to roll up their sleeves and head into the laboratory.

Flow analysis is known to be both a versatile and a powerful technique for a range of monitoring applications. For some of us, however, flow analysis techniques may be remembered because of the custom software used with the technique. Such software was typically either rudimentary, a continual work in progress or, in the worst case, a limiting factor. Thankfully, software options have significantly improved, a point also acknowledged by the authors as they dedicate an entire chapter to the discussion of commercially available software. It is clear early into the text that the authors have set out to create a comprehensive one-stop flow analysis resource, a goal they most certainly achieve.

The text spends time looking at all facets of the technique and in doing so does not simply focus on flow injection analysis, perhaps the most widely known of the flow analysis techniques, but instead walks the reader through the strengths and weaknesses of numerous flow analysis techniques such as segmented flow analysis, multicommutated flow injection analysis and multi-pumping flow systems.

While the book is clearly aimed at scientists, those scientists with an engineer hidden inside them will no doubt enjoy the text's fourth chapter, which touches briefly on the 'flow

workshop' and the likely mechanical and electrical tools required when developing new analytical flow methods. Other topics raised in considerable detail include chemical separation, detection and quantitation of species of interest.

Having gained the necessary knowledge about flow analysis from the preceding chapters, I found it fitting that the rest of the book was devoted to real-world applications. Chapter 7 is dedicated to numerous environmental applications and in doing so provides the reader with a clear illustration of one of the technique's strengths – its flexibility.

Chapter 8, the text's final instalment, focuses solely on radiochemical analysis, where the authors emphasise the ability of flow analysis techniques to automate the process, thus minimising sample and standards handling.

As with any good book aimed at practical aspects of the science, the reader will discover a wonderful text full of diagrams to help reinforce points made by the authors. For the vast majority of the book, the reader will be hard pressed to find a single page that does not include an informative illustration or schematic.

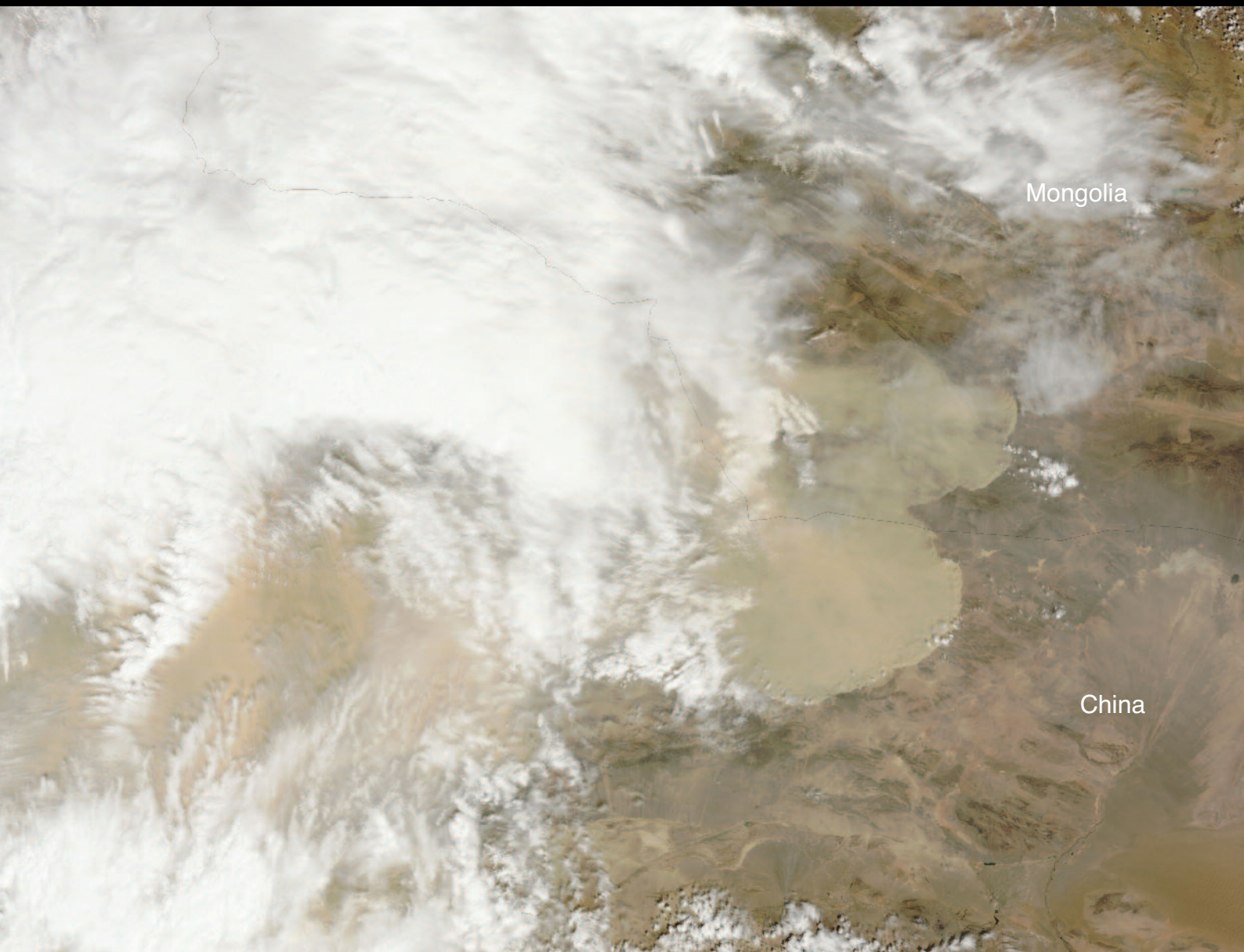
A stand-out feature of this book is the meticulous nature by which the authors have described practical aspects of flow analysis techniques. The book's thoroughness is sufficient to assist anyone with an interest in the area of flow analysis; however, readers with a background in analytical instrumentation or seeking to brush up on their knowledge will appreciate it the most.

