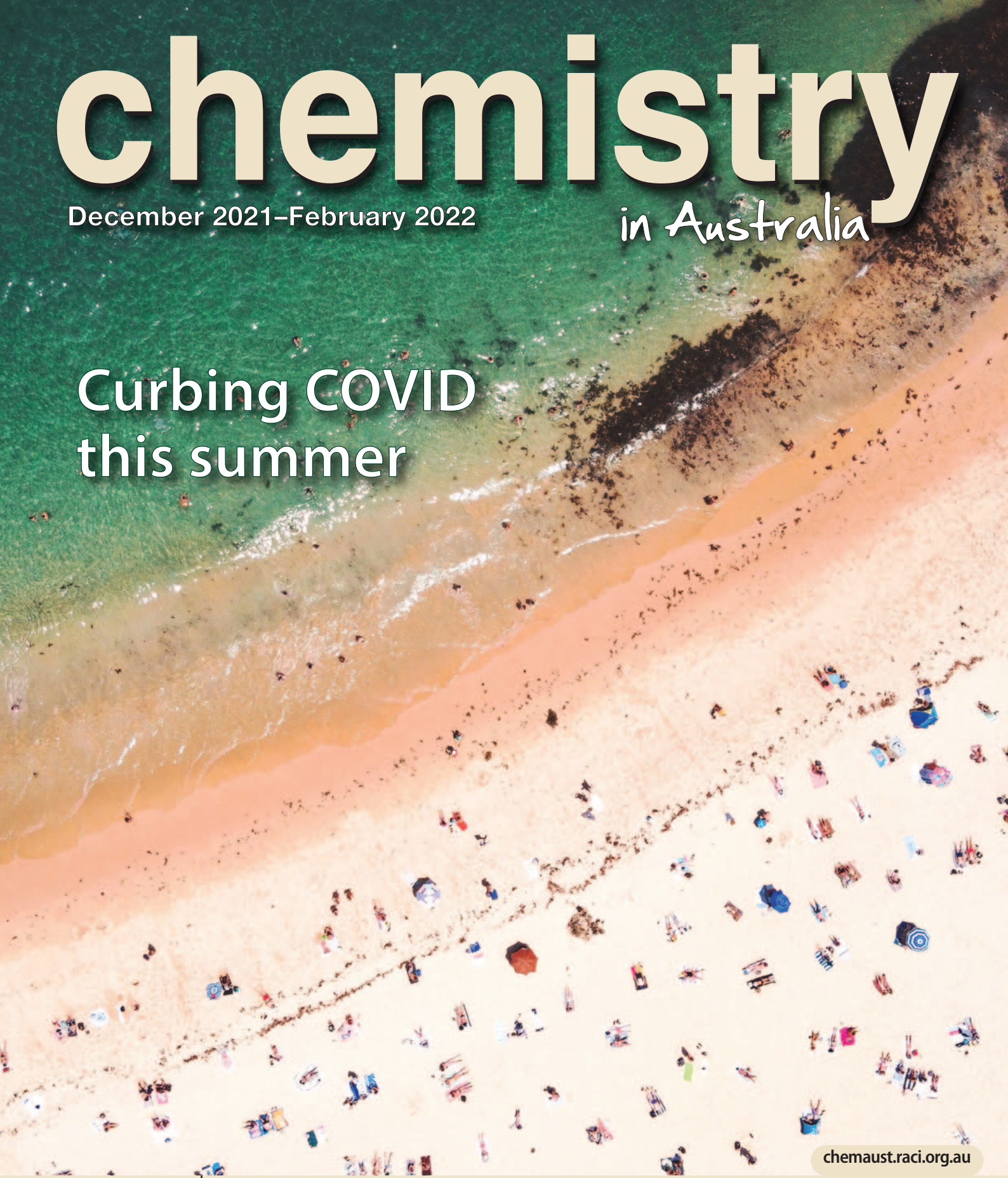
chemistry in Australia

December 2021–February 2022

Curbing COVID this summer



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chemistry in Australia

December 2021–February 2022

Wine Australia

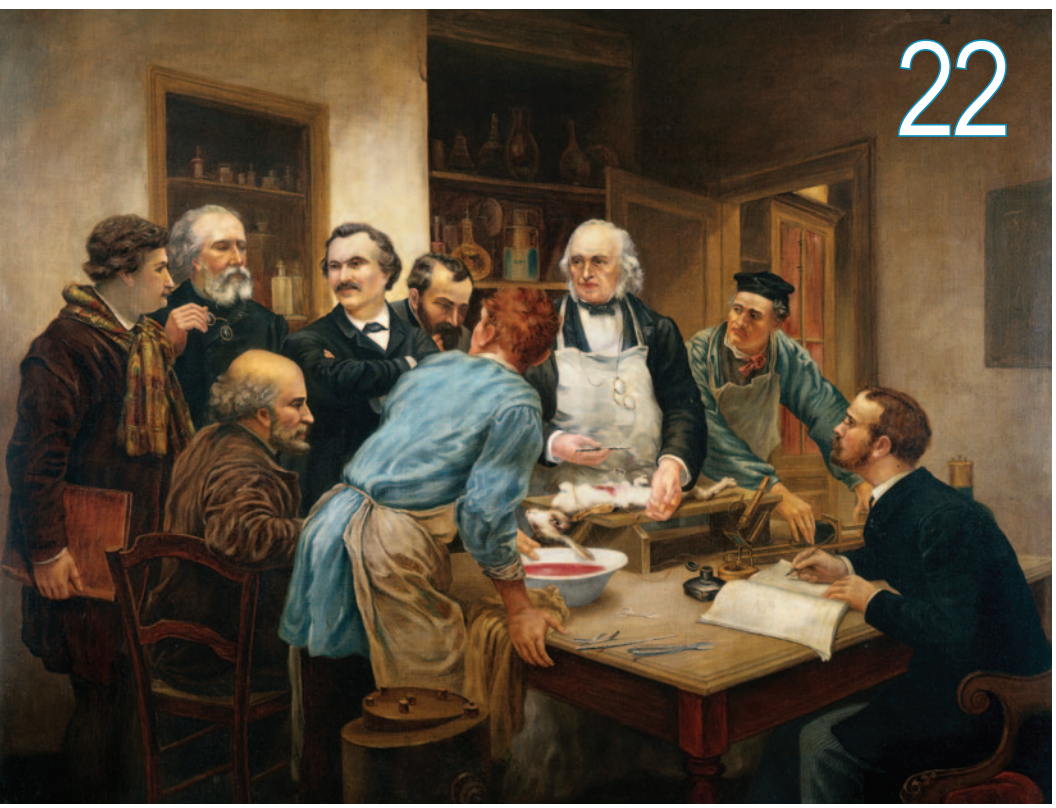
Manny Moreno/Unsplash

cover story

How COVID sparked a rethink on aerosol transmission

During the COVID pandemic, some vocal aerosol chemists have crunched new data, and some old myths, which changed our view of respiratory viruses.

18



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Fighting fakery and snake oil with chemistry

Society places a lot of trust in chemistry and chemists in general. We trust chemists and chemistry to provide information about things to keep us safe. Analytical chemistry shows that the active ingredient is present in the drugs we take. It tells us our water is safe to drink. Chemistry can show that a sample is pure and that no harmful component is present. Society has to trust chemists because only chemists can provide this information.

Today, students can access a lot of information through the internet and easily convert that information into an assignment response. This leads to a 'cut-and-paste' character to many submissions and a very weak understanding in our science students. Even more concerning is the pay-for-membership websites that can help 'tutor' students to deliver assignment-specific answers. This is a concern for the university sector because it essentially delivers an 'Uber-Uni' product that disrupts established methods of determining student capabilities. Many academics worry that this level of engagement with information may not indicate a true grasp of the principles involved. Perhaps this is reflected in the disparate scores between invigilated exams and less controllable assignments and other forms of assessment.

This is important for RACI's accreditation processes. Cash-strapped universities increasingly want to move away from face-to-face learning in laboratories and lecture theatres. Well-meaning education theorists looking to enhance student evaluations seek to reduce examinations in favour of less confronting means of assessment. As a profession, it is important that an RACI-accredited degree still holds value to employers of future chemists. It is also important that graduate chemists retain the integrity, professional standards and scientific capabilities our society trusts us to have.

The importance of chemistry, and science more broadly, has never been more evident than over the last two years. Not only has chemistry been able to produce vaccines, many companies have stepped forward with antivirals that may have potential as COVID-19 treatments. Merck's molnupiravir has been released in the UK as the drug Lagevrio, and it is the first COVID-19 treatment that can be taken as a tablet. The latest results on Pfizer's Paxlovid are also very encouraging. Several smaller drug companies and researchers in Australia are also investigating potential COVID-19 therapeutics.

It is worth reflecting on how significant chemistry and science has been in the fight to conquer a disease that didn't exist two years ago, in the human population at least. As with the many scientific breakthroughs delivered by chemistry, millions of people stand to benefit from these discoveries, but perhaps the significance may be lost on those who are not trained in our profession or who do not understand chemistry.

The internet tells us that 500 years ago Paracelsus apparently said '*Alle Dinge sind Gift, und nichts ist ohne Gift, allein die Dosis macht dass ein Ding kein Gift ist*', which I take to mean that everything is a poison and only the dose determines the toxicity. Too much food can cause heart disease. Too much water can kill by lowering sodium levels. Too much sodium is bad for our health.

Back in Paracelsus's day 'Theriaca' was touted as a miracle cure for everything from the plague to syphilis. The 'active' ingredient in the totally useless Theriaca was powdered viper. Quack cures have often been associated with snakes. The RACI was born in 1917, the same year that the US Bureau of Chemistry won a landmark court case against Clark Stanley Snake Oil Liniment. This established the term 'snake oil salesmen' and chemists have been involved in exposing such fakery ever since.

With drugs, chemists easily understand the idea of a 'dose'. We understand the concept of 'dose–response', as we understand concentrations, solubility, reaction mechanisms, kinetics and concentration curves. But the layperson may not have such an understanding, their 'knowledge' being derived from the internet and others' algorithm-amplified opinions.

With established drug companies delivering such promising results, it is surprising that people have fixated on unjustified 'treatments'. Perhaps fuelled by mischievous influences on social networks, or platforms seeking views and viewers to maintain revenue streams, non-scientists have embraced all manner of COVID cures, championing drugs that are only proven effective for their accepted purpose, such as de-worming treatments (ivermectin), antimalarials (hydroxychloroquine) and antibiotics (azithromycin). Chemists understand that none of these drugs delivers the wished-for therapeutic effect, at least at doses or conditions that are in any sense relevant.

We live in a golden age where almost all information on any topic is available instantly to us. With information comes disinformation, and misinformation, and it is the role of chemists as a profession to help filter out the more preposterous claims and guide the discourse into a more rational basis. This is where being part of the professional network of the RACI is so important. RACI-supported conferences, seminars and meetings, along with professional development seminars and accredited training opportunities, serve to raise our standard of scientific discourse and knowledge. As we emerge from the pandemic and turn our attention towards the scientific breakthroughs required to achieve global CO_2 reductions, chemists not only have a role to contribute to the discoveries, but also have a responsibility to help expose the snake-oil seller's miracle cures and flawed technologies.

Good luck in the fight!

Steven Bottle FRACI CChem (president@raci.org.au) is RACI President.

Thousands of undisclosed chemicals found in e-cigarettes

Vaping aerosols contain thousands of unknown chemicals and substances not disclosed by manufacturers, including industrial chemicals and caffeine, Johns Hopkins University researchers have found.

The results, published in *Chemical Research in Toxicology* (doi.org/10.1021/acs.chemrestox.1c00253), suggest people who vape are using a product whose risks have yet to be fully determined, and could be exposing themselves to chemicals with adverse health effects.

'Existing research that compared e-cigarettes with normal cigarettes found that cigarette contaminants are much lower in e-cigarettes. The problem is that e-cigarette aerosols contain other completely uncharacterised chemicals that might have health risks that we don't yet know about', said senior author Carsten Prasse, an assistant professor of environmental health and engineering at Johns Hopkins. 'More and more young people are using these e-cigarettes and they need to know what they're being exposed to.'

Previous studies of e-cigarettes have looked specifically for evidence of the hazardous chemicals found in traditional cigarettes. But here the researchers performed a non-targeted analysis to explore the full range of chemicals both in the vaping liquid and the aerosols.

Using a chemical fingerprinting technique based on liquid chromatography/high-resolution mass spectrometry, the team tested four popular products: Mi-Salt, Vuse, Juul and Blu. Although it is possible to buy vaping products in hundreds of flavours, for consistency they tested only tobacco-flavoured liquid.

They found thousands of unknown chemicals in the e-liquid, and the number of compounds increased significantly in the aerosol. Furthermore, they detected hydrocarbon-like compounds, typically associated with combustion, which manufacturers say is not happening during vaping. In traditional cigarettes, the condensed hydrocarbons generated during combustion are toxic.

'One of the main ways electronic cigarettes have been marketed is that they operate at temperatures below combustion, which would make them safer than traditional smoking', said lead author Mina Tehrani, a postdoctoral fellow in the Johns Hopkins Bloomberg School of Public Health. 'Our study shows that this novel fingerprinting approach can be applied to assess whether combustion-like processes are going on.'

The team found nearly 2000 chemicals, the vast majority of which are unidentified. Of those the team could identify, six substances were potentially harmful, including three chemicals never previously found in e-cigarettes. Tehrani was particularly surprised to find the stimulant caffeine in two of the four products. Caffeine has previously been detected in e-cigarettes but only in the caffeine-oriented flavours like coffee and chocolate.

'That might be giving smokers an extra kick that is not disclosed. We wonder if they are adding it intentionally', she said.

Besides caffeine, the team found three industrial chemicals, a pesticide and two flavourings linked with possible toxic effects and respiratory irritation.

'People just need to know that they're inhaling a very complex mixture of chemicals when they vape. And for a lot of these compounds, we have no idea what they actually are', Prasse said. 'I have a problem with how vaping is being marketed as more healthy than smoking cigarettes. In my opinion we are just not at the point when we can really say that.'

Co-author Ana M. Rule, an expert in metals exposures from vaping with the Johns Hopkins Bloomberg School of Public Health, says many young people who vape never smoked – so they aren't making a healthier choice, only starting out with a risky one.

'There are millions of middle school and high-school students vaping that would not otherwise think of smoking', she said. 'For them there is no risk reduction, only increased risk.'

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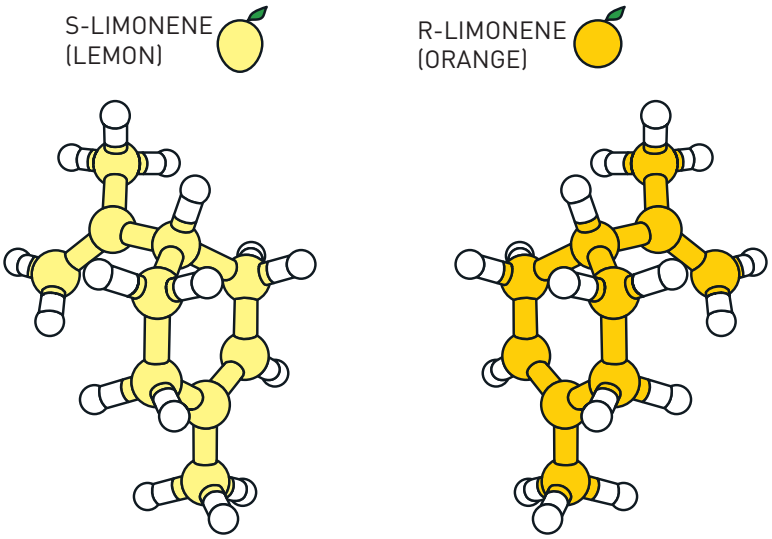
ISSN 0314-4240 e-ISSN 1839-2539

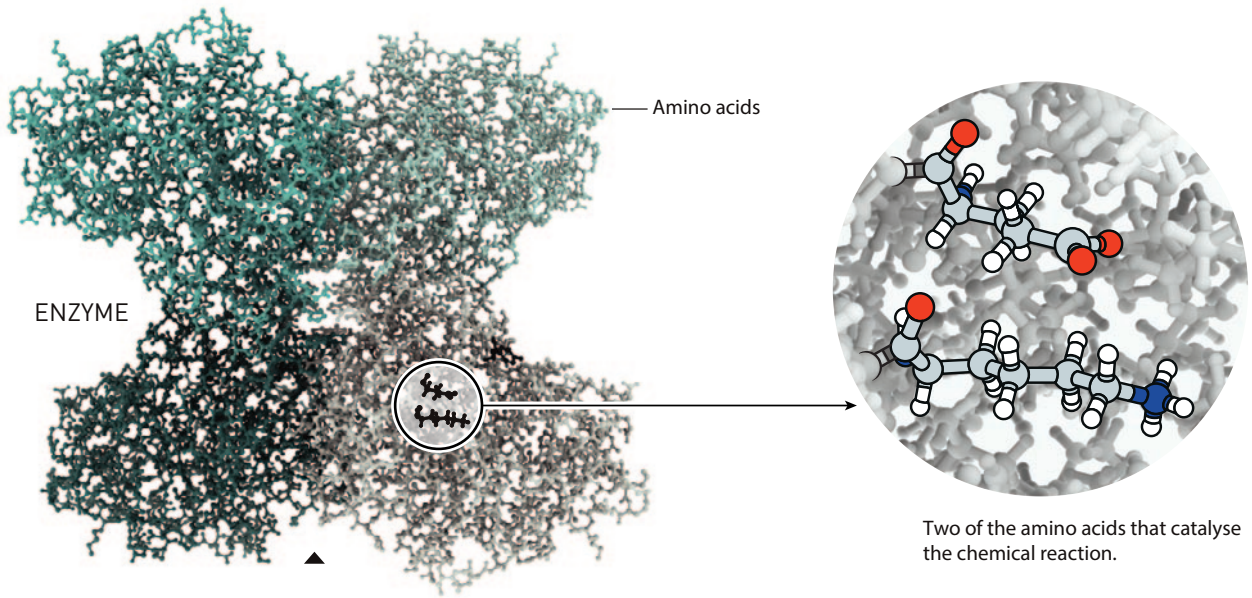
An ingenious tool for building molecules



The Nobel Prize in Chemistry 2021 has been awarded to Benjamin List (Max-Planck-Institut für Kohlenforschung, Mülheim an der Ruhr, Germany) and David W.C. MacMillan (Princeton University, USA) 'for the development of asymmetric organocatalysis'.

Building molecules is a difficult art. List and MacMillan are awarded the Nobel Prize in Chemistry 2021 for their development of a precise new tool for molecular construction: organocatalysis. This has had a great impact on pharmaceutical research, and has made chemistry greener.

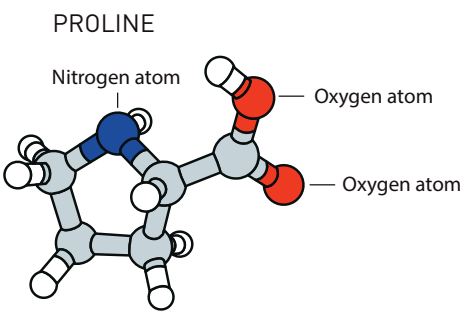
Many research areas and industries depend on chemists' abilities to construct molecules that can form elastic and durable materials, store energy in batteries or inhibit the progression of



Two of the amino acids that catalyse the chemical reaction.

1 Enzymes consist of hundreds of amino acids, but frequently only a few of these are involved in the chemical reaction. Benjamin List started to wonder whether an entire enzyme was really required to obtain a catalyst.