Michael Leist MRACI CChem

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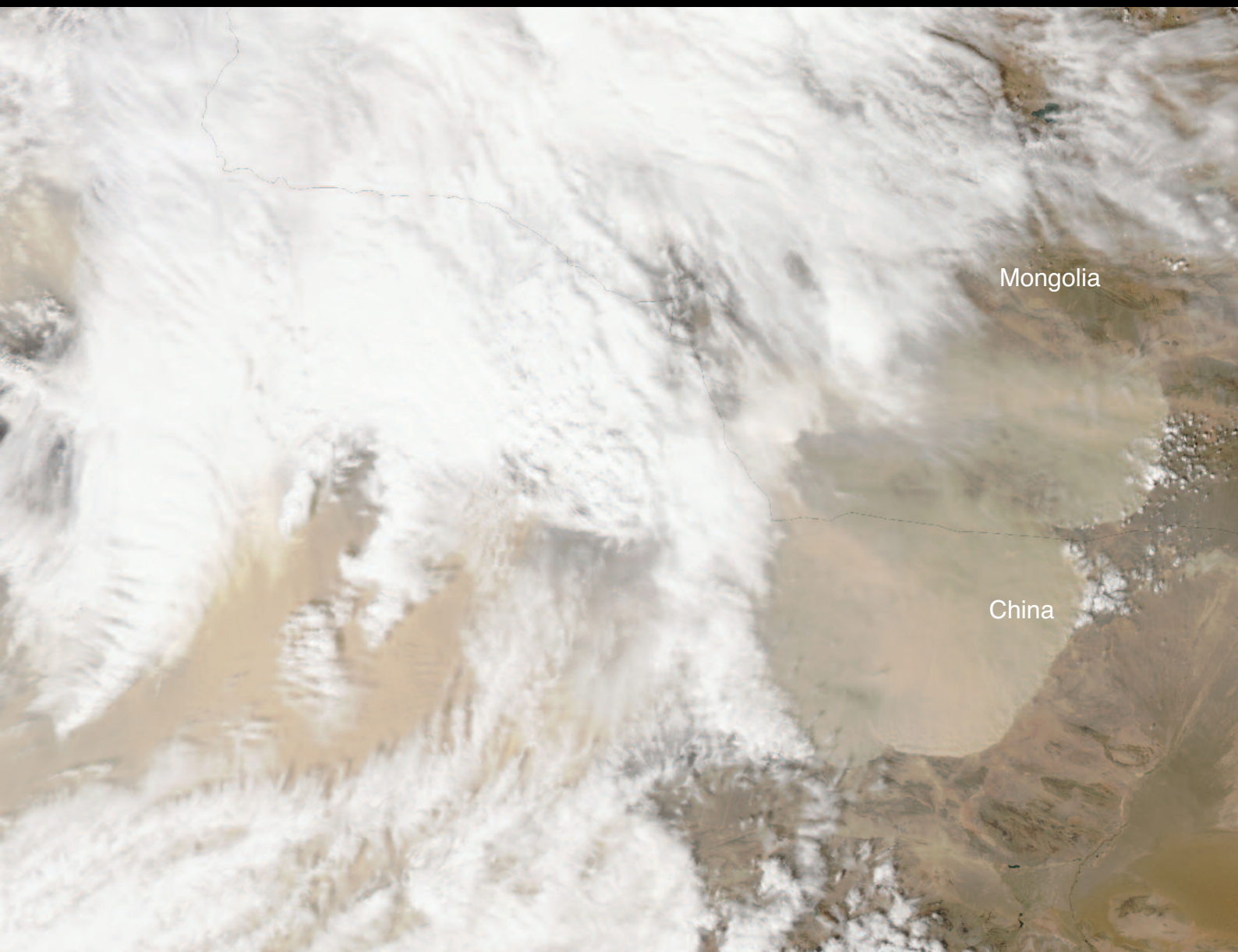
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China's Great Wall of Dust



A wall of dust was barrelling across northern China on 23 April 2014, when the Moderate Resolution Imaging Spectroradiometer (MODIS) acquired these images from NASA's Aqua and Terra satellites. The first image was taken at 12:35 p.m. local time, and the second image is from 2:20 p.m.

Dust storms are common in the deserts of northern China, but they peak during the spring when large storms and weather fronts move in from Siberia. In this case, a very large front appears to be pushing east across Asia, kicking up dust ahead of it. On the ground, the dust brought visibility down to less than 50 metres, veiling parts of north-west China in yellow haze.



Mongolia

China

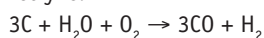
The winds and resulting dust are widespread, since a dense airborne dust plume is visible under the clouds throughout the scene. The large storm also extended to the Taklimakan Desert (immediately south-west of the area shown here) on 23 April, 24 April and 25 April.

First published by NASA; references at <http://earthobservatory.nasa.gov/IOTD/view.php?id=83554>. NASA images courtesy Jeff Schmaltz, LANCE/EOSDIS MODIS Rapid Response Team at NASA GSFC. Caption by Holli Riebeek.

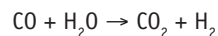
New coal chemistry

In the beginning of the Industrial Revolution, the chemical industry was based on coal as the principal feedstock and more particularly coal tars and liquors produced from low-temperature coal gasification to produce town gas. The second oldest Australian company (AGL) had its origins in this industry – town gas from coal. After World War II, coal as a feedstock was replaced by oil and this era saw the development of large-scale technologies for the production of petrochemicals. Nowadays, industrial chemicals made from coal are rare, except in China where a revolution in the use of coal as a chemical feedstock is taking place.

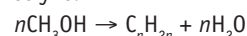
The new technologies, principally discovered and developed in the West, are now being commercialised in China where abundant deposits of coal are to be found. The process involves multistep routes, which first involve gasification of coal in advanced gasifiers. Using a mixture of oxygen and steam, these units convert the coal into synthesis gas, a mixture of carbon monoxide and hydrogen. Gasification is a complex process; the simplified stoichiometry is:



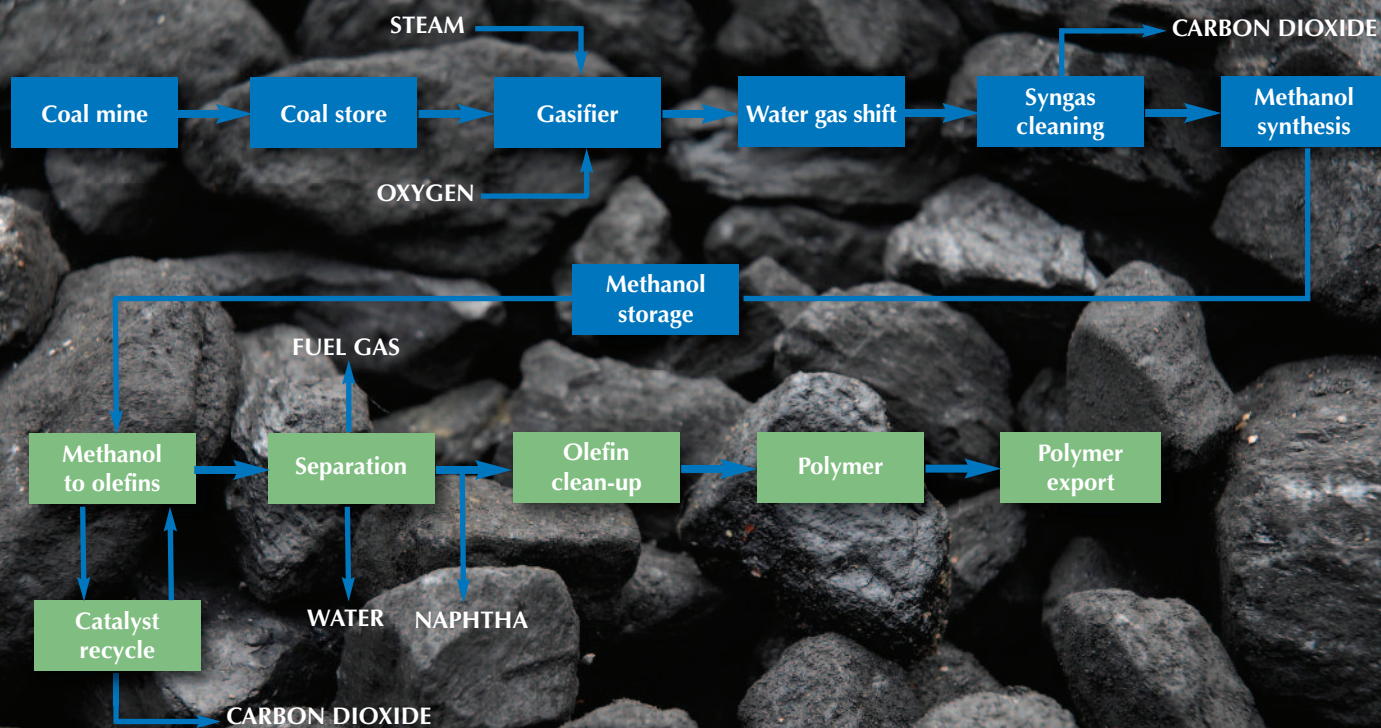
Water gas shift, both within the gasifier and in a downstream unit converts some of the carbon monoxide into hydrogen:



After cleaning and removal of carbon dioxide, the final synthesis gas has two moles of hydrogen per mole of carbon monoxide. Synthesis gas of this composition can be used for the Fischer–Tropsch process to produce fuels and chemicals (as practised in South Africa) and elsewhere using natural gas as a feedstock. The new technologies, however, convert the synthesis gas to methanol, from which olefins can be made using molecular sieve catalysts. There are two processes, one produces ethylene, propylene and some butenes, while the other produces only propylene as the olefin product. Both processes produce naphtha as a by-product. The chemistry is complex, the simplified stoichiometry is:



The main unit operations are shown in the flowchart below. A typical coal to olefins plant will use five million tonnes (Mt) of coal to produce about 1.67 Mt methanol, which is used to produce about 600 kt of olefins.



Principal unit operations for conversion of coal to olefins.

In the past five years, nine facilities have been completed and a further 20 are in the planning or construction phase. If all these projects come to fruition, China will produce over 16 Mt of polymers from coal, which is more than the current production from naphtha.