2 Benjamin List tested whether an amino acid called proline – in all its simplicity – could catalyse a chemical reaction. It worked brilliantly. Proline has a nitrogen atom that can provide and accommodate electrons during chemical reactions.



diseases. This work requires catalysts, which are substances that control and accelerate chemical reactions, without becoming part of the final product. For example, catalysts in cars transform toxic substances in exhaust fumes to harmless molecules. Our bodies also contain thousands of catalysts in the form of enzymes, which chisel out the molecules necessary for life.

Catalysts are thus fundamental tools for chemists, but researchers long believed that there were, in principle, just two types of catalysts available: metals and enzymes. List and MacMillan are awarded the Nobel Prize in Chemistry 2021 because in 2000 they, independent of each other, developed a third type of catalysis. It is called asymmetric organocatalysis and builds upon small organic molecules.

'This concept for catalysis is as simple as it is ingenious, and the fact is that many people have wondered why we didn't think of it earlier', said Johan Åqvist, chair of the Nobel Committee for Chemistry.

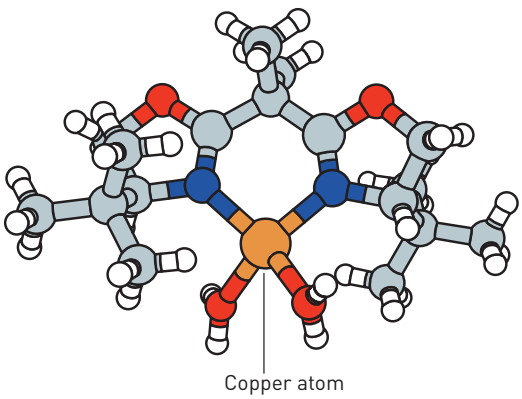
Organic catalysts have a stable framework of carbon atoms, to which more active chemical groups can attach. These often contain common elements such as oxygen, nitrogen, sulfur or phosphorus. This means that these catalysts are both environmentally friendly and cheap to produce.

The rapid expansion in the use of organic catalysts is primarily due to their ability to drive asymmetric catalysis. When molecules are being built, situations often occur where two different molecules can form, chiral molecules, which are mirror images of each other. Chemists will often only want one of these, particularly when producing pharmaceuticals.

Organocatalysis has developed at an astounding speed since 2000. List and MacMillan remain leaders in the field, and have shown that organic catalysts can be used to drive multitudes of chemical reactions. Using these reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells. In this way, organocatalysts are bringing the greatest benefit to humankind.

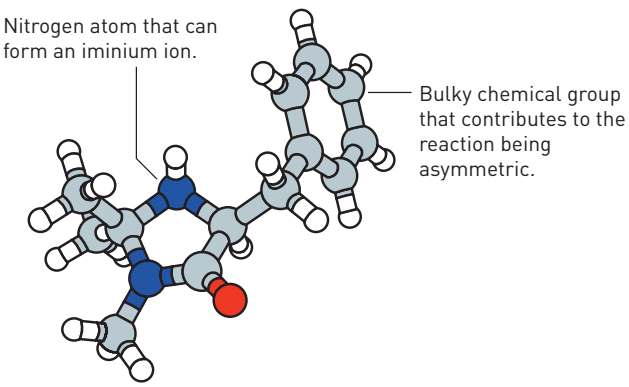
Nobel Prize Outreach

METAL CATALYST



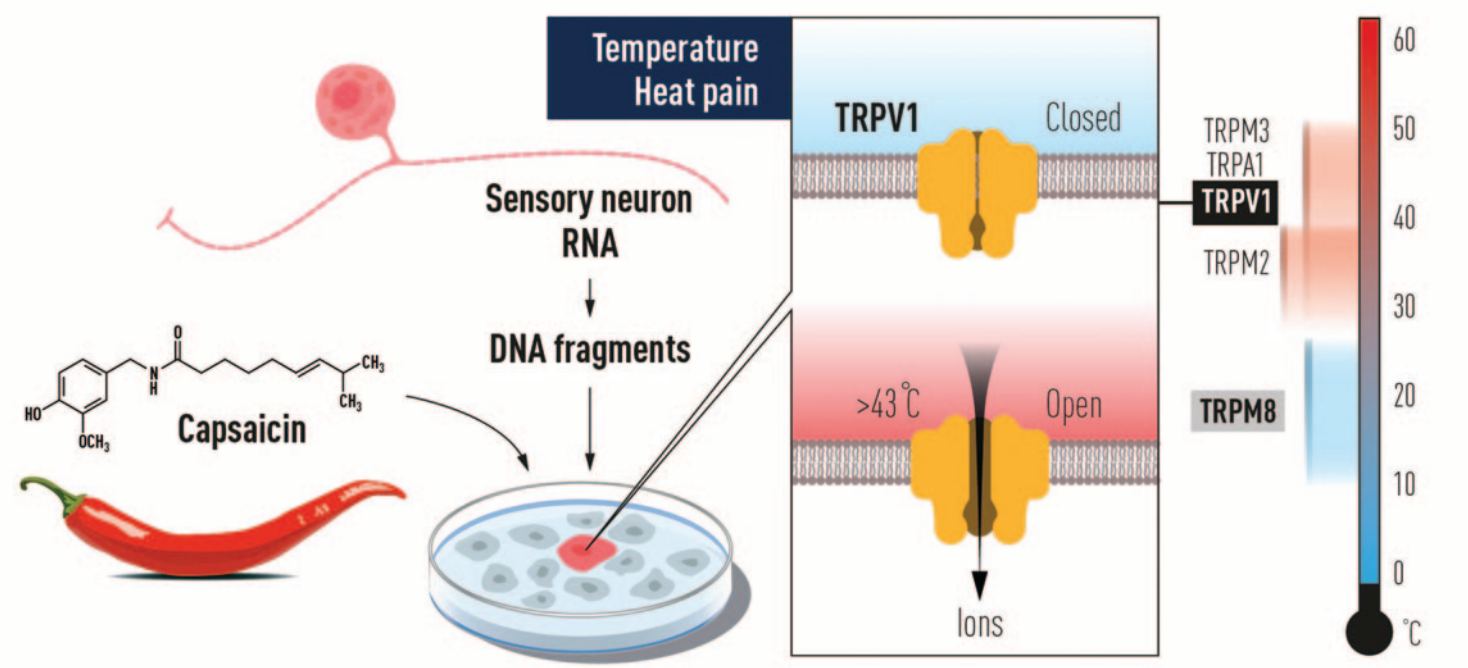
1 David MacMillan worked with metal catalysts that were easily destroyed by moisture. He therefore started to wonder whether it was possible to develop a more durable type of catalyst.

MACMILLAN'S ORGANOCATALYST



2 He designed some simple molecules that could create iminium ions. One of these proved to be excellent at asymmetric catalysis.

Receptors for temperature and touch



David Julius used capsaicin from chili peppers to identify TRPV1, an ion channel activated by painful heat. Additional related ion channels were identified, and we now understand how different temperatures can induce electrical signals in the nervous system.

The 2021 Nobel Prize in Physiology or Medicine has been awarded jointly to David Julius and Ardem Patapoutian 'for their discoveries of receptors for temperature and touch'.

Julius used capsaicin, a pungent compound from chili peppers that induces a burning sensation, to identify a sensor in the nerve endings of the skin that responds to heat. Patapoutian used pressure-sensitive cells to discover a novel class of sensors that respond to mechanical stimuli in the skin and internal organs. These breakthrough discoveries launched intense research activities, leading to a rapid increase in our understanding of how our nervous system senses heat, cold and mechanical stimuli.

In 1944, Joseph Erlanger and Herbert Gasser received the Nobel Prize in Physiology or Medicine for their discovery of different types of sensory nerve fibres that react to distinct stimuli; for example, in the responses to painful and non-painful touch. Since then, it has been demonstrated that nerve cells are highly specialised for detecting and transducing differing types of stimuli.

In the latter part of the 1990s, Julius at the University of California, San Francisco, USA, saw the possibility for major advances by analysing how the chemical compound capsaicin causes the burning sensation we feel when we come into contact with chili peppers. Julius and his co-workers created a library of millions of DNA fragments corresponding to genes that are expressed in sensory neurons. They hypothesised that the library would include a DNA fragment encoding the protein capable of reacting to capsaicin. They expressed individual genes from this collection in cultured cells that normally do not react to capsaicin. After a laborious search, a single gene was identified that was able to make cells capsaicin sensitive. Further experiments revealed that the identified gene encoded a novel ion channel protein, and this newly discovered capsaicin receptor was later named TRPV1. When Julius investigated the protein's ability to respond to heat, he realised that he had discovered a heat-sensing receptor that is activated at temperatures perceived as painful.

Independently of one another, both Julius and Patapoutian used menthol to identify TRPM8, a receptor that was shown to be activated by cold. Additional ion channels related to TRPV1 and TRPM8 were identified and found to be activated by a range of different temperatures. Many laboratories pursued research programs to investigate the roles of these channels in thermal sensation by using genetically manipulated mice that lacked these newly discovered genes.

While the mechanisms for temperature sensation were unfolding, it remained unclear how mechanical stimuli could be converted into our senses of touch and pressure. Patapoutian, working at Scripps Research in La Jolla, California, USA, and his collaborators first identified a cell line that gave off a measurable electric signal when individual cells were poked with a micropipette. After an arduous search, Patapoutian and his co-workers succeeded in identifying a single gene

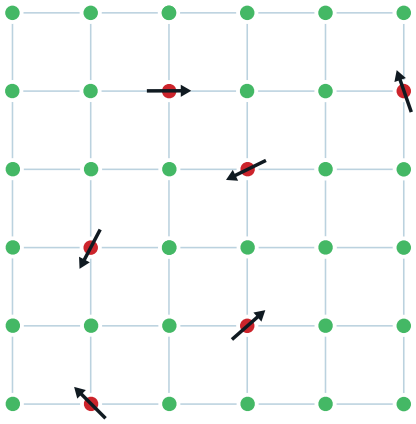
whose silencing rendered the cells insensitive to poking. A new mechanosensitive ion channel had been discovered and was given the name Piezo1, after the Greek word for pressure. Through its similarity to Piezo1, a second gene was discovered and named Piezo2. Sensory neurons were found to express high levels of Piezo2, and further studies firmly established that Piezo1 and Piezo2 are ion channels that are directly activated by the exertion of pressure on cell membranes.

The breakthrough by Patapoutian led to a series of papers from his and other groups, demonstrating that the Piezo2 ion channel is essential for the sense of touch. Moreover, Piezo2 was shown to play a key role in the critically important sensing of body position and motion, known as proprioception. In further work, Piezo1 and Piezo2 channels have been shown to regulate additional important physiological processes, including blood pressure, respiration and urinary bladder control.

TRP and Piezo channels also contribute to many additional physiological functions that depend on sensing temperature or mechanical stimuli. Intensive ongoing research originating from this year's Nobel Prize-awarded discoveries focuses on elucidating their functions in a variety of physiological processes. This knowledge is being used to develop treatments for a wide range of disease conditions, including chronic pain.

Nobel Prize Outreach

Complex physical systems



Spin glass

A spin glass is a metal alloy where iron atoms, for example, are randomly mixed into a grid of copper atoms. Each iron atom behaves like a small magnet, or spin, which is affected by the other magnets around it. However, in a spin glass they are frustrated and have difficulty choosing which direction to point. Using his studies of spin glass, Parisi developed a theory of disordered and random phenomena that covers many other complex systems.

Iron

Copper

The Nobel Prize in Physics 2021 has been awarded 'for groundbreaking contributions to our understanding of complex physical systems' with one half jointly to Syukuro Manabe (Princeton University, USA) and Klaus Hasselmann (Max Planck Institute for Meteorology, Hamburg, Germany) 'for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming' and the other half to Giorgio Parisi (Sapienza University of Rome, Italy) 'for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales'.

Three Laureates share this year's Nobel Prize in Physics for their studies of chaotic and apparently random phenomena. Manabe and Hasselmann laid the foundation of our knowledge of Earth's climate and how humanity influences it. Parisi is rewarded for his revolutionary contributions to the theory of disordered materials and random processes.

Complex systems are characterised by randomness and disorder and are difficult to understand. This year's prize recognises new methods for describing them and predicting their long-term behaviour.

One complex system of vital importance to humankind is Earth's climate. Manabe demonstrated how increased levels of carbon dioxide in the atmosphere lead to increased temperatures at Earth's surface. In the 1960s, he led the development of physical models of Earth's climate and was the first person to explore the interaction between radiation balance and the vertical transport of air masses. His work laid the foundation for the development of current climate models.

About 10 years later, Hasselmann created a model that links together weather and climate, thus answering the question of why climate models can be reliable despite weather being changeable and chaotic. He also developed methods for identifying specific signals, fingerprints, that both natural phenomena and human activities imprint in the climate. His methods have been used to prove that the increased temperature in the atmosphere is due to human emissions of carbon dioxide.

Around 1980, Parisi discovered hidden patterns in disordered complex materials. His discoveries are among the most important contributions to the theory of complex systems. They make it possible to understand and describe many different and apparently entirely random materials and phenomena, not only in physics but also in other, very different, areas such as mathematics, biology, neuroscience and machine learning.

'The discoveries being recognised this year demonstrate that our knowledge about the climate rests on a solid scientific foundation, based on a rigorous analysis of observations. This year's Laureates have all contributed to us gaining deeper insight into the properties and evolution of complex physical systems', said Thors Hans Hansson, chair of the Nobel Committee for Physics.

Nobel Prize Outreach

Tongue-in-cheek award with cult status for cinema air study

The 2021 Ig Nobel Prize in Chemistry goes to scientists from the Max Planck Institute for Chemistry and the University of Mainz.

The Ig Nobel Prizes honour scientific achievements that 'should first make people laugh and then make them think'. The spoof prizes, first awarded by the US journal *Annals of Improbable Research* in 1991, have long since acquired cult status among scientists. This year's chemistry award recognises a study that proves the connection between the air in cinemas and different age ratings. The study was carried out in cooperation between the Max Planck Institute for Chemistry and the University of Mainz.

In their work, the teams led by Jonathan Williams from the Max Planck Institute for Chemistry (MPIC) and Stefan Kramer, professor at the Institute for Computer Science at the University of Mainz, demonstrated the connection between the concentration of isoprene in the air of a cinema and the FSK age rating (Germany's motion picture rating organisation). Isoprene is stored in muscle tissue but escapes through our breath during movement. With the systematic data collected and evaluated by Kramer's team, the smell of fear could be visualised in concrete numbers.

Evidence of creativity

'Through the joint project, we have created a great link between the Atmospheric Chemistry Department at the Max Planck Institute for Chemistry and the Data Mining group at the University of Mainz, which helps us analyse atmospheric data', explained Williams. The scientist, who was born in England – where self-deprecation tends to be used as an art form – is delighted about winning the spoof award.

'The prize is a testament to our creativity as scientists and our willingness to see the bigger picture. We like to do experiments that may seem idiosyncratic at first, but which end up revealing new phenomena. This is part of the basic research that is the defining element of the Max Planck Society. Our work on measurable fear in cinema air has already set many new studies in motion', said Williams.

Tension in the air: the more nervous moviegoers are, the more isoprene they emit – a measurable indication of how stressful a film is. Erik Witsoe/Unsplash

'In our many years of cooperation with Jonathan Williams from the MPIC, we have always found extraordinary questions for the application and further development of machine learning methods' added Kramer.

The Ig Nobel Prizes are presented each year two weeks before the announcement of the real Nobel Prizes at the Sanders Theatre of Harvard University in Cambridge, Massachusetts. Because of the coronavirus pandemic, this year the award took place digitally on 9 September.

Through their collaboration, the researchers have opened the door to an interdisciplinary research direction that combines expertise from the fields of atmospheric chemistry, breath analysis, emotional response analysis and data mining. Nevertheless, Williams found the nomination for the iconic research award rather surprising. After all, this study represents only a fraction of his actual research work. His main research focus is outdoor atmospheric chemistry.

The study entitled 'Proof of concept study: testing human volatile organic compounds as tools for age classification of films' was published in the open access journal *PLoS ONE* in September 2018. As Williams recalls, the cinema study was met with a great response in the media at the time. Many people love the cinema, which means the topic is of interest to the general population. Whether *Psycho*, *Silence of the Lambs* or *Saw*, many thrillers have burned themselves into society's film memory with their shock moments. 'Whether we are scared or laughing, our emotions are in the air', said Williams. This gave him the idea of examining the air as a measurable indicator for age ratings of films. Kramer added to the idea by investigating whether the smells produced by viewers reliably reflect the level of violence, sex, antisocial behaviour, drug use and swearing in the film being shown.

Innovative film assessment: air measurement in the cinema

The researchers connected a mass spectrometer to the ventilation system of a cinema auditorium. During 135 film screenings, the researchers measured and analysed how the composition of the cinema air changes every 30 seconds. They discovered a relationship between the isoprene concentration in the air and the age rating of the film. 'Apparently, we involuntarily move back and forth in our seats or tense our muscles when we are nervous and excited. This also causes us to exhale more isoprene', explained Williams. How tense the audience is when watching a film provides a good indication of how stressful the film is for children and adolescents.

A continuation of the cinema study is being planned. Williams would now like to investigate whether people leave a chemical fingerprint in the air, not only of their tension but also of other emotional states.

Max Planck Institute for Chemistry, Mainz (Germany),
https://www.mpic.de/5036088/ig-nobelpreis

Work now ‘more intense’ for science journalists

BulentBARIS/iStockphoto

A major new study looking at the working conditions and practices, professional ethos and future expectations of science journalists suggests that work has become ‘more intense’ for those plying their trade around the world.

The *Global Science Journalism Report 2021*, published by SciDev.Net/Centre for Agriculture and Bioscience International (CABI) to celebrate its 20th anniversary, reveals that 64% of respondents said the number of projects they work on in one week has grown in the past five years. This percentage is slightly higher in Africa and Europe.

The survey found that in general science journalists work on one story, item or package over a two-week period but that women were more likely to work on five items over the same period. Despite this, the report states that 46% of respondents are happy with their jobs and 81% believe that they will ‘certainly or probably’ still be working in the field in the next five years.

In total, 633 science journalists from 77 countries – of which 54% were women – responded to a questionnaire.

The Brazilian Institute of Public Communication of Science and Technology/House of Oswaldo Cruz, the London School of Economics and the ISCTE-Lisbon University Institute also led on the research in partnership with the World Federation of Science Journalists. Collaborators included the Australian National Centre of Public Awareness of Science, the Center for Ethics in Science and Journalism and SciComm X.

‘Although this survey revealed some important distinctions among science writers working in different social, cultural and political circumstances, what is remarkable is how similar many of the responses are’, said Tim Lougheed, Executive Director of the World Federation of Science Journalists. ‘Science writing, science communication and science journalism appear to have a genuinely global character.’

The report also suggests that 73% of respondents did not agree with the assertion that ‘science journalism is a dying profession’, and 33% rejected the idea that ‘science journalism is in crisis.’ Female professionals would also most recommend the career to a young student, the survey further reveals.

Researchers also asked about the impact of the COVID-19 pandemic on their work. The survey revealed that peer-reviewed scientific articles, scientists from journalists’ countries and official institutions are the sources participants have used the most.

Furthermore, more than half (55%) of journalists admitted to using preprint materials in their COVID-19 stories and 59% said they adopted different procedures when covering preprint research articles.