Relative to ethane steam cracking (see May issue, p. 36) producing ethylene from coal is far more complex and requires the availability of low-cost coal to offset the higher capital and non-feedstock operating costs. The economics of these two routes are compared in the graph, where the sensitivity of ethylene production cost is plotted against the feedstock price expressed in energy terms (\$/GJ).

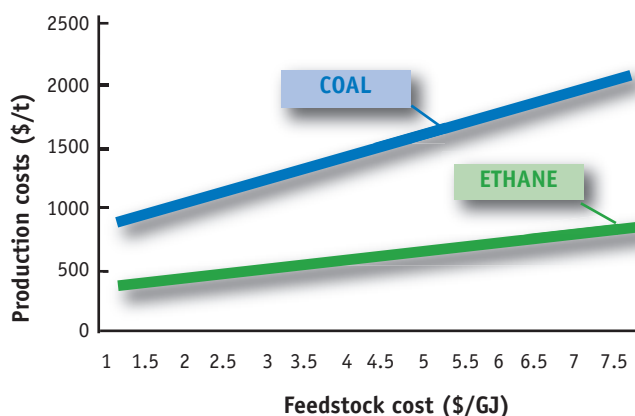
The graph clearly illustrates the cost advantage of using ethane steam cracking to produce ethylene, mainly as a consequence of the lower capital cost (lower intercept on the ordinate axis) and the gentler slope of the line reflects the higher thermal efficiency of the process – about 77% for ethane cracking compared to 30% for coal conversion.

So why is China pursuing this process? There are several reasons. Gas resources in China are remote and not well developed; in fact, China imports LNG into the eastern seaboard so there is little ethane for cracking into chemicals. The principal feedstock is naphtha, which is used in large integrated facilities in the east from imported naphtha or oil. Production costs are very high and strongly dependent on the prevailing oil price. With oil at \$100/bbl, ethylene production costs exceeds \$1500/t and, even with the low oil prices at present (\$65/bbl), production cost is in excess of \$1000/t.

China has vast and well-developed coal reserves in the west and it makes sense to use this indigenous feedstock rather than imported oil-based feedstock. Furthermore, mining costs are low, similar to Australian mining costs, so that feedstock is available for about \$1–1.5/GJ (\$20–30/t) and this gives a production cost below the cost of naphtha cracking.

Furthermore, the main process plant can be produced by the Chinese manufacturing industry at a cost saving of 30–40% relative to US costs (compare Australia where manufacturing costs are considered to be 40% above US equivalent costs).

The high added-value products (commodity plastics and the like) are relatively easy to transport by rail, barge or road so that it makes sense to establish the coal-to-chemicals facilities in the coal regions rather than on the eastern seaboard.



Comparison of ethylene production economics (US Gulf 2013, basis).

Olefins are not the only chemicals being produced from coal in China. The PVC industry is long established where coal is converted into acetylene by electrolytic fusion of coal and limestone to produce calcium carbide. Hydrolysis of the carbide produces acetylene, to which is added hydrogen chloride to give vinyl chloride monomer and then PVC. The intermediate production of methanol has also spurred interest in the production of acetic acid for acetate-derived polymers.

In the past five years, nine facilities have been completed and a further 20 are in the planning or construction phase. If all these projects come to fruition, China will produce over 16 Mt of polymers from coal, which is more than the current production from naphtha.

The poor efficiency, which results in a large carbon dioxide emission from these facilities, is not today an issue in China. China has promised to reach peak carbon dioxide emission by 2030, by which time many millions of tonnes of chemicals could be being produced from coal. Ironically, this promise to reach a peak carbon dioxide emission in 2030 is lauded by many in the West concerned with limiting emissions. But if the chemical industry grows as planned, China's emissions could increase considerably by the 2030 deadline.

In the past 10 years, China has made major strides in establishing new technologies for chemicals production. Such rapid developments of process technology are nowadays rare. But, as illustrated by the US developments of shale oil and gas production, they are not impossible given the right alignment of economic drivers (high oil price) and the will – in the case of China, political requirement to minimise oil import, and, in the US, the desire of landowners to earn income from their land assets.

The will to expand the chemical industry appears absent in today's Australia, and as trade with China grows, we will use more chemical products made from Chinese coal rather than produced from indigenous, oil, gas or even coal.



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

Evidence for the threshold learning outcomes

The Learning and Teaching Academic Standards project was established to facilitate and coordinate the definition and implementation of academic standards. Initially it was intended that the Tertiary Education Quality and Standards Agency (TEQSA) would use the Academic Standards as one of several criteria in the accreditation of universities and other higher education providers, but the passage of time and a change of federal government in 2013 has created some uncertainty about this. Nevertheless, these national Academic Standards are an important quality assurance measure for universities, and the Australian Council of Deans of Science endorsed the Learning and Teaching Academic Standards Statement for Science as a generic, high-level statement of Bachelor of Science threshold learning outcomes (TLOs) in 2011. All TLOs for specific science disciplines are subordinate to the overall Science TLOs.

Under the leadership of the RACI, a draft statement for the Chemistry TLOs was prepared and published as an appendix to the Science Statement. The Chemistry TLOs were refined through regional and national consultations (see March 2013 issue, p. 35) and ratified in October 2013 by the annual (Chemistry) Professors and Heads of Department meeting facilitated by the RACI.* The RACI is using the Chemistry TLOs as part of its accreditation of universities' chemistry degrees (see October 2012 issue, p. 14).

Preliminary work by Madeleine Schultz, James Mitchell Crow and Glennys O'Brien has shown that collating evidence that demonstrates the achievement of the Chemistry TLOs is not straightforward. Since mid-2014, a national project, headed by Sigg Schmid, has been working on a framework to evaluate whether achievement of the various Chemistry TLOs is demonstrated by specific assessment items. The project, which is funded by the Australian Government's Office for Learning and Teaching (OLT), has held preliminary consultations and information sessions at various conferences, including the December 2014 RACI National Congress. Equally critical is the collation of exemplary assessment items for each Chemistry TLO that can be used in curriculum design. Generation of these outcomes will benefit from an external perspective since the chemistry education community worldwide is concerned with improving assessment of learning outcomes to inform curriculum reform. Nationally, reflection within the chemistry

community on assessment of the Chemistry TLOs is relevant to other disciplines using the Science TLOs.

As part of the OLT-funded project, a series of workshops will inform university academics of the current status of the Chemistry TLOs, provide professional development so that academics can understand the TLOs and analyse how their existing assessment tasks do (or not) provide evidence for the Chemistry TLOs, and obtain further feedback about evidencing the TLOs. In particular, the workshops will address which types of knowledge (factual, conceptual, procedural and/or metacognitive knowledge) are required to successfully complete an assessment item, which, if any, practical (laboratory) skills are required, which cognitive processes in Bloom's taxonomy are required, and which specific TLOs are demonstrated by successful completion of the assessment item. The Victorian/Tasmanian workshop will be held in Melbourne on 6 July, and the Queensland workshop will be held in Brisbane on 15 July, with workshops to follow in other states.

All RACI members are invited to contribute to the discussion about assessment tasks that evidence the Chemistry TLOs. Chemistry academics are invited to submit assessment tasks, along with examples of student work (<https://scilearn.sydney.edu.au/assessments/index.cfm>). You are also invited to participate in the Melbourne and Brisbane workshops planned for 6 and 15 July, and similar events in other cities.

For further information, please contact the Chemistry TLO team: Sigg Schmid (Chair, University of Sydney, siegbert.schmid@sydney.edu.au), Glennys O'Brien (University of Wollongong), Adam Bridgeman (University of Sydney), Ian Jamie (Macquarie University), Kieran Lim (Deakin University), Simon Pyke (University of Adelaide), Madeleine Schultz (Queensland University of Technology), Daniel Southam (Curtin University) and Simon Bedford (University of Wollongong).



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The Academic Standards were first initiated by the (then) Australian Learning and Teaching Council (ALTC), which was then replaced by the Office for Learning and Teaching (OLT). As this column goes to print, the federal government has announced that it is transferring the responsibilities of the OLT to a new institute, to be established to promote excellence in teaching and learning in universities. The RACI has committed to using the Threshold Learning Outcomes for reaccreditation of chemistry degrees, but the future of the Threshold Learning Outcomes in a broader national context is unclear.

*The current version of the Chemistry Threshold Learning Outcomes and additional information can be found on the ChemNet website, chemnet.edu.au.

Assessment of astringency

During my teaching career in oenology, I was always amazed in introductory sensory science classes at the marked variation in the assessment of astringency across the group. It has been demonstrated that even with a group of experienced tasters, the standard deviation in astringency scoring is around 25–30%. Professor Ann Noble from the University of California Davis was one of the key researchers opening up the issues that contributed to this variation and was able to show that two of the major factors are individual differences in salivary flow rate and the response to repeat tastings. To some extent, training of the sensory panellists can help reduce confusion regarding repeat tastings. To address the differences in salivary flow, some studies have attempted to partition panellists into different groups on the basis of their salivary flow rates. While this helps reduce the variation, the task becomes extremely time-consuming and expensive. Even if unpaid in-house tasters are used, ‘bribes’ by way of chocolates at the end of each session and movie tickets or dinner vouchers after a certain number of sessions are needed. And a minimum commitment of around three months is required for training and actual experimental work.

Following a visit by Ann Noble to the National Wine and Grape Industry Centre in Wagga Wagga, I started using time–intensity (TI) plots in my teaching. They should be called intensity versus time plots as they show in-mouth intensity as a function of time, but I will stick with the more common TI terminology. The TI concept for wine sensory assessment has been described by Ann with Ulrich Fischer (see *Food Qual. Pref.* 1994, vol. 5, pp. 55–64). Experimentally, the TI plots require the taster to concentrate on what is happening in the mouth and sketch the change in astringency sensation over time. Ann and Ulrich found that tasters with a high salivary flow rate reached a peak in astringency sensation faster than those with medium flow rate, while tasters with low flow rate took the longest to reach a peak. There was about a 10-second range over the three categories. The peak intensity was smallest for tasters with a high flow rate and largest for those with a low flow rate. These results underscore the need to separate tasters by salivary flow rate in order to generate reliable information on describing astringency.

A totally different approach to the description of astringency and mouth-feel in general was developed in 2000 by Richard Gawel from the University of Adelaide and colleagues from the Australian Wine Research Institute (*Aust. J. Grape Wine Res.* vol. 6, pp. 203–7). Richard’s mouth-feel wheel sets out a hierarchy of descriptors and the way by which this was established is rather fascinating. Astringency is a tactile sensation and not a taste response. This is reflected in a loss of lubrication or a drying-out sensation, for which the most commonly proposed mechanism is the interaction between salivary proline-rich proteins and polyphenolic compounds from the wine. This interaction and possibly even precipitation of a

protein–polyphenolic complex reduces the capacity of the salivary proteins to lubricate and so the mouth feels dry (see bit.ly/1PgqLXD). Other more complex mechanisms are now being described, and I will write about them in a subsequent article.