Nearly half (48%) of the respondents said that scientists were more easily available to talk to during the COVID-19 pandemic than in previous years, and 37% found that scientists were more open and talkative than before the pandemic.

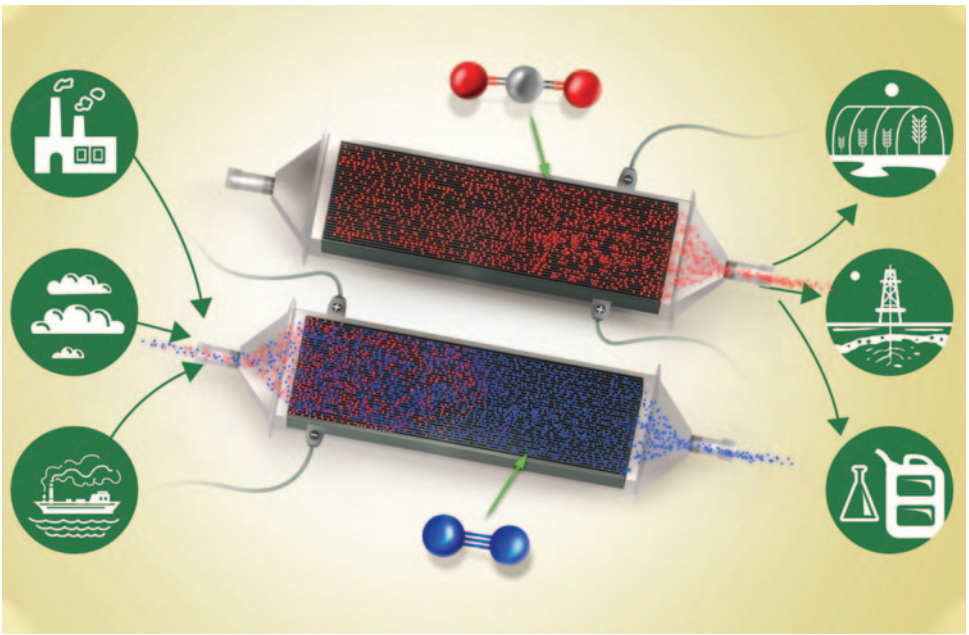
Other findings include suggestions that Facebook is the social network on which science journalists are most present, followed by LinkedIn, Twitter and Instagram.

Regarding subject matter, science was given as the main topic covered by participants, followed by environment, technology, health and medicine, and climate change.

A final assertion from the report is that many science journalists agree that as science and technology become more interesting, so does science journalism; that science communication is a high-quality product; and that the proliferation of press releases from journals, universities and researchers, combined with budget cuts in newsrooms, lead to mass production that is not of good quality.

CABI

CO_2 monitors could track indoor COVID-19 risk in near real time



A flow of air or flue gas (blue) containing carbon dioxide (red) enters the system from the left. As it passes between the thin battery electrode plates, carbon dioxide attaches to the charged plates while the cleaned airstream passes on through and exits at right. MIT

Researchers from the Massachusetts Institute of Technology (MIT), USA, have developed a way of using carbon dioxide monitors to help estimate the risk of catching COVID-19 and other airborne diseases in near real time.

They say it could help track the evolving risk of transmission in indoor spaces and may lay the groundwork for the air quality monitoring systems of the future. Such systems could predict transmission rates of airborne diseases like COVID-19 or seasonal flu, and work in concert with ventilation systems to adjust the air within buildings to keep the risk of transmission low.

The research builds on previous work from the authors, which provided a guide to the risk of airborne transmission in different indoor settings. Using data from super-spreader events, they produced a mathematical model that estimated the average length of time it would take to become infected when sharing a space with someone who had COVID-19.

From this they produced a safety guideline, setting limits on time spent in shared spaces, and adjusted by factors including the size of room, numbers of infected and susceptible people, what they were doing and whether ventilation and masks were in use.

Writing in *Flow: Applications of Fluid Mechanics* (doi.org/10.1017/flo.2021.10), Martin Z. Bazant, professor of chemical engineering and applied mathematics, and John W.M. Bush, professor of applied mathematics, along with co-authors Ousmane Kodio, Alexander E. Cohen, Kasim Khan and Zongyu Gu, explain that they have now been able to express the same safety guideline in terms of the concentration of CO_2 in the air, which is easily measured.

The researchers say there is overwhelming evidence that the virus that causes COVID-19 is mainly spread by airborne droplets, breathed out by infected people. Measuring CO_2 tracks how much air people are breathing out and the rate at which it is removed by ventilation.

The work combines those measurements with three models, which look at the dynamics of gas, infectious aerosols and disease transmission. The authors stress that concentrations of CO_2 and of airborne pathogens are not strictly linked, as the amount of virus in the air is affected by several factors, including the use of face masks.

So, their model takes into account more than 40 variables (including masks, ventilation, air filtration, activity levels and the number of people likely to be infectious or susceptible to infection at different stages of a pandemic) to estimate how much virus is present, and therefore the risk of infection, in near real time.

This is expressed as an indoor reproductive number, which represents how readily the virus is transmitted to others, assuming a number of infectious people are in the room. This changes over time and is used by the researchers as a measure of safety: provided the number stays below a certain level, people can continue to share a space.

They ran two demonstrations – one in a small office with two occupants, and the other in a lecture hall with 12 people. The demonstrations showed it was possible to track a theoretical reproductive number and also highlighted the factors that increase or reduce danger. Wearing masks dramatically increased the amount of time people could share a space without the reproductive number climbing above the safety limit. Filtration also increased the time taken to exceed safe limits, but by a much lesser extent.

The researchers acknowledge that the assumptions made and uncertainties about many of the parameters in the model, such as the concentration of virus in droplets of breath, and the relative susceptibility of different groups to infection, limit the accuracy of their guidelines. They hope these uncertainties will reduce as more data about real-world spreading events is analysed.

Together with app developer Khan, the researchers have now made their model available as an online tool, to help people reduce risk to themselves and others in different indoor settings.

Cambridge University Press

Wastewater testing for COVID-19 takes flight

CSIRO has analysed wastewater samples from long-haul flights of returning Australians, which prove signals of the SARS-CoV-2 virus can be detected even before passengers show symptoms.

The research from CSIRO scientists, working with Qantas and the University of Queensland, demonstrates that wastewater surveillance can provide valuable data for public health agencies and help improve confidence in Australia's safe reopening to the world.

CSIRO lead author Dr Warish Ahmed said as global travel returns, wastewater testing of flights can be an effective way to screen incoming passengers for COVID-19 at points of entry.

'It provides an extra layer of data, if there is a possible lag in viral detection in deep nasal and throat samples and if passengers are yet to show symptoms', Ahmed said.

'The rapid on-site surveillance of wastewater at points of entry may be effective for detecting and monitoring other infectious agents that are circulating globally and provide alert to future pandemics.'

Professor Jochen Mueller from the University of Queensland's Queensland Alliance for Environmental Health Sciences and co-author on the research said wastewater testing could be a useful additional tool.

'The paper recommends that wastewater surveillance should be used as part of an efficient clinical surveillance and quarantine system – providing multiple lines of evidence of the COVID-19 infection status of passengers during international travel', Mueller said.

'Wastewater surveillance from large transport vessels with their own sanitation systems significantly improves our ability to control the spread of infection from overseas travellers.'

Published in *Environment International* (doi.org/10.1016/j.envint.2021.106938), the study analysed wastewater samples from lavatories of 37 Australian Government repatriation flights from COVID hotspots, including India, France, the UK, South Africa, Canada and Germany, landing at Darwin International Airport between December 2020 and March 2021.

The research found wastewater samples from 24 of the 37 repatriation flights (65%) showed a positive signal for the virus that causes COVID-19 despite all passengers (except children under age five) testing negative to the virus 48 hours before boarding.

Infected people shed the virus in their faeces about two to five days before showing symptoms. Traces of the virus can also be detected in wastewater from people who were previously infected, still shedding the virus, but are no longer infectious to others (although this is typically a weaker signal).

During 14 days of mandatory quarantine after arriving in Australia, clinical tests identified only 112 cases of COVID-19 among the 6570 passengers (1.7%).

There was 87.5% agreement between the positive detections by surveillance of the wastewater (i.e. detection of SARS-CoV-2 RNA) and the subsequent clinical detections made during the passengers' quarantine.

This was the first official study of wastewater from Australian repatriation flights returning from hotspots and the first time researchers have matched the plane wastewater testing with the follow-up clinical data testing of passengers in quarantine.

For the study, CSIRO undertook the wastewater analyses, and much of the data analysis with input from the University of Notre Dame, USA. Qantas designed the sampling trap with input from the University of Queensland and both organisations were involved in study design and wastewater sampling.

The participants of this study were quarantined at the Howard Springs Quarantine Facility in the Northern Territory.

The latest study builds on earlier work published in the *Journal of Travel Medicine* in July 2020 (doi.org/10.1093/jtm/taaa116), which detected fragments of the SARS-CoV-2 virus in aircraft and cruise ships.

According to the latest paper, surveillance of wastewater from aircraft and cruise ships offers a convenient and cost-effective means of monitoring infectious agents that could be globally scaled to detect and manage the importation of disease.

CSIRO

Qantas developed a sampling trap for collecting wastewater samples from planes to avoid cross contamination from flight to flight.
Qantas

New light on future of critical metals demand during energy transition

A recent CSIRO report has uncovered powerful and counterintuitive insights into the future supply and demand of critical metals needed to support the transition to a low-emissions future.

Trajectories for metals used in electric vehicles (EVs) may be more complicated than what is currently accepted, according to one scenario modelled using the Physical Stocks and Flows Framework (PSFF) tool.

The report *Known unknowns: the devil in the details of energy metal demand* uses the bespoke tool to look at three EV battery metals (cobalt, lithium and nickel) under three different EV uptake scenarios.

CSIRO's Critical Energy Metals Mission-in-development lead, Dr Jerad Ford, said the PSFF tool uses factors not currently accounted for in traditional forecasts to test the demand and supply assumptions.

For instance, it is commonly assumed that demand for newly mined metals like cobalt and nickel will continue to increase for the foreseeable future, as they are essential for high-performance lithium-ion batteries used in EVs.

But by accounting for additional factors such as changes in battery chemistry, quicker EV uptake and higher levels of recycling, the PSFF tool suggests that, even within the same scenario, new cobalt may have an extremely short demand window before an extended glut, nickel will peak early then fall back sharply, and lithium will remain stronger for longer before also trailing off in the out years.

'This challenges conventional wisdom that the demand for these battery metals will mirror each other', Ford said.

The report also looks at the potential for retiring EV batteries to meet the electricity storage requirements of a renewables-based electricity grid.

However, the PSFF is not intended to be used as a prediction tool.

'A PSFF does, however, enable the development of internally consistent scenarios to explore how "views" on major components of the energy transition will play out and interact with each other', Ford said.

The PSFF tool isn't limited to battery metals and could be used by leaders wherever major new technologies require new mixes of metals, to input their assumptions about the market to understand the implication for their business.

'This tool allows us to take assumptions about a range of factors to test what supply and demand will look like for different metals under those conditions, empowering Australian businesses to manage risk and stay ahead of the market', Ford said.

Download a copy of the report at bit.ly/31B4FSr.

CSIRO

Mass spectrometry portfolio to advance quantitative analysis

Lab managers, technology leaders and principal scientists in pharmaceutical, food and environmental laboratories can now benefit from accelerated throughput and improved sensitivity to meet rapidly changing regulatory requirements, and provide the fast responses needed for tackling emerging human and environmental health risks.

The Thermo Scientific TSQ Plus triple quadrupole mass spectrometer (MS) portfolio increases workflow throughput through superior data acquisition and polarity switching speeds. The improved low-mass product ion transmission efficiency enhances sensitivity for key target applications.

The new portfolio, which consists of the TSQ Altis Plus, TSQ Quantis Plus and TSQ Fortis Plus MS, can be used across a range of applications, from targeted quantitation to cutting-edge research. Intuitive mass calibration routines and method optimisation, in combination with market-leading chromatography and data processing software solutions, offer improved ease of use to address future analytical challenges.

Users of the TSQ Plus triple quadrupole MS portfolio will benefit from:

- increased system uptime due to enhanced quadrupole mass stability
- direct instrument method transfers from the existing Thermo Scientific TSQ MS portfolio to the TSQ Plus MS portfolio, enabling simplified transfers
- integration with mzCloud database to provide selective reaction monitoring transition information with predicted collision energy
- integration with industry-leading liquid and ion chromatography systems and software, delivering powerful quantitative application solutions.

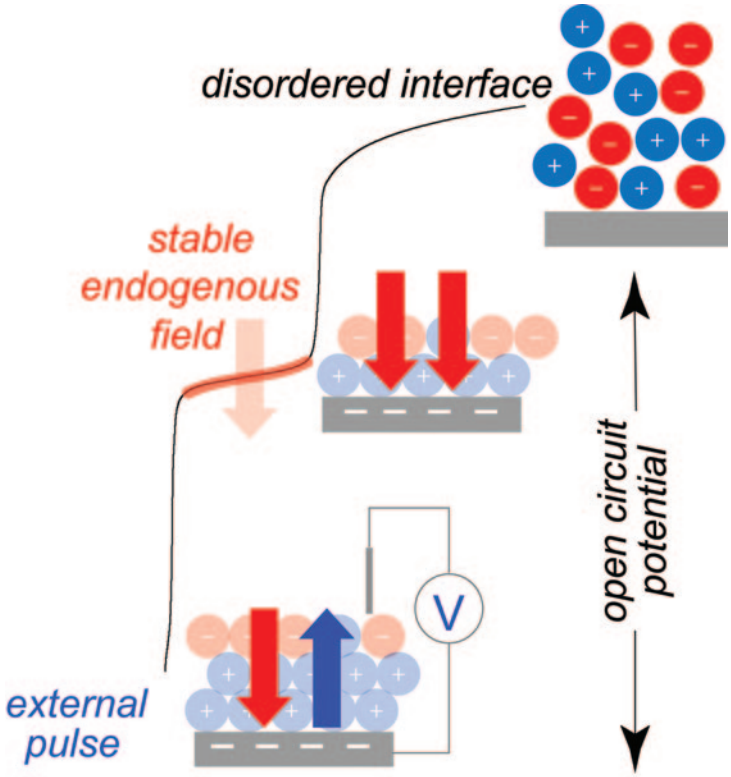
For more information on the TSQ Plus triple quadrupole MS portfolio, please visit www.thermofisher.com/TSQPlus.

Erratum

In the September–November 2021 issue, the article 'COVID-19 lockdown highlights ozone chemistry in China' (p. 7) incorrectly referred to NO_x and VOCs as 'components' of ozone. The article should have said that these chemicals 'contribute to the generation' of ozone.

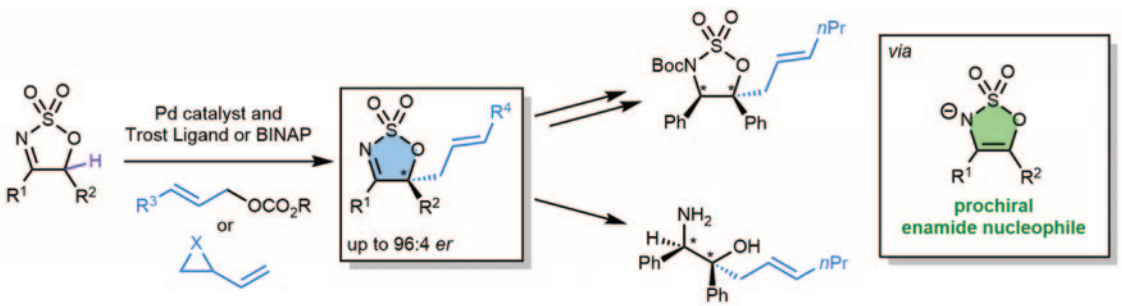
Long-lived electric field of a liquid salt

Ionic liquids are organic salts that are liquid at room temperature. The adsorption of ionic liquids on metallic electrodes defines how these systems perform in applications ranging from energy storage to catalysis and lubrication. The electric-potential-driven ordering and subsequent relaxation of electrode–ionic-liquid interfaces are slower than for molecular solvents, but how slow has remained unclear. Methods currently available to probe the dynamics of these interfaces, such as atomic force microscopy and neutron reflectometry, have shortcomings and are technically demanding. A team of researchers from Curtin University, ANU and Monash University has reported an extremely simple way to monitor the ordering of ionic liquid at interfaces using readily available open-circuit potentiometry (Belotti M., Lyu X., Xu L., Halat P., Darwish N., Silvester D.S., Goh C., Izgorodina E.I., Coote M.L., Ciampi S. *J. Am. Chem. Soc.* 2021, **143**, 17 431–40). The endogenous electric-field signatures of several ionic liquids were shown to persist for days in the absence of mechanical perturbations, and polarisable molecular dynamics simulations unveiled a correlation between the magnitude of the endogenous field and key molecular and dynamical properties of the liquid. This method will aid the selection of ionic liquids that can facilitate reactions by electrostatic catalysis.



Asymmetric synthesis of cyclic sulfamidate imines

Chiral 1,2-amino alcohols are important molecular building blocks for preparing more complex scaffolds containing N- and O-heteroatoms, including bioactive heterocyclic molecules. In a step towards the development of a new synthesis of more synthetically challenging and less readily accessible chiral trisubstituted 1,2-amino alcohols, PhD student Quoc Hoang Pham and the team led by Chris Hyland and Stephen Pyne at the University of Wollongong have successfully developed the palladium-catalysed asymmetric allylic alkylation reaction of 4,5-disubstituted cyclic sulfamidate imines (Pham Q.H., Tague A.J., Richardson C., Hyland C.J.T., Pyne S.G. *Chem. Sci.* 2021, **12**, 12 695–703). This work is the first example of the use of prochiral enamide anions in a palladium-catalysed allylic alkylation reaction, and leads to valuable allylated heterocyclic products with a tetra-substituted stereogenic centre. Using a Trost chiral ligand, or in some cases (*R*)-BINAP (where BINAP is 2,2′-bis(diphenylphosphino)-1,1′-binaphthyl), the protocol was found to tolerate a wide range of imines, allyl carbonates, as well as several related vinylic substrates. Under optimised reaction conditions, *C*-allylated products were exclusively produced in generally high enantiomeric ratios and good yields. The allylated products were demonstrated to serve as precursors to chiral trisubstituted 1,2-amino alcohols through diastereoselective reduction reactions. Other methods are available to prepare related 1,2-amino alcohol derivatives, but these methods often suffer from regiochemical issues that lead to mixtures of isomeric products or give products of low enantiomeric purity. Thus, it is anticipated that the new method will be valuable to chemists working on target syntheses.