In aroma and flavour descriptive sensory analysis, chemical standards are used to guide the taster in identifying words that best describe the character. Richard and his colleagues used physical standards when setting up the mouth-feel wheel. The panel members had access to solids such as talc, wet clay, silk, velvet, chamois and so on. The task then was to match the sensation in the mouth with the actual feel of the solid substance. The workload was massive, with tasters tasting 72 wines in the first phase and 75 in the second. The tasting and discussion of terms took between six and seven weeks in each phase.

This highly structured mouth-feel wheel has greatly assisted developing a common vocabulary for sensory scientists. Its role for guiding consumers in their understanding of astringency is somewhat limited. Kate Lattey and colleagues from the AWRI noted in 2009 that there is a ‘lack of alignment’ between descriptors used by winemakers and consumers (*Aust. J. Grape Wine Res.* vol. 16, pp. 189–202). Perhaps, then, formal descriptive analysis for astringency may be more valuable from a scientific perspective, for example when comparing different winemaking strategies, with only a limited role in common use.

The relationship between chemical composition of a wine and astringency presents a challenge for the analytical chemist. There are a large number of assays described in the literature (see our 2012 review in *Trends Food Sci. Nutr.* vol. 27, pp. 25–36 for a reasonably up-to-date list). The majority of the assays involve precipitation of the polyphenolic or tannin compounds in the wine. Many are protein-based assays, attempting to replicate in some way the salivary protein–polyphenolic interaction that occurs in the mouth. Until recently, the most common assay was the ‘Glories method’ developed by the late Professor Yves Glories of the University of Bordeaux. The protein used is gelatin, but the heterogeneity in the sources of gelatin affect the reproducibility of the method. Mucin and ovalbumin appear to provide a more reproducible outcome. Correlation between the astringency score of tasters and the measured chemical analysis score are generally reasonable ($r=0.8$ or higher). There has been little attempt, however, to develop a predictive model based on the chemical analysis score. More of this in a subsequent column.



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.

What's in a name?

The naming of elements after cities or countries was in vogue in the late 19th century – gallium (1875), germanium (1886), polonium (1898), scandium (1876) and thulium (1879) – with francium (1939) coming along later. In the 20th century, it was people – einsteinium (1952/1961), fermium (1954) and mendelevium (1955). Of course, there are some ‘names’ in later years, but like Dr Tom Lehrer (they hadn’t come to Harvard) I’d like to retain my historical perspective.

Place names were given to chemical substances, too, the earliest inorganic ones I could find being Prussian Blue and Paris Green. It was in the domain of organic chemistry, however, that this naming practice was most common. In 1935, Professor J.C. Earl and his student Alan Mackney reported the preparation of an unusual compound that was later shown to be a 1,2,3-oxadiazol-5-one, which exists with separated positive and negative charges and is described as a *mesionic* structure. By 1946, further members of this group had been prepared and the name sydnone was bestowed on them, denoting the city where they were first prepared. Rolf Huisgen and his students responded in the early 1960s with another class of mesoionic compounds, which they called munchnones, honouring München (Munich).

Natural products were favourite targets of namers. Nickon and Silversmith (*Organic chemistry: the name game*, 1987) listed a few natural products with names given to them by Dr Maurice Shamma of Pennsylvania State University, reflecting their countries or regions of origin. Most of the names have not been taken up by other researchers, which is a pity because I liked the sound of srilankine, isolated from *Alseodaphne semicarpifolia* Nees in Shamma’s home country. Something similar led to the name canadine for a tetrahydroberberine alkaloid isolated in 1888 from the plant *Hydrastis canadensis*. There were local examples, too, such as australine, a tetrahydroxypyrrolizidine with glucosidase-inhibiting properties that was isolated from the seeds of *Castanospermum australe* (the Queensland black bean) in 1988. Baker and Smith isolated *p*-allylphenol from *Eucalyptus* species and referred to it as australol but the name never stuck.

In 1914, Robert Robinson and H.G. Smith reported the isolation of tasmanol from *Eucalyptus risdoni* Hook, which had been collected on the slopes of Mt Wellington, Tasmania. They thought it was a phenol, but Victor Trikojus and Doug White, who worked on the same sample in 1932, judged it to be an acid because it formed a ‘methyl ester’, among other derivatives. Some of the original oil was still available in 1956, when Birch and Elliott again isolated the compound of interest, showed it to be a β -triketone and so renamed it tasmanone. Later work suggested that the Tasmanian tree was probably *E. tasmanica* Blakely. Hellyer, Bick, Nicholls and Rottendorf (1963), who collected a sample from the same locality, found

that it contained only 0.5% of tasmanone, which explained why only small quantities had been available to earlier researchers. However, the leaf oil of *E. camfieldii* Maiden growing at Hornsby, New South Wales, contained 40% tasmanone and with these larger quantities the uncertainties left from earlier work could be resolved and the exact structure was published.