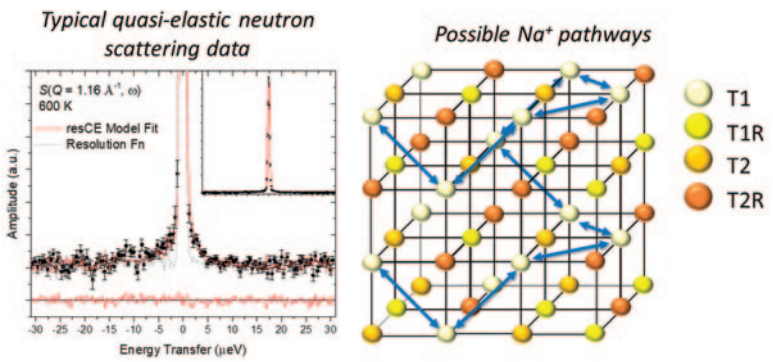


Why comet tails are not always green

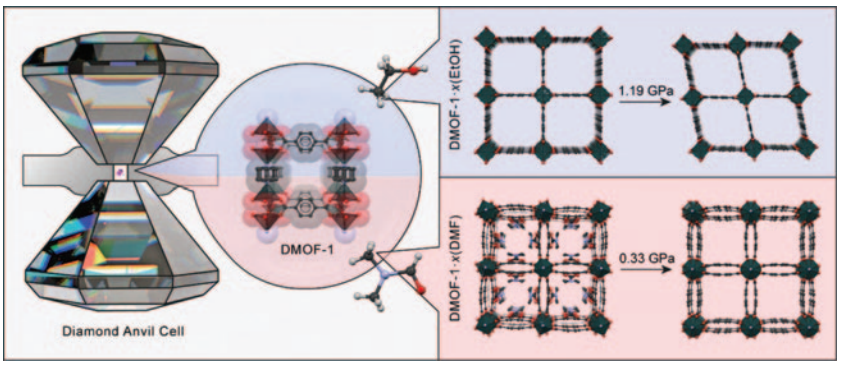
The coma of a comet is the fuzzy ball of glowing gas that evaporates off the nucleus as a result of sunlight. In many comets, the coma is green, due to the presence of dicarbon, C_2. This molecule also contributes to the colour of blue flames. Dicarbon comes from the break-up of larger organic molecules – the sort of molecules that are the ingredients of life. As a comet approaches the sun, the coma gets brighter, and shrinks. This is because the dicarbon molecules are destroyed by sunlight, and so cannot travel as far from the nucleus. Because they get destroyed, they never make it into the tail, and so the tail is no longer green. Until now, it was not known how this happens. Australian researchers have solved this astronomical riddle (Borsovszky J., Nauta K., Jiang J., Hansen C.S., McKemmish L.K., Field R.W., Stanton J.F., Kable S.H., Schmidt T.W. *Proc. Natl Acad. Sci. USA,* in press). The researchers synthesised dicarbon molecules and destroyed them with UV laser light with a very precise energy. The recoiling carbon atoms were smashed onto a detector to precisely measure their speed, allowing a determination of the strength of the C–C bond: 602.782(29) kJ/mol.

Visualising dynamics in solid-state ionic conductors on the atomic scale

Ionic conductors transport electrical charge in the form of ions and are used as electrolytes in lithium-ion and sodium-ion batteries. Solid-state batteries, which use solid-state ionic conductors, are being developed because they are inherently safer and can produce higher-energy densities than batteries based on liquid electrolytes. The key challenge in developing solid-state batteries is that conduction in solid-state ionic conductors is typically inferior to that in liquid-based electrolytes. An understanding of the conduction mechanism is critical to the design of better ionic conductors. Bulk techniques such as impedance spectroscopy are informative, but very few techniques can probe diffusion mechanisms on the atomic level. Now researchers at ANSTO, the University of New South Wales, and the University of California, San Diego (USA), have used high-resolution neutron diffraction coupled with quasi-elastic neutron scattering to uncover the diffusion mechanism in magnesium-doped sodium phosphate on the atomic scale (Cheung E.A., Nguyen H., Tang H., Stampfl A.P.J., Avdeev M., Meng Y.S., Sharma N., de Souza N.R. *J. Am. Chem. Soc.* 2021, **143**, 17 079–89). They demonstrated coupled anion–cation dynamics, in which a proportion of the sodium is bound to phosphate groups that rotate as sodium diffuses. The approach used in this study could be applied to a wider range of sodium- and lithium-based ionic conductors to understand atomic-scale dynamics.



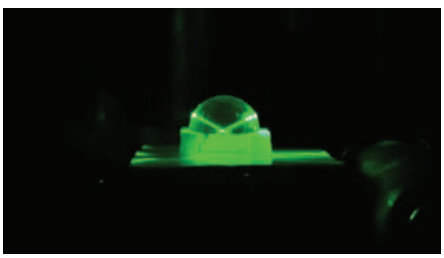
Guest-mediated MOF flexibility under pressure



Metal–organic frameworks (MOFs) commonly undergo flexible structural changes in response to guest adsorption or desorption that can be exploited for numerous applications. The pillared-layered DMOF-1 framework has previously been reported to undergo pore-shape transformations in response to guest adsorption, adopting square, rectangular and rhombus-shaped channels with ethanol (EtOH), dimethylformamide (DMF) and benzene adsorbents, respectively. Researchers from the University of Western Australia have gained new insight into the guest-mediated flexibility of this framework by high-pressure single-crystal X-ray diffraction (Turner G.F., McKellar S.C., Allan D.R., Cheetham A.K., Henke S., Moggach S.A. *Chem. Sci.* 2021, **12**, 13 793–801). A series of further structural changes were discovered on compression of each of the guest-loaded frameworks in a pressure-transmitting medium of their respective guest species. The EtOH-containing framework transformed from square to rhombus channels at 1.19 GPa due to intrusion of the pressure-transmitting medium into the channel. By contrast, the DMF-containing framework transformed from a body-centred to a primitive crystal structure at 0.69 GPa due to disordering of the DMF within the channel, while the benzene-containing framework was largely unresponsive to pressure. This behaviour highlights the importance of host–guest interactions on the flexibility of MOFs. More importantly, the loss of crystallinity, and therefore structural stability of the crystalline phase so important for selectivity, depends critically on the guest species.

No role for excimers in singlet fission

Singlet fission is a process that can create two excitons from a single photon. With judicious design, this process could be harnessed to create high-efficiency solar cells. The process involves a photoexcited chromophore interacting with a ground-state chromophore to yield two triplet excitons. But this interaction can also lead to excimer formation. The exact role of the excimer has been unclear, with some groups proposing that it serves as an intermediate. However, the team led by Tim Schmidt at the University of New South Wales recently demonstrated that the excimer could not be an intermediate in singlet fission in the widely studied chromophore TIPS-tetracene (where TIPS is 6,13-bis(triisopropylsilylethynyl)) (Dover C.B. et. al. *Nat. Chem.* 2018, **10**, 305–10). Now the team has shown that the excimer plays no observable role in singlet fission in the related chromophore TIPS-pentacene (Dvorák M., Prasad S.K.K., Dover C.B., Forest C.R., Kaleem A., MacQueen R.W., Petty II A.J., Forecast R., Beves J.E., Anthony J.E., Tayebjee M.J.Y., Widmer-Cooper A., Thordarson P., Schmidt T.W. *J. Am. Chem. Soc.* 2021, **143**, 13 749–58). By building a total internal reflection spectrometer and undertaking careful NMR measurements, they were able to show that the emission spectrum of TIPS-pentacene is unchanged at very high concentrations and that aggregation is only present at the highest concentrations measured. These findings make it abundantly clear that excimers are not required nor desirable in singlet fission.



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.

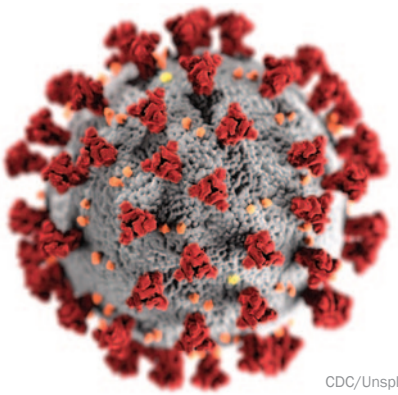
Air of caution

How COVID sparked a rethink on aerosol transmission

BY **JOEL RINDELAUB**

Marc Dufresne/iStockphoto

During the COVID pandemic, some vocal aerosol chemists have crunched new data, and some old myths, which changed our view of respiratory viruses.



CDC/Unsplash

Early in the COVID-19 pandemic, the guidance on non-pharmaceutical interventions was much different from that in place today. Initially, mask use was not supported by many Western government agencies, with the US Surgeon General explaining (in a now deleted tweet posted on 29 February 2020): 'Seriously People – STOP BUYING MASKS! They are NOT effective …'

The World Health Organization was also in on the action, releasing a scientific brief on 29 March 2020 emphasising that COVID-19 was not airborne (bit.ly/3BeiC58).

While recommendations have clearly changed since then, it took fresh data (bit.ly/3nt8hgF) to overcome old beliefs on viral transmission. In the process, it has fundamentally changed how we view respiratory viruses.

Aerosol scientists take a stand

Not everyone was on board with initial guidance that downplayed the potential for airborne transmission of COVID-19, to put it lightly. Many aerosol chemists did not feel that the WHO was actively listening to their concerns regarding the need for a more cautious approach to public health guidelines.

One of the most vocal critics was Professor Donald Milton at the School of Public Health, University of Maryland, USA, whose reply to the WHO regarding their rejection of aerosol transmission left no room for misinterpretation: 'I think the WHO is being irresponsible in giving out that information. This misinformation is dangerous' (n.pr/3GiSWbj).

It's not often the WHO gets called out for misinformation by a world-leading scientist. But that's exactly what happened in April 2020. And Milton

wasn't alone. In July 2020, Milton and QUT physicist and aerosol researcher Lidia Morawska published an open letter that was co-signed by 239 experts in the field, calling for the international medical community to recognise the threat of aerosol transmission (also referred to as airborne transmission) (bit.ly/3mlBpY5).

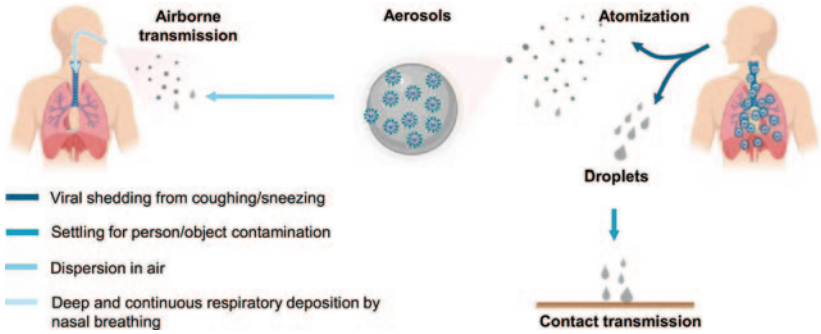
Aerosol assumptions

One particular focus of aerosol researchers was the restrictive limits that medical officials put on aerosol travel, which were the basis for the recommendations on social distancing. The idea that respiratory particles could only travel 2 metres was based on historical assumptions, not recent data. In fact, it went against the very physics that defined the field of aerosol science.

In the early guidance on COVID-19 transmission, there was a distinct cut-off size (5 μm) for defining respiratory particles. Anything smaller than 5 μm was considered by health officials as an aerosol and anything larger than 5 μm was labelled as a droplet. The prevailing opinion among the medical community was that droplets greater than 5 μm were large enough to succumb to the forces of gravity, falling to the ground within 2 metres of being expelled.

This assumption was not in line with aerosol scientists' understanding of how airborne particles behave. The transport and fate of aerosol particles depends on their size, and particles larger than 5 μm can travel much farther than 2 metres under normal conditions. In a room with stagnant air flow, aerosols can travel around 10 metres and remain airborne for hours. The more appropriate threshold used by aerosol scientists is 100 μm, the size that better separates particles on their aerodynamic behaviour. Thus, to aerosol scientists, anything smaller than 100 μm (rather than 5 μm) is defined as an aerosol, as these sizes can remain suspended in the air for more than 5 seconds when released from a height of 1.5 metres.

Thus, to aerosol scientists, anything smaller than 100 μm (rather than 5 μm) is defined as an aerosol ...



Transmission of COVID-19.
Renyi Zhang, Yixin Li, Annie L. Zhang, Yuan Wang and Mario J. Molina/CC-BY-4.0 via Wikimedia Commons

The disagreement in terminology highlighted the disconnect between aerosol researchers and public health officials. Particles larger than 5 μm are regularly exhaled in breath, yet public health protocols were based on the assumption that exposure to these respiratory particles could be easily mitigated by social distancing. Furthermore, the smaller aerosol particles less than 5 μm were being overlooked, yet they were actually the most important with regard to transmission.

Respiratory particle generation

When someone coughs, talks or even breathes, most of the particles released are of the smaller variety rather than the larger droplets, with particle concentrations on the order of thousands per litre of air. These aerosol particles are also the ones most likely to transmit SARS-CoV-2, as viruses are typically enriched in respiratory particles smaller than 5 μm.

The asymmetric viral distribution within particle sizes relates to how respiratory aerosols are generated. During breathing, the smaller aerosol particles are created when air interacts with the thin liquid film lining the respiratory tract. Conversely, the larger particles are primarily created by air passing through the oral cavity and interacting with saliva. As airflow and speech volume increase during activities such as singing and shouting, greater numbers of aerosols are produced.

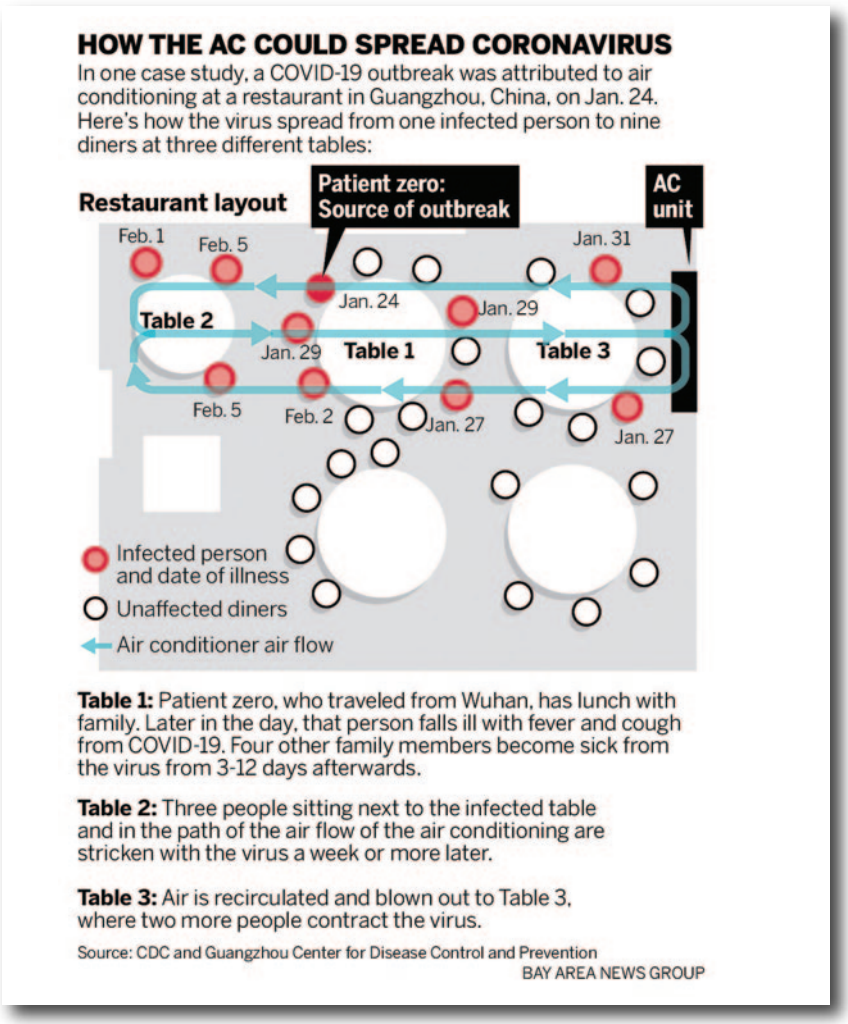
The small size of virus-laden aerosol particles also affects their ability to cause infection. The smaller the particle, the deeper it can penetrate the respiratory system when inhaled. Thus, the smallest particles – those less than 5 μm – can deposit in the lungs, causing lower respiratory infection and potentially requiring smaller viral concentrations to do so than intranasal and upper airway infections.

Evolution of aerosol data

When considering guidelines and health recommendations, the WHO traditionally requires a high evidentiary threshold for implementing changes. While this ensures the organisation consistently reports well-established scientific opinions, it also means that an outdated disposition is harder to correct. To redefine aerosol transmission related to COVID-19, the WHO desired more robust studies and

a higher burden of proof. However, investigating viral transmission, especially via tiny aerosol particles, is no easy task in a laboratory environment. Besides the technical challenges associated with measuring RNA concentrations in particles smaller than 5 μm in diameter, attempting to determine the amount of viral RNA required to initiate infection also remains difficult.

As the pandemic progressed, epidemiological studies were able to highlight the prevalence of aerosol transmission. At a restaurant in Guangzhou (China) in January 2020, nine patrons sitting within the airflow of a single asymptomatic case became infected despite no close interactions (bit.ly/3jCfr0U). In February 2020, reports from the *Diamond Princess* cruise ship quarantined at a Japanese port suggested that passengers may have been infected via long-range transport, an assertion that was supported by later modelling work (bit.ly/3jCfycQ). The next month, a superspreading event occurred during a church choir rehearsal in the USA where 53 of the 61 members became infected despite following social distancing protocols (bit.ly/2XJ7hw0). In Australia, long-range transmission at a Western Sydney church service occurred in July 2020, leading to 12 secondary cases, including one that was 15 metres away from the index case. Further events at meat packaging plants (bit.ly/3pAfWwf), across hotel hallways in New Zealand, and from rows apart during air travel (bit.ly/3vOenfh) supported the airborne nature of the virus.



By April 2021, the WHO had declared that aerosols were the dominant mode of transmission for COVID-19, nearly a year after aerosol chemists had come to the same conclusion (bit.ly/3jWevF5). With airborne respiratory particles now at the forefront of the COVID-19 pandemic, updated public safety protocols and recommendations have been needed to reflect the newly gained knowledge.

Ventilation, masks and distancing

Perhaps the most important change in the future is to apply better indoor ventilation strategies. Nearly all superspreader events have happened in indoor environments where airflow is reduced compared with outdoor areas. Since aerosols can concentrate indoors, a greater emphasis on clean air exchange is required inside areas of habitation. In buildings with central air, greater outdoor air exchange can be used alongside higher efficiency filters, with current advice recommending filters with a minimum efficiency reporting value of at least 13. Stand-alone HEPA (high-efficiency particulate air) filters can also be used to help clean re-circulated air, and there is potential for using upper room UV treatment to deactivate viruses.

At a restaurant in Guangzhou (China) in January 2020, nine patrons sitting within the airflow of a single asymptomatic case became infected despite no close interactions.

In the absence of a central air system, the simple act of opening a window can improve ventilation by up to a factor of three.

In the absence of a central air system, the simple act of opening a window can improve ventilation by up to a factor of three. Current recommendations state that, ideally, indoor environments should have at least four to six air changes per hour. The use of carbon dioxide sensors could also be of use when trying to monitor the amount of exhaled breath in certain indoor environments, with target concentrations below 800–1000 ppm CO_2 recommended. Cleaner indoor air would have long-ranging benefits beyond viral infections, as polluted indoor environments are associated with increased incidences of respiratory illness and decreased cognitive performance.

In addition to ventilation, proper mask use can help reduce COVID-19 transmission. Health guidelines were originally updated to recommend mask use when it was discovered that asymptomatic and pre-symptomatic individuals could transmit the virus. Now, the most effective types of masks and their fit also should be added to recommendations. Single-layer cloth masks, like scarves and bandanas, are far less useful than triple-layer cloth masks, surgical masks and N95 respirators. N95 masks, which can filter at least 95% of particles, have the best filtration efficiency if worn correctly, although the limited supply and fit testing required for their optimal use make them less practical in many applications. Surgical masks are typically 50–75% efficient; however, their efficiency can be improved to 60–90% by modifying the fit for a better seal around the face or by using them in combination with a tightly fitted cloth mask. Overall, even if a mask is not completely effective, widespread use across a community can help reduce viral transmission.

A better understanding of the social distancing guidelines could be beneficial as well. While virus-laden aerosols can infect at any nearby distance, the large droplets theoretically would be relevant to the 2 metres closest to another individual, regardless of indoor or outdoor location. Distancing within indoor environments should be as far as allowable. Much like with other interventions, a 2-metre distance doesn't guarantee safety from the virus, and it is best to use a combination of preventative approaches to help lower the spread of COVID-19.

With the insight gained from COVID-19 research, experts now have more confidence that other respiratory viruses have similar airborne properties, such as influenza, respiratory syncytial virus and human rhinovirus. Thus, the interventions we apply to help fight COVID-19 are likely to help keep communities safe beyond the realm of the current pandemic.

Joel Rindelaub is a research fellow at the School of Chemical Sciences, University of Auckland, New Zealand.

Masks and particle size

N95 masks are typically manufactured with non-woven polypropylene. Importantly, this material can hold an electrostatic charge that allows for particle attraction, a critical mechanism in mask filtering efficiency at flow rates relevant to breathing. N95 masks (or the similar P2 by AS/NZS Standards) filter at least 95% of non-oil particles at 0.3 µm (at least 94% efficiency for P2). The 0.3 µm particle size is the most penetrating for these types of masks, and the filtering efficiency of N95 masks usually increases with aerosol particle size. Surgical masks contain three layers, with a hydrophilic inner layer to absorb moisture, a middle filtering layer, and an outer hydrophobic layer. Surgical masks were designed to limit the release of larger particles (i.e. those greater than 5 µm); however, their relatively loose fit does not allow for the capture of smaller particles.

The efficiency of these masks can be improved by modifications to create a tight seal around the face. The most efficient cloth varieties emulate surgical mask composition, also consisting of three layers that use an internal material such as cotton and an outer material such as polyester. Due to the material, fit and lack of electrostatic charge, single-layer cloth masks are not recommended for use when other options are available.

Ehsan ahmadnejad/Unsplash

Marvellous medicine

A century of insulin extract

sunnychicka/iStockphoto

Insulin injections have saved countless lives in the 100 years since the hormone's isolation and scale-up by Canadian chemists and physiologists.

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

A century ago, six-year-old Sydney girl Phyllis May Adams lay dying. She had fallen ill the previous year, and now weighed just 10 kilograms. Her salvation lay wrapped in cotton wool, in the care of the purser of a P&O ship arriving from Vancouver. So great was her need that her father met the ship mid-harbour to rush home her first dose of the new miracle hormone extract, insulin.

The idea that saved Phyllis' life had originated just two years before, although the disease that almost took it – diabetes – had been discussed for millennia.

The word 'diabetes' dates back to the second century CE, when Arataeus of Cappadocia described the excessive drinking and urination that is symptomatic of the untreated condition. It comes from the Greek verb διαβαίνω ('diabaino'), which roughly translates to 'to pass through'. The disease has been noted across the world and throughout history: in the *Ebers Papyrus* (Egypt) from around 1500 BCE; in the works of Sushruta 'the father of surgery' (India) in the eighth century BCE; and in China in the works of Chang Chung-Ching, about 200 BCE, and Chen Chuan, about seventh century CE. It has been noted in the classical world by Arataeus of Cappadocia and by Galen (~150 CE); and in the Middle East, in Avicenna's textbook *El-Kanun* ('The canon of medicine') during the 11th century. Mediaeval scholar Moses Maimonides (12th century CE) described the illness in detail, including symptoms of acidosis.

The beginning of a solution came from Oskar Minkowski and Joseph von Mering in 1889 at the University of Strasbourg. Continuing experimentation on dogs (see box p. 23), they were able to induce diabetes in an animal by removing its pancreas. It soon developed polyuria, and its urine was found to contain 12% sugar. They went on to show that by implanting a small portion of pancreas

subcutaneously in depancreatised dogs, hyperglycaemia could be prevented until the implant either was removed or spontaneously degenerated.

In 1910, English physiologist Edward Albert Sharpey-Schafer proposed that diabetes developed in the absence of a particular substance that the pancreas produced. He called this chemical 'insulin' (from the Latin *insula*, meaning 'island') after the pancreatic 'islets of Langerhans' (see box p. 25). This was followed by a series of attempts to extract insulin from ground-up pancreases, all of which failed because another major pancreatic product, digestive enzymes, destroys insulin on contact.

All of this history came together in a rush, starting in October 1920. Lacking sufficient patients in his newly established practice in Ontario, young and unknown Canadian surgeon Frederick Banting took a job as a university lecturer. While preparing for a class, he read an article stating that the islets of Langerhans deteriorate more slowly than other pancreatic tissue. It gave him an idea, but he had neither the expertise nor the facilities to investigate.

In November 1920, Banting met with eminent biochemist John Macleod at the University of Toronto. Macleod was sceptical of Banting's idea, but after some persuading agreed to share his lab and resources for the summer break.

Macleod offered two research students, Charles Best and Clark Noble, summer jobs at his lab. After a coin toss, Best won the right to work with Banting on the insulin project. Best and Banting started work in May 1921. They tied off the pancreatic ducts of the first of several dogs, causing atrophy of the exocrine region of the subject's pancreas.

After the pancreas was allowed to atrophy, the degraded pancreas should only have produced insulin. Best and Banting euthanised the dog, crushed the pancreatic glands in a cool mortar and froze the tissue in salt water. To this powder, they added 100 millitres of 'physiological salt' (0.9% NaCl, at the same osmotic pressure as blood serum), and then injected five millilitres of this intravenously to a depancreatised dog. Within two hours, the animal's blood sugar concentration had decreased considerably.

The experiment was repeated several times, and different treatments of foetal calf pancreas were also trialled. These organs had the advantage of being readily available from abattoirs (cattle were impregnated prior to slaughter to more rapidly fatten them up), as well as being richer in insulin. By November 1921, Best and Banting had kept a dog alive with insulin extract for 70 days.

However, the extraction process was inefficient, and the product

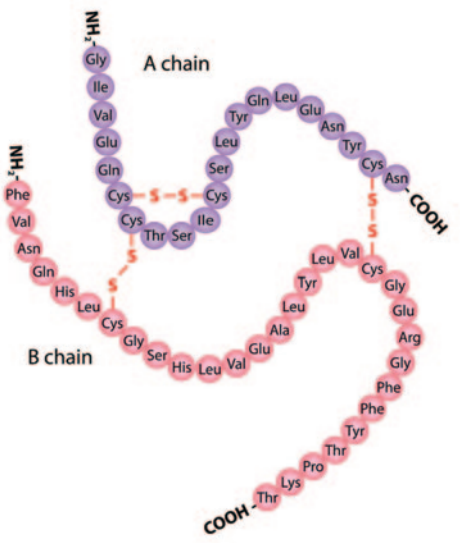
An acquired taste

In 1675, English anatomist and physician Thomas Willis added the term 'mellitus' (Latin for 'honey sweet') after noting the sweet taste of diabetic urine. His *Pharmaceutice rationalis* refers to diabetes as 'the pissing evil'.

It seems that many physicians have noted the same sweetness of taste, the urine's stickiness, and its ability to attract ants. These discoveries raise some interesting questions about early pathology methods.

The high sugar levels in blood serum (hyperglycaemia) of people with diabetes mellitus was identified by English physician Matthew Dobson in 1776 – because of this, he deduced that diabetic urine always contained sugar that was not formed in the kidneys. In the 19th century, Parisian Claude Bernard determined both that the liver played a role in glucose production and that it was an excess of glucose that caused diabetes. His work involved some very clever (but cruel) experiments on dogs that disproved the theoretical role of the lungs in diabetes, and established that the liver synthesises glycogen from glucose and then stores it, thereby contributing to stable blood sugar levels.

An oil painting of Claude Bernard and pupils by Léon Augustin L'Hermitte, 1889.



Insulin consists of two peptide chains: the A chain is 21 amino acids long and the B chain is 30 amino acids long. The two chains are joined by two disulfide bonds.
Alila07/Dreamstime

Walden ... discovered that pH is much more important to insulin solubility than alcohol concentration.

impure. Chemist James Collip was brought onto the team in December to produce a more practical insulin-extraction process. He based his method on alcohol purification. By placing mashed (pig) pancreas in contact with alcohol, insulin would stay dissolved up to a critical concentration of alcohol, then would suddenly precipitate. The recovered precipitate represented a more purified form of insulin.

In 1922, on 11 January, the team trialled their insulin extract on a critically ill child – 14-year-old Leonard Thompson. Within 24 hours, his dangerously high blood sugar level had dropped, but he developed a severe abscess at the injection site. Collip worked furiously to further improve the purification process.

On 23 January, Thompson was given a second dose. His blood glucose dropped from 520 to 120 mg/dL in 24 hours and urinary ketones disappeared. History had been made. Thompson continued his treatment without obvious side-effects, and survived another 13 years before dying of pneumonia in 1935.

On 25 January, Banting, Best, Collip and Macleod signed a memorandum agreeing not to take any action to inhibit the manufacture of insulin on a large scale, to seek neither a patent nor a commercial collaboration. They jointly prepared a paper to the Association of American Physicians, delivered by Macleod on 3 May, and news spread like wildfire.

But disaster struck just weeks later. Collip was unable to produce mass quantities of insulin. Following the same recipe as the lab, his larger batches lacked the active ingredient.

Macleod brought on Eli Lilly and Company, a manufacturer of medicinal capsules out of Indiana. The problem of purification was passed to 27-year-old chemist George Walden. He immediately thought of the work of Danish chemist Søren Sørensen a decade earlier. Based on that work, he discovered that pH is much more important to insulin solubility than alcohol concentration.

By August 1922, Eli Lilly was ready to commence shipments of insulin to the newly established diabetes clinic at Toronto General Hospital.

Half a world away at the University of Adelaide, physiologist and biochemist Thorburn Brailsford Robertson received the details of the manufacturing process from Macleod. Experimenting with this, Robertson determined that the digestive juices of newly slaughtered animals destroyed

The 1, 2, 3 of diabetes mellitus

People with type 1 diabetes constitute about 10% of the population with diabetes mellitus. When Galen described the condition in the second century BCE, he stated that he had seen only two cases in his entire life. Type 1 diabetes is an auto-immune condition generally triggered by a viral infection such as rubella, mumps or rotavirus. If the virus and the body's insulin-secreting cells have some antigens in common, antibodies produced to attack the virus also begin to kill insulin-secreting cells. This type of diabetes develops suddenly and irreversibly, and if not diagnosed and treated quickly can be fatal.

Type 2 diabetes constitutes 85% of all cases of diabetes mellitus, and its prevalence continues to grow. This form of diabetes develops as cells lose the ability to effectively use insulin. The beta cells continue to produce insulin, but as the cellular resistance increases, the insulin production eventually becomes insufficient. Overeating stresses the membranous network in cells called the endoplasmic reticulum. Excessive nutrients cause the cell to close or dampen insulin receptors on the cell surface – the cell is 'full'. Physical activity can overcome this by using up the nutrients in the cells, opening the insulin 'gates' to allow more glucose in.

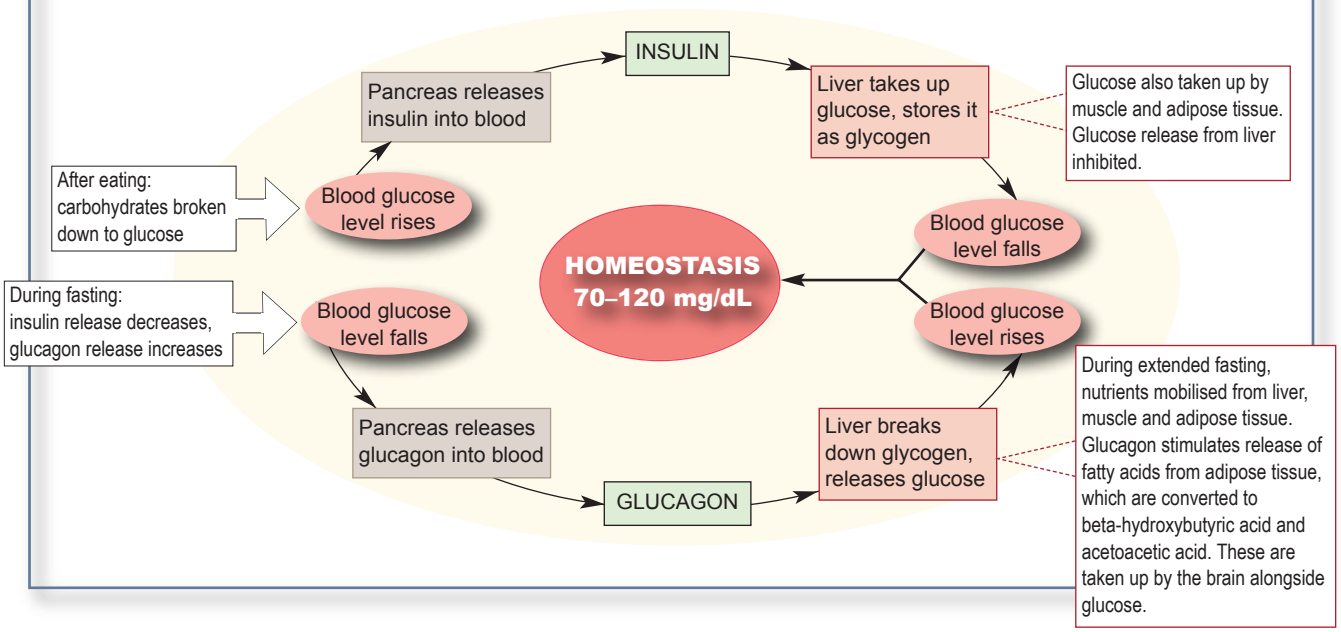
Type 3 or gestational diabetes is a temporary condition experienced as a complication of pregnancy. Blood glucose values rise above normal, but below the levels that are diagnostic for diabetes. Hormones produced by the placenta cause insulin resistance, but most women can produce enough insulin to overcome this resistance. It can be treated in the short term, but does leave women vulnerable to higher risk of developing type 2 diabetes later in life.

For information about diabetes symptoms, treatment and the latest research, visit www.diabetesaustralia.com.au.

Seeking the sweet spot

Two pancreatic products – insulin and glucagon – play a key role in glucose homeostasis, and in regulating energy storage. The pancreas also produces water, bicarbonate and digestive enzymes.

Within the pancreas are approximately one million clusters of cells called the islets of Langerhans, collectively weighing about a gram. About 75% of the cells in the centre of each cluster produce insulin, while peripheral cells secrete glucagon, somatostatin and pancreatic polypeptide. Each islet is supplied by one or two tiny arterioles that branch into many capillaries, as well as many (mostly autonomic) nerve endings that monitor and control function. Islet function can be initiated by autonomic nerve signals, by circulating metabolites such as glucose, amino acids and ketones, and by various hormones.



most of the insulin before it could be extracted. He developed a variation of the process that was cheaper, faster and higher yielding than procedures used in the rest of the world.

On 7 January 1923, gravely ill nine-year-old Dawson Hanna became the first person to receive the insulin extracted by Robertson. Throughout January, it was all Robertson and his students could do to keep up with her treatment. Working with volunteers at the abattoir and with Mark Mitchell (the Vice Chancellor's son, and the only one among them wealthy enough to own a car), they would race the fresh pancreases from the slaughterhouse to the university. Robertson's students volunteered their time to help improve the process.

This improved when abattoir veterinarian T.A. Burrage suggested snap-freezing the pancreases to preserve the insulin. Over the 18 months that the abattoir was the sole supplier of insulin, the slaughterhouse workers gave up their free time to freeze the trays of pancreases, knowing the hundreds of lives that depended on their effort.

The 1923 Nobel Prize in Physiology or Medicine was awarded jointly to Banting and Macleod 'for the discovery of insulin'. Banting shared his cash prize with Best; Macleod shared his with Collip.

Phyllis May Adams survived to age 81 and was an inspiration to many Australians living with diabetes. She received two Kellion Victory Medals from Diabetes Australia for living with diabetes. Her lifetime was the very fortunate result of a medical breakthrough achieved in astounding timeframes.

By May 1924, death from diabetes was no longer inevitable. A *New York Times* quote sums it up succinctly: 'One by one the implacable enemies of man, the diseases which seek his destruction, are overcome by Science. Diabetes, one of the most dreaded, is the latest to succumb'.

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

The RACI congratulates all of the 2021 RACI National Awards recipients and looks forward to presenting their awards in person at the National Congress next year.

Watch the winners discuss their work and awards at bit.ly/3wNcT5m.

Leadership in the chemical sciences

Leighton Memorial Medal

Awarded in recognition of eminent services to chemistry in Australia in the broadest sense. Commemorates the distinguished career of A.E. Leighton.

Professor Michelle Coote, Research School of Chemistry, Australian National University

I am most proud of proposing the Rita Cornforth and Margaret Sheil awards – taking them from a half-baked idea in my Laureate grant to formulating their selection criteria, pitching them to the equity committee, and now seeing them actually awarded to Australia's best female chemists. … In science I am most proud of my work on using electric fields to catalyse chemical reactions, and I would like to acknowledge and thank my research group past and present, and my collaborators, who have all played a massive role in this work.

Margaret Sheil Leadership Award

The Margaret Sheil Leadership Award recognises an outstanding female leader working in the chemical sciences.

Professor Kate Joliffe, University of Sydney

I've been heavily involved in the Women in Supramolecular Chemistry Group that works to try and increase diversity and make a community of supramolecular chemists so that everybody feels comfortable being part of that community. … I've taken time to adopt leadership positions in the hope that it will inspire others to do the same …

Fensham Medal for Outstanding Contribution to Chemical Education

Recognising outstanding contributions to the teaching of chemistry and science in general over an extended period, the Fensham Medal is the most senior award for education in the RACI.

Professor Gwen Lawrie, Teaching Focused Academic, University of Queensland

I believe that teachers, while they work in isolation in the classroom, need the support of communities of practice, and I've been fortunate to work with colleagues across Australia in developing those networks. Some of the initiatives that we've had, which were recognised through this award, include finding out what makes excellent chemistry teachers in universities and also developing resources for students that are shared through a website …

Leadership in the chemical sciences

Citations Award

There are a considerable number of chemists – members of the RACI – who make substantial contributions to chemistry, and, especially to the progress of the profession over a period of many years.

Associate Professor Amir Karton, Head of Computational Chemistry Group, University of Western Australia

In my lab, we develop quantum mechanical methods for highly accurate calculations of chemical properties. We use these methods to design new molecules and materials with desired properties. … We have over 50 very successful [computational chemistry] groups around the country. … It's an amazing feeling to be part of this very strong and supportive scientific community …

Distinguished Fellowship

A distinguished fellowship is the recognition of highly distinguished contributions to the profession in academia, government or industry and the RACI.

The 2021 recipients are Professor Stephen Pyne, Dr Richard Thwaites, Dr David Edmonds, Dr Pieter Scheelings and Professor Dave Winkler.

The Distinguished Fellows will feature in the March–May 2022 issue.

Applied Research Award

The Applied Research Award is given to a member of the RACI who has contributed significantly towards the development of, or innovation through, applied research, or in industrial fields.

Scientia Professor Justin Gooding, University of New South Wales

We develop a lot of sensing devices but what we really do is make surfaces that interact with biological systems in really well-defined ways … My research team are very enthusiastic about entrepreneurship and they've started up multiple start-up companies themselves. So I think they're the reason the award was given to me.