It’s easy to see why these names were bestowed and accepted by the chemical community, but there is one substance that I found most elusive – the terpene australene. When I found that it had been isolated from the kauri, *Agathis australis*, I thought that must have been the initial discovery and act of naming, but further research showed that naming occurred much earlier. In fact, australene had been first identified in the early 1850s by the French chemist Marcelin Berthelot (1827–1907), who isolated it from *essence anglaise* (English oil), which he referred to as *essence du pin austral*. An isomeric compound, terebenthene, was isolated from French turpentine derived from *pin maritime*, as well as from *Pistacia terebinthus*, the source of pistachio nuts. Further investigations, including measurements of optical rotation by Berthelot and others, showed that australene and terebenthene were the D- and L-isomers, respectively, of α -pinene. They occur very commonly in essential oils and before modern methods of purification and identification many researchers thought that they had isolated a new hydrocarbon, which turned out, upon later investigation, to be just one of these pinenes. Thus, for greater or lesser periods of time, we had terebenthene, eucalyptene, laurene, olibene, massoyene and australene. You will guess that many of these names derive from the plants from which that particular oil was obtained.

The French or Bordeaux turpentine came from *Pinus maritime*, which grows in southern Europe and especially along the Mediterranean coast. That species name has survived until today and still appears in plant lists, but this is not true of *P. australis*, the name of which has disappeared from catalogues. *P. australis* was the long-leaved pine that grew along the Georgia and the Carolina coasts in the US but once nomenclature settled down it became known as *P. pinaster*. This pine and some related species were important sources of turpentine in the US, fostered by the American Turpentine Farmers Association in the ‘turpentine belt’ that covered southern states from the Atlantic to the Mississippi.

Watch out for halepensisine when all those ‘lone pines’ (*Pinus halipensis*) are distributed to schools in the ANZAC commemoration.



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.

11th International Symposium on Ionic Polymerization

5–10 July 2015, Bordeaux, France
<http://ip15.sciencesconf.org>

35th Australasian Polymer Symposium

13–15 July 2015, Gold Coast, Qld
www.35aps.org.au

12th International Conference on Materials Chemistry (MC12)

20–23 July 2015, York, UK
www.rsc.org/events/international

24th International Symposium: Synthesis in Organic Chemistry

20–23 July 2015, Cambridge, UK
www.rsc.org/events/international

IUPAC 2015

48th General Assembly 6–13 August 2015,
 45th World Chemistry Congress 9–14 August 2015,
 Busan, Korea
www.iupac2015.org

13th Conference on Laser Ablation (COLA-2015)

31 August – 4 September 2015, Cairns, Qld
<http://cola2015.org>

13th Annual UNESCO/IUPAC Workshop and Conference on Macromolecules and Materials

7–10 September 2015, Port Elizabeth, South Africa
<http://academic.sun.ac.za/unesco>

22nd International Clean Air and Environment Conference

20–23 September 2015, Melbourne, Vic.
<http://casanz2015.com>

4th Federation of Asian Polymer Societies – International Polymer Congress

5–8 October 2015, Kuala Lumpur, Malaysia
www.4faps-ipc.org.my

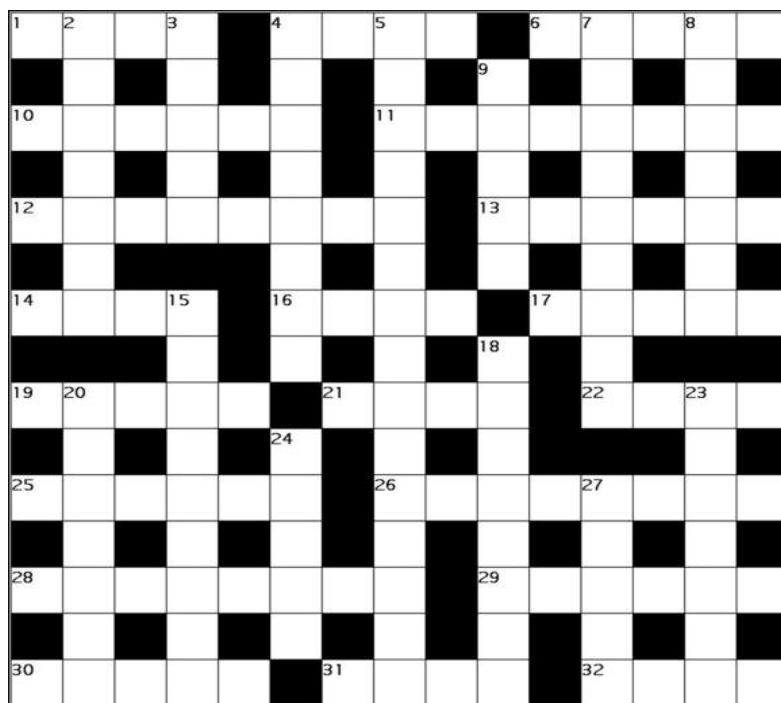
2015 Sustainable Industrial Processing Summit and Exhibition

9 October 2015, Turkey
www.flogen.org/sips2015

Pacificchem 2015

15–20 December 2015, Honolulu, Hawaii
www.pacificchem.org

RACI events are shown in blue

**Across**

- 1** Radical current rise. (4)
4 The French doctor an animal. (4)
6 Regal, new, grand. (5)
10 Tot making further comment. (6)
11 Unusual clue (not 6): solve for a monosaccharide (8)
12 A chromate ion reacted in the absence of holmium and neon? That smells! (8)
13 Dimensionless quotients: 882276. (6)
14 RCO⁻ produced from 21 Across, using carbon to replace radical. (4)
16 Exclusively singular. (4)
17 Measures dynamic viscosity with balance?! (5)
19 Pascal, in time, put on a surface coating. (5)
21 Electron removal with early use derived from 12 Across compound. (4)
22 Start exposing vinyl ether resin at any time. (4)
25 Scout examination. (6)
26 See ring with another electron to give what might be free and renewable. (8)
28 Directed star batter who retired on one. (8)
29 Is main due as alternate consisting of two 14 Acrosses bound to a nitrogen? (6)
30 Available property as fixed. (5)
31 & 32 Across Time measurement system used by Kirk started a revolution. (8)
32 See 31 Across.