Weickhardt Medal for Distinguished Contribution to Economic Advancement

This award shall be made every year to a full member (MRACI and above) of the RACI who, in the opinion of the judging committee has contributed significantly towards the economic advancement of the Australian economy through work in the chemistry area.

Professor Anthony Weiss, McCaughey Chair in Biochemistry, University of Sydney

The award … recognises … the ability of the lab to be able to commercialise technology. … I've been listed as an inventor on over 160 awarded patents in 21 different patent families across the globe. I established a company called Elastogen in 2008, which was sold successfully in 2018 in one of the largest health transactions ever in Aussie history. … This has been quite a journey, a very invigorating journey and I'm absolutely thrilled to be able to receive this award and I deeply thank RACI for the privilege.

Achievements in research and innovation

(See p. 27 for the winner of the Applied Research Award, and p. 29 for the winners of the Cornforth Medal and the Rennie Memorial Medal.)

H.G. Smith Memorial Award

Recognises contribution to the development of some branch of chemical science.

Professor Spencer Williams, School of Chemistry and Bio 21 Institute, University of Melbourne

We invented a series of antifibrotic drugs that led to formation of three start-up companies: Fibrotech Therapeutics, OccuRx and Certa. The drugs have now successfully passed human phase I safety studies and have entered phase II efficacy studies. Our vision is that these drugs could one day provide hope to sufferers of type 1 diabetes. This award is a huge honour that reflects the tireless contributions of my co-workers as well as the generous and sustained interest of my collaborators.

Excellence in the education sector

(See p. 26 for the winner of the Fensham Medal for Outstanding Contribution to Chemical Education.)

Centenary of Federation Teaching Award in Chemistry

The RACI offers a series of annual awards for the recognition and reward of outstanding excellence in the teaching of chemistry in Australia at both primary and secondary school levels.

Lesli Findlay, Head of Science, Covenant Christian School

Even students who might struggle in day-to-day science learning – when they are given the opportunity to do their own research project and complete that, they can reach an incredibly high standard when they're really interested and enthusiastic themselves.

RACI Chemistry Educator of the Year Award

This award is designed to encourage developing teachers, and is open to tutors, lecturers and senior lecturers (academic levels A, B and C) teaching in undergraduate or postgraduate university courses.

Dr Reyne Pullen, Education Focused Lecturer, School of Chemistry, University of Sydney

[In my classroom, I look] to create an environment where students feel safe. So they feel safe to take risks, they feel safe to ask questions and they feel safe to engage in an active way … having an online space, a community they can speak with and once again feeling safe enough to reach out … is really central to my own teaching philosophy. … For me this [award] is really the first step and it motivates me to continue improving my own teaching, but it also gives me confidence to kind of say, 'I've done a good job'.

Women in chemistry

(See p. 26 for the winner of the Margaret Sheil Leadership Award.)

Rita Cornforth Lectureship

The award is offered to an outstanding female early-career chemist for an opportunity to gain broader recognition of their career achievements to date.

Dr Becky Fuller,
Senior Lecturer,
University of Tasmania

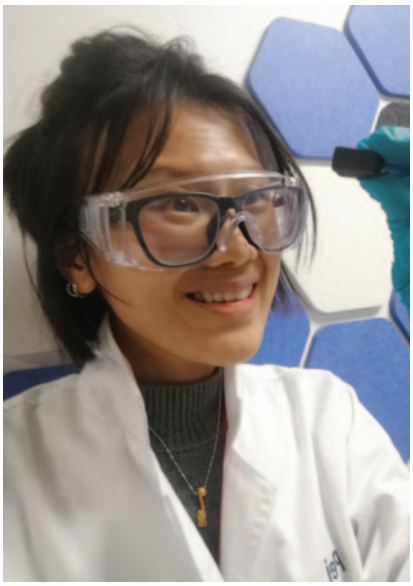
I work on a really diverse set of materials, including coordination complexes, magnetic nanoparticles and stable organic radicals, and they have a really broad range of applications, from contrast agents to molecular magnets and catalysts. … The long timeframe for me to get to this point because of my family commitments means I often forget I'm still … at the start of my career, so this award not only recognises my achievements but also my persistence and I think it really highlights that the Australian chemistry community is progressive in recognising non-traditional career paths.

Chemistry students and early career chemists

(See box this page for the winner of the Rita Cornforth Lectureship.)

Cornforth Medal

The medal, bearing the words 'For a Thesis on Chemical Research', is designed to give recognition of outstanding achievement in chemistry and to promote chemical communication.



Dr Pei Lay Yap,
PhD student,
University of Adelaide

My PhD thesis consolidates the development of multifunctional graphene-based composites based on hydrothermal, chemical reduction, thermal and photoinitiated thiol-ene click approaches. This work integrates the fundamental understanding and application of knowledge on their surface properties to address the most concerning water pollution challenges. This award … inspires me to keep pursuing my research dreams, despite all the hardship and challenges, to fulfil my passion for science.

Rennie Memorial Medal

Recognises excellence in research in chemical science.

Dr Markus Müllner,
ARC Future Fellow,
University of Sydney

Since joining the Australian chemistry community, I have driven the synthesis and application of polymer architectures. Our use of bottlebrush-like macromolecules in the area of self-assembly, but also as functional materials for biological studies, have helped improve or advance our fundamental understanding of this material class … Having the award go to a polymer chemist is great because it allows me also to highlight … the polymer research that has been carried out around Australia.

Chemistry students and early career chemists

Masson Memorial Award

Established as a memorial to the late Sir David Orme Masson, founder of the RACI, this award is open to RACI members who are eligible to proceed for a year's study of Chemistry at BSc Honours level.

Bethany Yee, Bachelor of Science, University of New South Wales

… because of coronavirus, I've done two-thirds of my degree online, which has been quite disheartening – not being able to get into the labs and do the fun stuff … this [award] has just encouraged me and made me want to pursue chemistry even more.

Edward Moore, Honours student, University of Tasmania

My research project for my Honours is in metal–organic frameworks and specifically in ZIF-8, and seeing if we can encapsulate dyes into the ZIF-8 crystals as a means of understanding this ability of ZIF-8 in different media … [Winning this award] gives me strength and understanding that I can continue to pursue this higher education and further knowledge in chemistry while being supported by the national academic body for chemistry.

2021 Titration Competition results

North Sydney Boys High School achieved a wonderful result in this year's **RACI Titration Competition**, with teams finishing first and fifth.

'The boys put so much effort in', explained science teacher Laura Sacchetta, who coordinated the RACI Titration Competition at the school. 'When I opened up my emails and saw that we had come first and fifth in the country, I cried. I couldn't believe it.'

This achievement was even more notable because the school had to navigate the added complexity of COVID restrictions. 'The fact that we got eight groups going to the state finals and then we had teams finish first and fifth in the nationals, it was just nice to see all their hard work and effort pay off,' said Laura. 'We started training for the state competition at the beginning of term 2, which meant they would come in mornings and afternoons, where they just practised and practised. Our fantastic lab assistant also played a big part, providing lots of tips and hints, which really helped.'

The **RACI Titration Teacher Challenge** is an opportunity for educators and their scientific technician staff to demonstrate their individual expertise by doing the same analysis as that done by students in the Titration Final. The 2021 winner was Kazuyuki Hosokawa from Beenleigh State High School (Queensland), whose result was spot-on. A total of 42 entries were received, with 24 competitors submitting a result. Of those, seven achieved a result of Excellent standard.

When asked about tips for teachers wanting to participate next year, Kazuyuki's advice was, 'Don't overthink it. It's just looking for that endpoint, so be cautious but don't stress about it.'

RACI congratulates everyone who participated in the competitions.

Elaine Bergmann and **Michelle Jeavons**. To find out more about these and other RACI school events, visit www.raci.org.au/schools.

2021 Prime Minister's science prizes

Professor Edward C. Holmes (University of Sydney) received the $250 000 Prime Minister's Prize for Science for almost 30 years of pioneering research on genome sequencing data, providing invaluable insights into diseases such as HIV, Ebola, SARS and, most recently, COVID 19. Last year, Holmes was the first person to share the COVID-19 virus' genome sequence, which enabled scientists to start vaccine design within days.

The $250 000 Prime Minister's Prize for Innovation was awarded to Professor Anthony Weiss AM, FRACI CChem (who also received the RACI's Weickhardt Medal, see p. 27) (University of Sydney) for his research into accelerating and improving the repair of human tissue. In 2008, he founded Elastagen to commercialise his research and inventions.

Other prize winners were Mr Scott Graham, Head of Agriculture at Barker College (New South Wales) (Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools); Mrs Megan Hayes, Mudgeeraba Creek State School (Queensland) (Prime Minister's Prize for Excellence in Science Teaching in Primary Schools); Professor Sherene Loi, Translational Breast Cancer Laboratory, Peter MacCallum Cancer Centre (Frank Fenner Prize for Life Scientist of the Year); Dr Keith Bannister, CSIRO Astronomy and Space Science (Malcolm McIntosh Prize for Physical Scientist of the Year); Associate Professor Michael Bowen, Kinoxis Therapeutics and the University of Sydney's Brain and Mind Centre (Prize for New Innovators)..

The Prime Minister's Prizes for Science are awarded for outstanding achievements in scientific research, research-based innovation and excellence in science, mathematics or technology teaching.

The online presentation of the prizes can be viewed at www.industry.gov.au/pmprizes.

Minister for Science and Technology

Vale Peter Fensham AM (1927–2021)

A driving force in science education

Tony Miller/Monash University Archives

Professor Peter Fensham AM, FRACI CChem, passed away on 23 August 2021 at the age of 93. He has been an international driving force in science education. His legacy is indisputable, as evidenced through his diverse scholarly works, leadership roles and innumerable national and international awards. Peter is universally remembered for his endless leadership, collegiality, approachability, positive nature and caring personality.

Having completed his first PhD in Chemistry at Bristol and a second PhD in Social Psychology at Cambridge in the UK, Peter returned to the University of Melbourne to become a reader in physical chemistry where his work on self-diffusion in tin (involving radioactive tin-113) was published in *Nature* in 1949. His ongoing interest in how students learnt chemistry catalysed his appointment as the first Professor in Science Education in Australia at Monash University in 1967. Peter's desire to connect science education researchers and students across Australia resulted in his foundation of the Australasian Science Education Research Association (ASERA) in 1971. This organisation has since grown to become a highly regarded and influential national body whose conferences are structured to sustain Peter's goal of having accessible and affordable meetings that involve positive and constructive environments for students to share their work. Peter's careful mentoring and generous nurturing of science education research students is widely acknowledged as establishing a strong culture in the field. ASERA continues to generate high-impact curricular research outcomes and innovation that has widely influenced classroom practice in Australia and internationally.

Also in 1971, Peter became the first national president of the Australian Science Teachers Association, initiating his lifelong commitment to developing effective science teachers. His passion for promoting students' access to science education is internationally recognised, captured in a book dedicated to his vision (*A vision for science education: responding to Peter Fensham's work*, Routledge, 2004). Peter was deeply and personally invested in social justice, equity and compassion, advocating that scientific knowledge is a source of human empowerment underpinning social responsibility. His seminal essay 'Science for all: a reflective essay' (bit.ly/3DAH9mR) seeded the phrase now synonymous with Peter's drive for curricular reform in science education and providing access to science for all students, not just potential future scientists. Peter continued to work long after his retirement in 1992 – his recent 2020 review of intended, achieved and unachieved values of science education (bit.ly/327ahUL) challenges key stakeholders to act on repeated recommendations for integrating real-world science and technology issues with the application of science knowledge in school science education.

The RACI Fensham Medal for Outstanding Contribution to Chemical Education was established in 2010, it was inspired to celebrate the substantial impact that Peter achieved on chemistry education in Australia. His 1983 Royal Society of Chemistry Nyholm lecture focused on conceptions, misconceptions and alternative frameworks in chemical education. Peter shared his thoughts on teaching and learning chemistry that still underpin contemporary practices in a 2013 interview (bit.ly/3CAN1uM), which provides fascinating insights into Peter's career journey and serves as an inspiration for us all.

Gwen Lawrie FRACI CChem

Vale David Wood AM (1937–2021)
RACI President 2010–2012

Professor David Wood FRACI CChem was an international statesman of the chemical engineering profession, being the first President of the World Chemical Engineering Council. He served as Head of the Department of Chemical Engineering at the University of Melbourne from 1982 to 1996 before serving as Dean of the Faculty of Engineering until his retirement from the university in 2002. He was a strong advocate for women to study chemical engineering. David was also an enthusiastic educator who placed the student at the centre of his activities whether he was a lecturer, head of department or dean.

When he completed his PhD at the University of London, David never intended to work at the University of Melbourne. He applied to work for a CSIRO division located in the Melbourne suburb of Port Melbourne. Dr Clive Pratt, the division chief, suggested that David work in the fledgling department of chemical engineering at Melbourne for a couple of years before joining CSIRO. When he joined the department, there were just four other academics, no building, and no teaching laboratories.

David was a natural teacher. He developed and taught a subject that was known in the department as Process Engineering. In the subject, students were given vague, poorly defined problems that sought to replicate the types of real-life problems encountered in industry. Some students loved the subject, some hated it, but all agreed that it helped to prepare them better for their roles as engineers. David was also known for the way he inspired students, convincing some who doubted their own abilities that that they could become engineers.

When David was appointed head of department in January 1982, the department was not particularly known for its research accomplishments. By the time he left the role, the department was one of the strongest in the country, being home to the G.K. Williams Centre for Extractive Metallurgy and the Advanced Mineral Products Centre. As Dean, David turned the Faculty of Engineering at Melbourne towards Asia, establishing valuable links with leading institutions across the region. He also established the role of Assistant Dean (Equity and Diversity).

David was chair of the Organising Committee for the Sixth World Congress of Chemical Engineering. Today, it remains the largest chemical engineering-focused conference ever held in Australia. Not only did the conference see the establishment of the World Chemical Engineering Council, but the Melbourne Declaration of Sustainable Development was also proclaimed, a document signed by leaders of many of the world's professional chemical engineering societies.

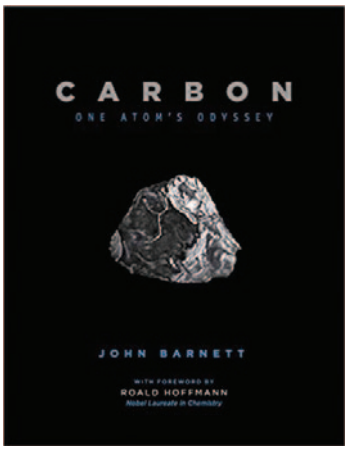
Following his retirement from the university in 2002, David continued to serve the profession, most notably providing guidance and advice to the chemical engineering program at Tianjin University in China. Shortly after this, the program became the first in China to receive IChemE accreditation.

Since joining IChemE in 1959 as a student member, David served in many capacities including as editor of the quarterly *Chemical Engineering in Australia*, Chair of IChemE in Australia and Vice President of IChemE 1995–1997. He also acted as an accreditation assessor across three decades. Between 2010 and 2012, he served as President of the RACI and chaired this magazine's committee. David was the diving force behind the 2017 RACI Centenary Festival.

David was awarded the 2001 Chemeca Medal, IChemE's Arnold Greene Medal in 2001 'for his outstanding service to the profession in Australia, including his Chairmanship of the Board of IChemE in Australia, his Editorship of *Chemical Engineering in Australia* and his inspired leadership of the World Congress group' and the IChemE Council Medal in 2008 'in recognition of sustained and invaluable efforts in China, particularly in relation to Tianjin University'.

David retired to the small community of Tawonga in north-eastern Victoria where he continued to serve, this time his local community including U3A and Probus. David is survived by his wife Elene, his children Michael and Alison and five grandchildren. Our profession is greatly enriched by his work over more than six decades.

David Shallcross (courtesy IChemE)



Carbon: one atom's odyssey

Barnett J., No Starch Press, 2021, hardback, 64 pp., ISBN 9781718501225, $29

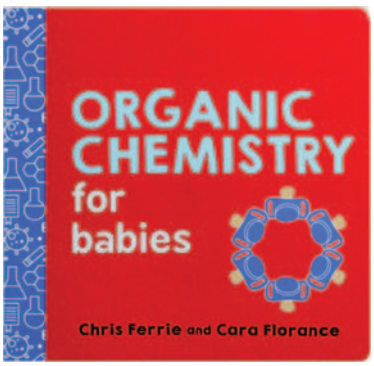
This book could be viewed as a luxury edition of the last story entitled 'Carbon' in Primo Levi's wonderful book *The periodic table*. Levi is one of my favourite authors and *The periodic table* is, in my view, his finest work. Levi's story is re-told by John Barnett with greater brevity, accompanied by large, attractive pencil drawings illustrating the book from beginning to end. Barnett offers the complete work as a tribute to the genius of Levi and has a foreword written by Roald Hoffman, a Nobel Laureate in chemistry. Levi's *The periodic table* was launched in 1975 but was not translated into English until 1984. Barnett's version of the carbon atom's odyssey differs from the original in that it was written almost half a century later, during which time the sciences had advanced greatly. Levi started his story with the carbon atom existing for 'hundreds of millions of years' as limestone and did not consider its 'very long cosmic history'. Barnett's version starts the carbon atom's odyssey 500 million years after the Big Bang, which occurred 13.8 billion years ago; he devotes 10 pages of pictures and text to explain the carbon atom's journey in becoming a part of a limestone cliff. Barnett also provides structural formulas throughout the book to indicate the chemical changes taking place, which will please chemists.

Now these two accounts resume with a similar story line: the carbon atom obtained its release from its captivity within limestone to its freedom as gaseous carbon dioxide through human intervention. Both accounts then continue the carbon atom's story as a series of transformations between carbon dioxide and living creatures, largely by following photosynthesis and decay. It is interesting to note Levi observed that carbon dioxide made up 0.03% of the atmosphere whereas today the figure has become 0.04%. Barnett does not comment upon this difference, the cause of the current concern about global warming. Levi mentioned that industry is 'still finding (but for how many more decades?) gigantic reserves of carbon' as coal and petroleum, which typified the 1970's disquiet about future petroleum supplies. Carbon dioxide in both essays appears benign and in balance rather than as a dangerous source of climate instability. Barnett follows most of the twists and turns mentioned in Levi's original work, but sometimes with subtle updates. For example, Levi mentioned the cedars of Lebanon; Barnett refers to the the cedars of Bsharri, Lebanon, as today this is the last place in which the cedars (*Cedrus libani*) still survive. Barnett also changes the journey of the carbon atom, preferring the entry of the carbon atom to his brain to be via a cyclamen's nectar, a bee and honey in a cup of Earl Grey tea rather than through a glass of milk, though Levi acknowledged there was 'an endless number of stories about carbon atoms'.

Both Levi's essay on 'carbon' and John Barnett's wonderfully illustrated book honouring Levi's achievement make thought-provoking reading. During the writing of this review, I found a way to obtain pleasure from the essay and the book simultaneously. There is a soundbite of Levi's essay read by Gerard McDermott on YouTube (bit.ly/304nkVW); listening to this while looking at the artwork of *Carbon: one atom's odyssey* enabled me to get the best of all possible worlds.

Bill Palmer FRACI CChem

Organic chemistry for babies



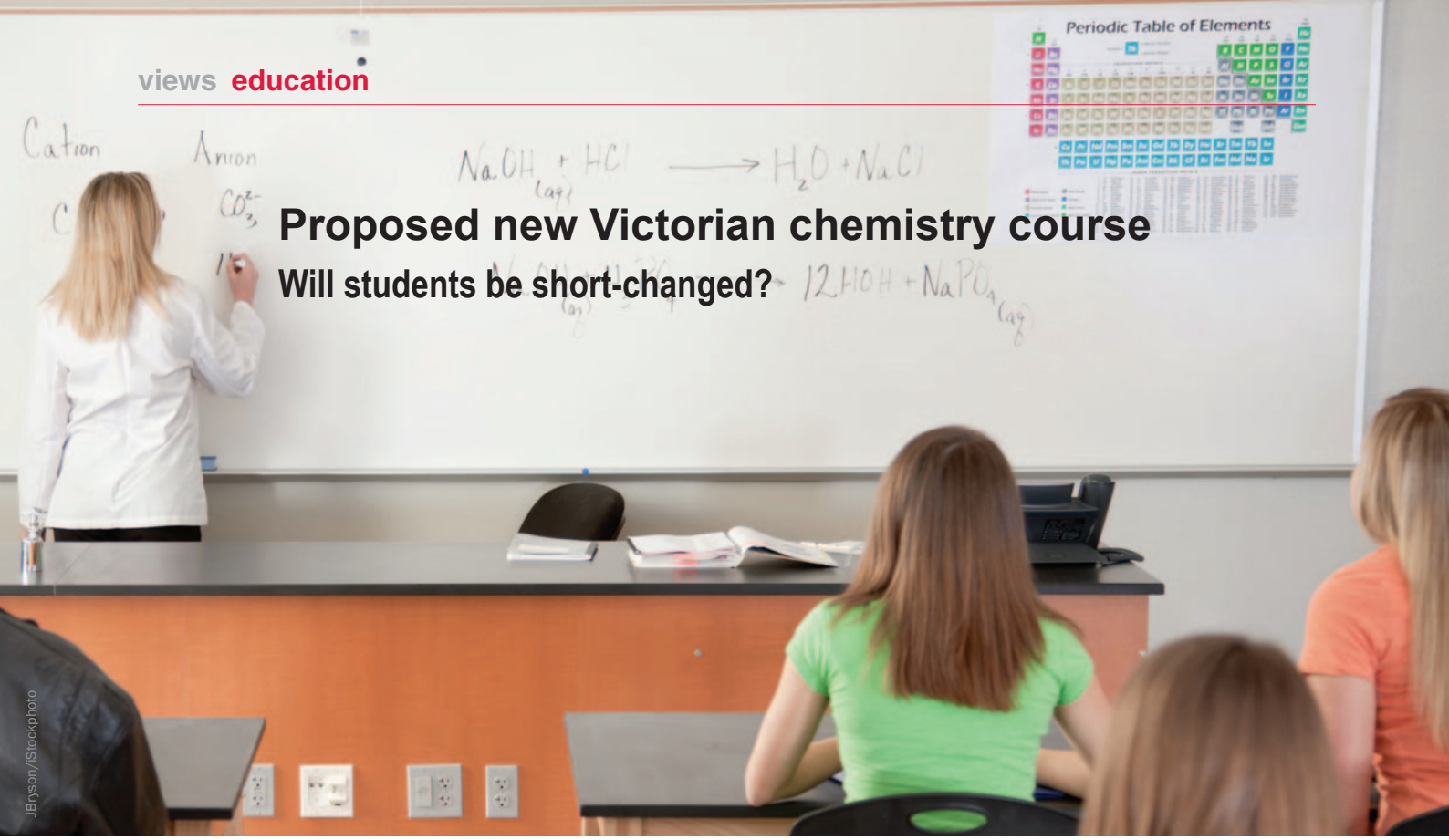
Ferrie C., Florance C., Sourcebooks Jabberwocky, 2018, board book, 24 pp., ISBN 9781492673781, $18

Chris Ferrie believes 'it is never too early to introduce small children to big ideas!' His co-author, Cara Florance, writes books 'to make science fun and approachable to families everywhere'. Ferrie is a physicist and senior lecturer for Quantum Software and Information with a PhD in applied mathematics. Florance is a biochemist who has a PhD in biochemistry with work experience in astrobiology and radiation decontamination. Both authors separately and together have written many science-based books for babies on topics such as evolution, quantum physics, general relativity, nuclear physics and enzymes.

Organic chemistry for babies and other books in the series are nicely produced to a standard pattern 20 centimetres square with 24 pages (12 cardboard boards) and 1.5 centimetres thick. They are said to be suitable for young ones up to three years old. They seem to play on the psychology of the parent as the following claims are made: 'Simple explanations of complex ideas for your future *genius*', and, at the end of the text, 'Now you know ORGANIC CHEMISTRY!'

In most organic chemistry books, the carbon atom is depicted as a black ball, but in *Organic chemistry for babies*, the carbon atom is represented by a red ball, which seemed a little odd. I did not notice any factual errors. The book is comparatively expensive but optimistic parents who happen to be chemists may see it as a worthwhile investment!

Bill Palmer FRACI CChem



JBryson/iStockphoto

Proposed new Victorian chemistry course

Will students be short-changed?

Immediately after the draft Victorian Certificate of Education (VCE) Chemistry Study Design was released for review, *The Age* featured an article headed 'Periodic chart off the table in chemistry shift' (14 July 2021, pp. 1–3). Never before have I seen such an outcry against a new proposed chemistry course. In the aftermath of that article, a number of practising and retired chemists and educators contacted me to express their shock and concern.

In fact, the newspaper's claim that the periodic table is to be removed from VCE Chemistry is not quite true. Some mention of it does remain in the Year 11 course, though some of the little there is only in an optional extension topic.

The official justification for the decision to reduce the study of the periodic table to just that and to transfer the rest to Year 10 Science, was that many teachers are saying that the current course is 'over-packed'.

It is most concerning that VCE Chemistry is allocated almost 20% less formal classroom time than interstate courses and the International Baccalaureate, which several Victorian schools offer in place of VCE. This time deficit certainly needs to be addressed, but taking away a rigorous study of the periodic table, the very cornerstone of chemistry, is not the way to do it!

The periodic table is central to building a real understanding and appreciation of chemistry. It is unique. No other science has a single organised table that tells us so much, can be used as a predictive tool, and is a shining example of how scientific knowledge is built over centuries of painstaking experimentation and collaboration. This is why it is a key feature of the International Baccalaureate course.

The bulk of the study of the periodic table should *not* be relegated to Year 10 Science because:

- it underpins much of the understanding, patterns and relationships within so many areas of senior Chemistry, such as the relative reactivities and other properties of the elements and their compounds, chemical formulas, structure and bonding, bond polarities and molecular shape. Without it, meaningful connections will be lost and their study will become superficial
- it enables students to 'develop insights into how knowledge in chemistry has changed and continues to change', a stated aim of the Study Design. There are so many wonderful stories behind the periodic table, including the discoveries and understandings that have arisen out of it
- in some Victorian schools, Year 10 Science is an elective subject. This is not the case in the other states. Students who do not choose Science in Year 10 but then decide to study Chemistry in Year 11 in Victoria or interstate will be at a considerable disadvantage.
- most Year 10 Science teachers have an insufficient or no background in chemistry (yet another issue that needs to be addressed). Their lack of training makes them ill equipped to competently teach the periodic table. This would most likely to lead to confusion and misconceptions, and could lead to students becoming disengaged
- some Year 10 Science teachers, even those with suitable qualifications, are likely to avoid teaching the periodic table altogether, on the grounds it is 'not really needed' in VCE Chemistry.

The new overarching theme of all four units is the contemporary issue of making chemical manufacturing and energy production more sustainable by moving towards a circular economy and adopting a green chemistry approach.

However, even though many aspects of it are excellent, this is not my only concern about this proposed Study Design.

The new overarching theme of all four units is the contemporary issue of making chemical manufacturing and energy production more sustainable by moving towards a circular economy and adopting a green chemistry approach. Although this is an important issue, and a means of fostering ethical values, my concerns with this are:

- this 'overkill' is very likely to disengage students before the end of their first year
- the over-emphasis is misguided, because students need a greater in-depth understanding of chemistry and access to a large amount of data before they can critically analyse processes used in chemical manufacturing and waste management. In fact, experts in this field have pointed out that a circular economy approach is not always the most sustainable
- most VCE Chemistry teachers will have little background in this area
- excessive focus on this one issue implies that it is the only important chemical issue facing humanity. Air pollution, water pollution, global warming and ocean acidification are also vitally important chemical issues.

The time spent on this theme denies students opportunities to gain a more balanced overview of chemical principles and processes. Not only the periodic table, but also many other important areas of chemistry have been given inadequate consideration.

For example, volumetric analysis has been deferred to almost the end of Unit 4. In the current Study Design, it is introduced in the middle of Unit 2. If adopted, this proposal may make Victorian Chemistry teachers reluctant to enter their students in the RACI Titration Competition. Pre-COVID, the RACI Victorian Branch usually had more than 400 teams – that is, more than 1200 students, mostly from Year 11 – enthusiastically competing in its annual state titration competition. Over the years, this fun competition has helped motivate and excite thousands of students about chemistry.

That aside, this decision makes no sense. Acid–base titrations, still performed in many commercial and industrial settings, are a perfect vehicle for building science investigation skills, such as taking accurate measurements and identifying errors, uncertainties and outliers, as well as building and consolidating student understanding of acid–base reactions, pH and stoichiometric calculations. Since acids and bases and gravimetric analysis are introduced in Unit 2, why not use this opportunity to introduce acid–base titrations?

Instead, the proposed Study Design places thermochemical equations and calorimetry in Unit 2. These have been traditionally studied in Unit 3 or Unit 4 together with the study of fuels. This works well because older students can manage the greater demands of these topics. The decision to put this in the middle of just introducing concepts such as concentration and stoichiometry does not allow students to 'crawl before they walk', a fundamental pedagogical principle. I suspect it will frighten many students off, especially when so many of them are without strong mathematical backgrounds.

Finally, a lack of balance is also seen in other topic areas. There is excessive emphasis on plastics and fuels, insufficient quantitative work in Units 3 and 4, insufficient biochemistry and too few relevant practical investigations that can safely be used to build scientific skills and understanding. There are so many other fascinating areas that would enrich the course and lend themselves to worthwhile practical work, such as transition metals, corrosion, polysilicates and nanoparticles, and analytical techniques such as chromatography, GC and HPLC.

In summary, the new proposed VCE Chemistry Study Design will short-change students in a number of ways. It needs considerably more work if it is to foster a true appreciation and mastery of chemistry and enable students to compete successfully in the international STEM community.

Jenny Sharwood OAM, MACE, FAIE, FRACI CChem is a chemistry education consultant and writer. She is a member of the RACI Victorian Branch Committee, Secretary of the RACI Victorian Chemical Education Committee and a member of the Victorian Branch Titration Competition Working Group. She was made an RACI Distinguished Fellow in 2020 and 2019 Chemistry Educator of the Year by the Chemistry Education Association.

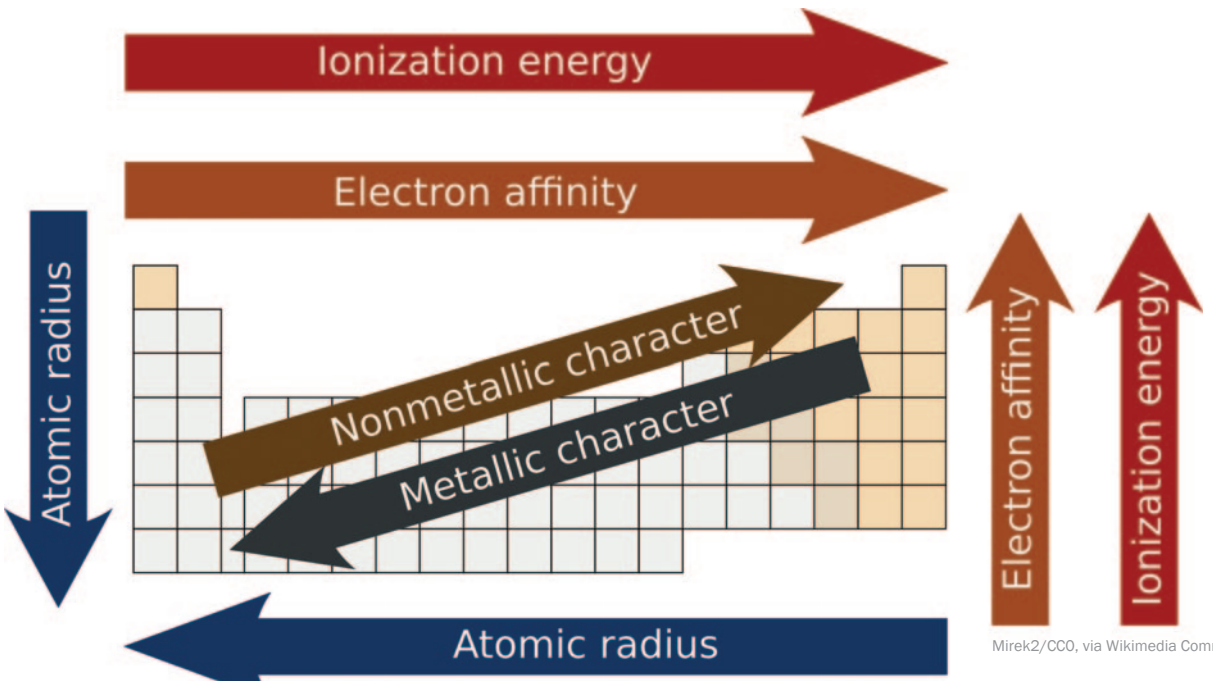
Continuous assessment of the periodic table – a tertiary perspective

A recent article in *The Age* (bit.ly/3mSG6Zz) on the proposed changes to the VCE Chemistry Study Design has sparked some heated debates within the science education community. While the new Study Design has proposed a streamlined approach and reframing of the theme, as it were, the article focused on the removal of content relating to atomic structure and the periodic table itself as an assessable item. Here we offer our perspectives on this controversy as educators with both secondary and tertiary experience.

The periodic table has long been one of the most identifiable features of chemistry as a physical science. Few science classrooms are without some form of the periodic table displayed on a wall and every chemistry textbook contains one. For good reason, too. Since the wide acceptance of Dmitri Mendeleev's proposed scaffolding in the late 1800s, the periodic table has become an integral tool in chemistry education from secondary (and even primary) school to career chemists, both theoretical and practical. While at first glance the usefulness of the periodic table might appear to be simply as an organised list of elements for memorisation, the depth of information held within is expansive: from details of atomic structure to periodic trends in properties and behaviour. Importantly, this serves a purpose from the outset of introducing chemistry as a discipline in secondary school through to high-level chemistry subtleties at the end of a graduate degree.

Reflecting on our own use of the periodic table in tertiary education across three Australian universities, we typically include it as one of the first features covered in first-year chemistry courses. Indeed, we often dedicate an entire week to periodicity and its consequences on every aspect of life. We try to instil an appreciation of its usefulness, that it is not something that exists just to be memorised and regurgitated verbatim – it is a valuable tool for helping students understand many chemistry concepts. This approach also provides a familiar visual representation for easing the student transition into university studies, and allows us as educators to establish the baseline understanding of the approach to learning we expect, irrespective of individual courses and program pathways. As students move into more advanced topics, the periodic table acts as a constant reference point for them to ground topics such as bonding, chemical and physical properties, stability and reactivity.

The proposal to shift the periodic table to non-assessed, assumed knowledge is an interesting one – and its success will depend on how the periodic table continues to be integrated into the secondary Chemistry syllabus. What we know from cognitive load theory is that novice learners, those who do not have specific knowledge about a topic, learn better with direct instruction; for example, through worked examples. Using the periodic table as a tool in solving chemistry problems is essential, and thus almost all scaffolded problem-solving activities for novice chemistry students will need to include steps that apply the information garnered from interpreting the periodic table. Using the periodic table to obtain information is therefore a sub-goal within broader learning outcomes, such as identifying the molecular mass of a compound, predicting bond



Mirek2/CC0, via Wikimedia Commons

type or determining molecule polarity. This means that knowledge of the periodic table and how it is used will need to be explicitly taught in earlier year levels and indirectly assessed in the context of these wider learning outcomes.

A potential danger of redesignating the periodic table from a specific assessment item to assumed knowledge is that a large portion of our student cohorts conflate what is assessed with what they need to know, therefore potentially attributing decreased importance to concepts designated as assumed knowledge. It is therefore imperative that VCE Chemistry teachers are supported to develop appropriately scaffolded activities that incorporate the skills associated with using the periodic table as part of more complex problem-solving. Another pitfall, related to supporting VCE Chemistry teachers with this new study design, is the prevalence of out-of-field teachers within Australian schools. Depending on their experience and the support they receive, these teachers may not have the pedagogical content knowledge to continuously draw links between assessable VCE concepts and key assumed knowledge such as the periodic table.

However, these challenges really belong to a bigger discussion on how we view assessment in general. Do we need to assess all content at a granular level? Or are we satisfied with having key content, such as the periodic table, assessed implicitly through more complex problems? The purpose of assessment is arguably twofold: as an opportunity to evaluate where a student is located on their learning journey to help the student reflect on their progress; and as a means to summatively evidence learning outcomes. If assessments are framed as opportunities for a student to demonstrate their knowledge and skills, then, yes, using the periodic table is a skill that should be assessed. If the intention is to simply obtain a numerical measure of a student's understanding, then, no, it is not essential that the use of the periodic table be evidenced as an isolated item because this can be demonstrated through the context of broader learning outcomes.

A potential danger of redesignating the periodic table from a specific assessment item to assumed knowledge is that a large portion of our student cohorts conflate what is assessed with what they need to know ...

The proposed new study design has some strengths. First, reducing the volume of material in the Chemistry curriculum should be seen as positive – Chemistry curricula Australia-wide have suffered from attempts to include more contemporary material, while maintaining the historical content (although valid concerns exist when contrasting the Australian curriculum to its equivalent in the UK). Second, the proposed changes as a whole allow for a streamlined and more modern reflection of chemistry and how it fits within society's current global challenges. Finally, part of the proposed changes aligns with a systems thinking philosophy, an important change that combats the siloing of chemistry concepts and embraces chemistry as a whole and its interdisciplinarity with other fields. Hopefully, all of this will excite and motivate both students and VCE teachers to the wonders of studying chemistry. Thinking of our own practice, we would like to see a topic such as organic molecule nomenclature receiving similar treatment – food for thought for the chemistry community!

A useful graphical summary has been put together by Reddit user kanga_r00 for any readers who may not have the time to wade through the extensive proposed changes (bit.ly/3CVJk46).