Down

- 2** Radical change to acids characterised by the formula HOOC-(CHOH)_n-COOH. (7)
3 Praseodymium is mass refractor. (5)
4 A technique for bonding peptide segments is used to tie off a vessel! (8)
5 Clue: we take logarithm to make a measurement of the relative mass of compound particles. (9,6)
7 Later loop train for one form of a 23 Down. (9)
8 & 23 Down Use male genes to change hydrogen, perhaps. (7,7)
9 Without exception 22 Across adds 39. (5)
15 Making 6 Across N₂ go over an extended span of time. (4-5)
18 Hidden reaction route with lithium radical. (8)
20 12 Across compounds with at least one hydroxyl group are no limits to lipolysis. (7)
23 See 8 Down.
24 Indicates possession of the instrument. (5)
27 Hard work to make powder. (5)

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

History of chemistry: 249th ACS meeting



David B. Cordes
Cordes '15

I recently attended the 249th ACS National Meeting at Denver, Colorado, 22–24 March 2015, with most of my time spent at the sessions of the Division of the History of Chemistry. On the first day, Sunday, two general papers were presented by Australians: Anthony T. Baker on the topic of the Sydney School of Coordination Chemistry, and myself on a little-known American chemistry textbook writer called James Hyatt.

Monday morning's papers related to chemical technology in antiquity: colour, ceramics, wine and metals as used and produced in antiquity. Further papers on this theme in the afternoon explored leather and tanning, organic dyes and pigments, scented oils and perfumes,

soap production and the technology of glass. Overall, this gave an excellent introduction to the uses of chemistry in the ancient world.

Tuesday was the showpiece day, which had obviously involved much careful planning by the organising committee under the chairmanship of S.C. Ramussen. The day's topic was 'Modern chemical warfare: history, chemistry, toxicology, morality'. The emphasis of most papers was on World War I. The stage within the room was set by more than a dozen oil paintings at the entrance and around the room by David B. Cordes of the Pacific University of Oregon that pictured scenes from World War I, each with a chemical message.

Joseph Gal started the morning session with a historical overview of modern chemical warfare, leading to an introduction of the main character of the morning's talks, Fritz Haber whose life and character were carefully dissected by a number of speakers. In these talks, a number of facts about his life were established. Some of these were his relative lack of success as a young man, his disagreements with his father about his career, his conversion from Judaism to Christianity and his nervous attacks for weeks at a time.

Haber was eventually successful at solving the problem of the synthesis of ammonia with Carl Bosch in what became known as the Haber–Bosch process, capable of producing fertiliser and which has allowed the green revolution in our own times, saving millions of lives. The use of the Haber–Bosch process to produce explosives allowed Germany to wage a lengthy war, when overseas supplies of potassium nitrate were cut off, causing huge loss of life. He married the first woman chemist to receive a doctorate from Breslau University, Clara Immerwahr, and they had one son. Just prior to the start of World War I, he became a heroic figure in Germany for his scientific brilliance. He used his influence to persuade army generals to use poison gas in the war although there was an international agreement forbidding its use. It was trialled with success, personally supervised by Fritz Haber, on one sector of the front. His wife committed suicide shortly after this, but Haber continued to supervise gas attacks, leaving home and his young son immediately after his wife's death. After the end of the war he secretly continued research on poisonous gasses in defiance of agreement to the contrary. Because of his Jewish heritage, he was dismissed from his position by Hitler; he died shortly afterwards. This is the scenario established historically.*

*See *Chemistry in Australia* August 2013, pp. 20–23; September 2014, pp. 20–23; June 2015, pp. 22–25.



David B. Cordes

The program included the film 'Haber: the father of chemical warfare' by Daniel Ragussis, which portrayed Haber as uncertain and unsure about the use of poison gas in warfare, but urging its deployment by an unnamed military commander. His wife was portrayed as being inconsistent, demanding and hysterical. Haber only agreed to supervise the gas attack because he saw the suffering of German soldiers and believed a gas attack would win the war for Germany. This almost completely reversed the historical position.

Daniel Ragussis answered questions about his film from his own home, using Skype. He was surprised and a little unprepared by the strength of the questioning and the detailed, documented evidence possessed by the questioners. In the end, Daniel was prepared to concede a lot to his questioners in terms of fact, but the film was his artistic recreation of events about a virtually unknown scientist. Wasn't it a good thing that the story was being told? He did agree to check the film's sale to schools as being a 'true' story. He said he hoped to remake the film as a longer version with better-known actors, but did not seem to expect this to happen soon.

Dr Donna J. Nelson of the Chemistry Department of the University of Oklahoma and future President of the ACS, who at the 2014 meeting in Dallas had explained her part as scientific adviser to the TV saga *Breaking Bad*, said a few words about the difficulties of ensuring that correct science is provided in popular entertainment.



David B. Cordes

The program continued into the afternoon with a variety of interesting speakers. Personally, I very much enjoyed this exceptionally good meeting.

Bill Palmer FRACI CChem

View the full series of David B. Cordes' paintings at www.chemicaljungle.com.

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