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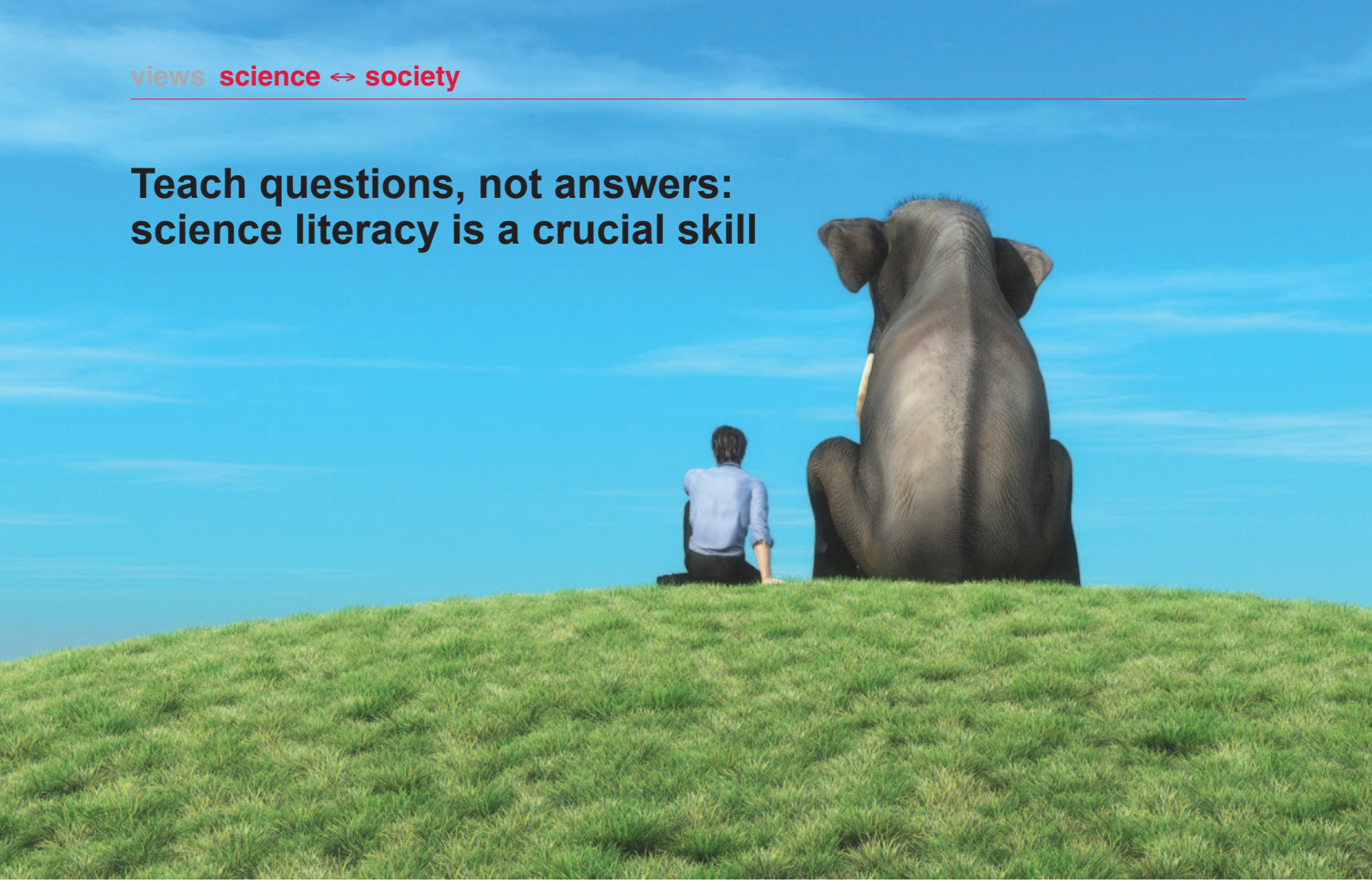
Teach questions, not answers: science literacy is a crucial skill



To get someone to change their beliefs, we need to get to the elephant. Orla/iStockphoto

It seems today the mistrust of official health advice and spread of 'alternative' treatments for COVID-19 are as frightening as the virus itself. How is it that so many people are ill-informed (and seemingly choose to be so) about the pandemic, despite decades of compulsory science education?

Of course we are entering a post-truth era in which fake news and conspiracy theories proliferate, while many have contempt for scientific facts.

But a deeper problem lies in the way we teach science. Our curriculum and instruction are still driven by content mastery and high-stakes testing, which has alienated many young people from scientific ideas.

Students are taught isolated and impersonal facts without understanding the history and processes of how scientists know what we know – an education in scientific literacy.

The Australian Curriculum defines scientific literacy as:

> *An ability to use scientific knowledge, understanding, and inquiry skills to identify questions, acquire new knowledge, explain science phenomena […] and draw evidence-based conclusions in making sense of the world, and to recognise how understandings of […] science help us make responsible decisions and shape our interpretations of information.*

While laudable as an educational goal, scientific literacy is seldom emphasised in practice. We need to do more to promote it in primary and secondary schools.

Why facts aren't enough

The problem with people's mistrust of science has little to do with their actual intelligence or overall education. After all, some educated people still believe the Earth is flat, and climate change is contentious.

Getting someone to accept a new idea goes beyond the brain to a broader consideration of the person's social, cultural and emotional factors.

American social psychologist Jonathan Haidt used a rider and elephant analogy to explain why we are resistant to new ideas and beliefs. The rider is the rational side of our mind while the elephant is the unconscious and emotional side. To change a person's view, it is useless to focus on the rider without addressing the elephant.

Science is full of strange ideas that are sometimes at odds with common sense, such as matter being made of moving atoms, or time being relative. Teaching these ideas as facts is like targeting the rider.

Many educational theorists have long argued the idea knowledge could somehow be 'transferred' from teachers and textbooks to students is untenable. The students will still interpret the taught content through a conceptual framework of prior knowledge and beliefs.

Years of research in science education has found teaching facts alone is an ineffective strategy when trying to change a person's ingrained misconceptions or 'alternative theories'.

A new approach to teaching scientific literacy

Scientific theories are built on evidence through the process of argumentation. Every fact and theory taught in the curriculum should be questioned and tested with evidence. Students should ideally observe or collect data for themselves.

There are many practical ways to show the Earth is round that can be done as a classroom activity. For instance, a classroom in Perth can interact online with another classroom in Bali (roughly the same longitude) to simultaneously measure the shadow from a metre stick and use the result to calculate the Earth's circumference.

Repeatedly asking students to question every fact will instil a lifelong value of critical literacy in science. It is crucial for young people to always evaluate the source of information and discern false claims that are not backed by empirical evidence, such as drinking bleach to treat coronavirus.

Science should also be taught as a dialogue within a community of people. This is the human side of science where ideas are discussed, argued and negotiated in the process of building consensus.

Mirroring this process, students must be given opportunities to practise evidence-based argumentation. Their innate theories about the world should be elicited and compared with accepted scientific theories, so students can see their relative merits and suitability in addressing a particular phenomenon or problem.

Emotions play a large part

Last but not least, emotions play a big part in science learning. Scientific issues that represent social concerns (such as the lockdown) and problems related to science and technology (the 5G network) can evoke a range of emotions among students.

It is important to acknowledge students' emotions as they deal with the moral and ethical issues in these ideas. Controversial issues not only provide an authentic learning context, but are also excellent topics for debate and argumentation.

Some studies have found allowing students to express their emotions during lessons on such social issues in science can enhance their empathy and disposition towards science.

The goal of scientific literacy is not new. But COVID-19 has brought a greater urgency to its importance. Scientific literacy is now no longer an educational aspiration that is good to attain, but a very immediate concern that impacts our survival in a post-truth society.

Many educational theorists have long argued the idea knowledge could somehow be 'transferred' from teachers and textbooks to students is untenable. The students will still interpret the taught content through a conceptual framework of prior knowledge and beliefs.

Kok-Sing Tang is an associate professor at Curtin University, Western Australia.
First published at www.theconversation.com.

Wine sensory analysis

For most of my time associated with the wine industry, I used descriptive sensory analysis in our research on wine and in teaching. Descriptive sensory analysis requires a team of tasters to agree on a set of words (descriptors) that characterise the wine. Complete analysis requires descriptors for appearance, nose and palate.

Many descriptors are specific to wine variety, and it is essential that the tasting panel agree on what the terms mean. This quite often requires experience and training over time to develop skills in identifying terms. It is also possible to set up standards for aroma and taste descriptors to further aid tasting panel training. Tasting needs proper facilities with no external distractions. The optimum is a set of sensory booths with conditions including wall colour, air conditioning and lighting that cannot influence the taster's impression. A detailed description of the requirements, at least in the European context, can be found at bit.ly/3q1XJrN.

Descriptive sensory analysis is time consuming and expensive. It is more common in research laboratories or large corporate wineries. A detailed descriptive sensory analysis is particularly useful when assessing the impact of different viticultural or winemaking practices on the sensory profile of the finished wine. This approach does not always reflect the response of consumers or wine professionals such as sommeliers. It does not reflect cultural differences in wine appreciation, an important issue with changing international markets. This has led to the development of other sensory methodologies, such as Rate-All-That-Apply (RATA) and Pivot® Profile (PP).

The RATA method is based on the CATA (Check-All-That-Apply) procedure, which seeks to engage consumers in a sensory evaluation process that assesses what they like or dislike about a wine style, in essence reversing the top-down procedure of winemakers indicating to consumers what attributes a wine may have. The CATA method can be performed in an open setting or in sensory booths with large numbers of participants. Tasters are provided with a checklist of terms and asked simply to check those that apply.

CATA has its limitations with discriminating products with subtle differences, and this is where RATA comes in. RATA uses a checklist of descriptors, and participants also need to provide a quality rating for each attribute. While traditional sensory analysts were somewhat sceptical about the ability of RATA to differentiate wines, recent comparative studies have pointed to the success of RATA as an accurate and rapid sensory strategy with a clear consumer focus. Lukas Danner and others from the University of Adelaide (*Am. J. Enol. Vitic*. 2018, vol. 69, pp. 12–21) established a methodology for comparing descriptive sensory analysis with RATA. Eleven trained panellists followed the descriptive sensory analysis route while 84 consumers (red wine) and 71 consumers (white wine) used the RATA approach. Multiple-factor analysis demonstrated marked similarities between the methods in discriminating the samples.


Wine Australia

PP is generating considerable interest and excitement. The method is a free descriptive one, whereby panellists compare wines against the pivot wine, but use comparative terms such as 'more astringent' or 'less sweet'. For wine, PP was first applied to Champagne in 2015 (*Food Qual. Prefer.* vol. 42, pp. 66–77) and has recently been used in an assessment of super-premium Shiraz from different Australian wine regions by research staff of the Australian Wine Research Institute (AWRI) and the National Wine and Grape Industry Centre (NWGIC) (*Food Qual. Prefer.* 2020, vol. 83, 103858). Dr Wes Pearson (AWRI) sees one advantage of PP in eliminating the 'subconscious bias of winemakers'. Winemakers often get caught in thinking about why a wine has a particular colour or aroma that tends to create an impression of what the sensory characteristics should be. Wes further argues that the advantage of PP for winemakers and sommeliers is that it 'plays to the strengths' of these wine professionals as they are making comparisons and already have an expansive vocabulary (bit.ly/31sglXJ).

To test the relevance of the PP method, a tasting was carried out with international sommeliers in May 2017 at the Somms of the World event in Sydney (see photo from Wine Australia). A similar event was also held during Vinexpo Hong Kong. The advantage of the comparative PP method was that it allowed the sommeliers to obtain a detailed understanding of the characteristics of Shiraz across Australian wine regions. This in turn benefits the Australian industry because it gives sommeliers and other wine professionals the confidence to explain the wine to their customers.

Considerable success is now being achieved with the PP approach. Choosing the pivot is also a critical issue. Dr John Blackman (NWGIC) has found that in a tasting with more than 100 participants using different pivots, the wines were still separated into the same basic groups. John indicates that the best option is to select a pivot that is fairly central to the wines being studied as this gives a better spread of wines around the pivot. Expect more exciting work to come.

Geoffrey R. Scollary FRACI CChem (scollary45@gmail.com) has been associated with the wine industry in production, teaching and research for the last 40 years. He now continues his wine research and writing at the University of Melbourne and the National Wine and Grape Industry Centre at Charles Sturt University.

Ethene, anyone?


Hôtel Métropole, Geneva

I've been having flashbacks since I discovered a herbicide in which the active ingredient is pelargonic acid – more correctly and clumsily known as nonanoic acid. It took me back to the 1960s when we struggled to fit ourselves and our students into systematic nomenclature for organic compounds. The old names may have lacked system but they had a ring of the history of chemistry that appealed to me and gave hints of where the substances could be found, or at least where they had first been identified.

Of course, systematic names have advantages, but most of us were only prepared to use them when we really had to. Consider some examples of linear aliphatic acids. Nobody ever talked about methanoic acid (formic acid, from the red ant *Formica rufra*) but ethanoic came a bit more easily because of our love for ethanol. I always had trouble with the goat acids – caproic, caprylic and capric – and I had to look them up before I could tell you they were C_6, C_8 and C_{10}. In just a few cases the traditional name morphed into the systematic name without much trouble: butyric acid (*buttersäure* in German, from rancid butter) aka butanoic acid.

I had not realised until I began researching this Letter that the torture of the 1960s had its origins way back in the 19th century, and that an International Chemical Congress was held in Paris in August 1889 to address the problems of nomenclature. The unification of chemical nomenclature was only one of four sections into which the Congress was divided, the others being concerned with the analyses of food, agricultural and pharmaceutical products, but it was nomenclature that dominated the reports of what had gone on in Paris. Many of the names of those taking part – mostly from Europe but there were representatives from Britain – were familiar to me from textbooks and named reactions.

The Congress heard reports of competing and often confusing names for chemical substances, and before heading for the obligatory banquet a group of French nationals that included Berthelot and Friedel was charged with forming an International Commission to 'promote uniformity of chemical nomenclature'. They were empowered to augment their membership, and this they did by adding, among others, Baeyer (Germany) Armstrong (Britain), Beilstein (Russia), Paterno (Italy), Remsen (USA), Bonkowski-Bey (Turkey) and Mourgues (Chili). Sending them on their mission, Friedel especially thanked the foreign members and stressed the importance of 'the use of the same language among chemists of all countries'. He felt sure they would succeed and hoped that they 'would be able to report such serious progress as to justify the summoning of another Congress'.

The members of the Commission worked hard on their task and met in April 1892 at the Hôtel Métropole in Geneva (built in 1854, it's still going – see photo) to complete their report. This was made available to national bodies and published in French-, German- and English-language journals. In *Nature*, Henry Armstrong provided a commentary to go with the French text. It had been agreed that although colloquial names would probably survive, every compound should bear a systematic name of such character that it can easily be translated into the corresponding formula, and vice versa. In order to help people into the new system, the names methane, ethane, propane and butane were to be retained, but for longer chains the Greek prefix, according to the number of carbons, would form the basis of the name. Carboxylic acids, with the carboxyl counted as one of the carbons in the chain, were given the *oique* (*oic* in English) suffix. Many other things we are familiar with, such as side-chain terms like methyl, ethyl and propyl, appeared in this Geneva system. With 46 recommendations, it was widely adopted but I had a chuckle at the example given for the use of the 'ene' ending for hydrocarbons containing a double bond: 'ethene'. However elegant and systematic it might be, ethene has struggled to catch on, but it turns up occasionally in crossword puzzles for which we can probably thank the Macquarie dictionary. I was surprised to find that it was first suggested by A.W. Hofmann, in a note published in the *Proceedings of the Royal Society of London* … in 1866.

Ian D. Rae FRACI CChem (idrae@unimelb.edu.au) is a veteran columnist, having begun his Letters in 1984. When he is not compiling columns, he writes on the history of chemistry and is an editor of *Historical Records of Australian Science*.

events

For further details, visit raci.org.au/events.

PhysChem Summer Festival
29 November – 3 December 2021, online
pcsf2021.org

VCE Chemistry Teachers Professional Development Day
RACI Victorian Chemical Education Committee
30 November 2021, RMIT University city campus, Melbourne, Vic.

IMRET2021 – Virtual Summit
1–2 December 2021

Chemraderie
2 December 2021, webinar

46th Annual Synthesis Symposium
3 December 2021, webinar

46th Annual Organic Synthesis Symposium
With plenary lecturer Professor Laura Anderson, University of Illinois
3 December 2021, online

End of Year Celebration – Careers Development 2021
9 December 2021, webinar

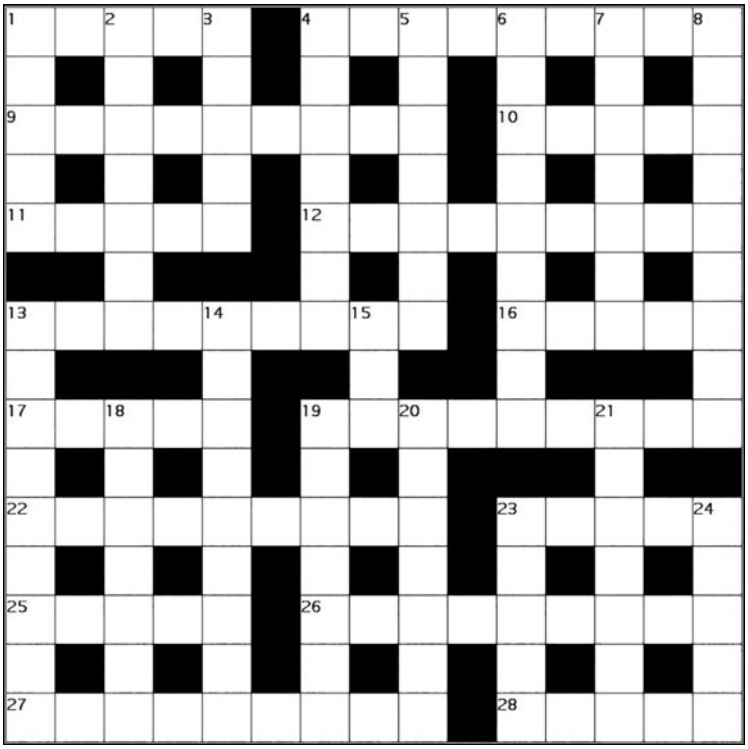
VIC Retirees' Annual Christmas Lunch & HLM Celebration
12 December 2021, Graduate House, University of Melbourne, Vic.

Global Women's Breakfast 2022 – Townsville
16 February 2022, Townsville, Brisbane, Adelaide, Perth

2022 NSW Branch Presidents' Dinner
25 February 2022, Concord, NSW

RACI 2022 National Congress
3–8 July 2022, Brisbane, Qld

cryptic chemistry



Across

1 Labour of love's answer. (5)
4 Battled and stole Spooner deficit. (9)
9 But of course, truly, 13 and 11 react. (9)
10 Graphics language somewhat inappropriate for more formal situations. (5)
11 Investigators in arsenic make important compounds. (5)
12 Growing signal: 21 Down a representative jailbird. (9)
13 Ester mess comes to terms. (9)
16 Passive nitre bomb. (5)
17 Expose oneself to start idyllic nudes cutting up rough. (5)
19 Reaction of atoms is up to making one. (9)
22 Imidazolidine-2,4-dione made into handy product. (9)
23 88 put on 86. (5)
25 Lack of interest in misbegotten nuisance calls. (5)
26 Life forms miss argon product. (9)
27 Three most ruined plastics like Bakelite. (9)
28 Bold 16331639. (5)

Down

1 Presents fellow getting up at first national academy symposium. (5)
2 Limit hydrogen and uranium to making one. (7)
3 They jump money. (5)
4 See 14 Down.
5 Mountain of molybdenum supply with reduced phosphorus. (7)
6 See! It fits around! (Swears.) (9)
7 A 57,9 amino acid. (7)
8 Record a beat sound scale. (9)
13 Gets Th/Li/S compound. Just a very small amount. (9)
14 & 4 Down Celestine filaments rust out badly. (9,7)
15 ρ = 45 + 8. (3)
18 Broke 58 dance rhythm. (7)
19 Parcels of light nosh – top variety. (7)
20 Thing to gather late today. (7)
21 Adds 53. Does I_2S mixture? (7)
23 Gets around cyclohexane and benzene, perhaps. (5)
24 Awful way between 11 and 39. (5)

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