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SCIENCE VICTORIA

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ISSN 2981-8664
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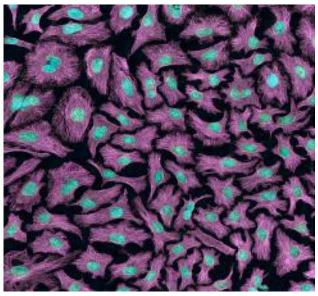
In This Issue

BIOTECHNOLOGY

Biotechnology is the use of science and technology to harness the power of living things for practical purposes. From designing drugs to developing more sustainable farming methods, biotechnology is a cornerstone of modern research.

In this edition, we explore the role of biotechnology in different areas, and how it is offering solutions to some of humanity's biggest challenges.



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Multiphoton fluorescence image of HeLa cells with cytoskeletal microtubules (magenta) and DNA (cyan). Image: NIH Image Gallery via flickr (Public Domain).

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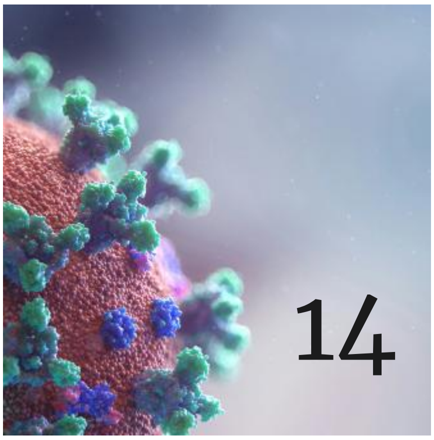

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For all 2025 editions and deadlines, refer to page 45.

MAR - APR 2025	**DUE DATE**
Preventing Future Problems	*5pm, 7 March*

Photograph: Jaron Nix via Unsplash

From the Editor

SCOTT REDDIEX
Editor-in-Chief — Science Victoria

Welcome back to Science Victoria for 2025!

Biotech

Biotechnology is all about using biological organisms and systems to perform a task, often the production of a substance. This means everything from producing alcohol and bread using yeasts, obtaining penicillin from *Penicillium* mould, through to things like bioremediation – cleaning up and removing pollutants from the environment using different bacteria, fungi, and plants.

Biotechnological processes are, perhaps understandably, incredibly commonplace in biomedical research. Use of different lab-adapted strains of the bacteria *E. coli* is a staple of fields like microbiology and immunology, where they are used to produce pieces of DNA, RNA, and proteins. Immortalised cell lines, similar to the controversially obtained HeLa cells, are also used every day in research labs around the world.

In this edition, we explore the field of biotechnology. I discuss how biotechnological processes supported our response to COVID-19, while Dr Catriona Nguyen-Robertson explores the story of insulin from discovery to mass production. Ana Krsteska explains the threat from the annual ryegrass weed, and the ways it is able to adapt to agricultural interventions.

Jack Harrison asks the question, should we utilise artificial intelligence (AI) to analyse patient test results? How do the public feel about it? Meanwhile, Haireya Abudureheman gets us up to date on 3D bioprinting of tissue and organs for human transplants.

Elsewhere in this edition, I take a look at former long-serving RSV President Robert Ellery's address on the state of science in the world of 1876.

This is also my last edition as editor of *Science Victoria*. It's been a wonderful experience building this magazine as a platform as an effective tool for quality science communication and advocacy, and I hope to see it endure.

We hope you enjoy this edition of *Science Victoria*.

SCIENCE VICTORIA

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Acknowledgement of Country
The Royal Society of Victoria acknowledges our headquarters are located on Wurundjeri land, never ceded, and convey our respect to Elders past and present. The RSV welcomes all First Peoples, and seeks to support and celebrate their continued contributions to scientific knowledge.

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Biotechnology

ROB GELL
President, The Royal Society of Victoria

Southern Blue Gum (*Eucalyptus globulus*). Photograph: Joan Simon via flickr (CC BY-SA 2.0).

This month's theme is biotechnology—a subject I don't know much about, though I've recently become interested in biofilms through work with colleagues.

Biofilms, it turns out, are practically everywhere; they're formed by bacteria and are linked to infectious diseases, posing public-health concerns as well as contributing to device-related infections.

The group I'm familiar with is investigating how to prevent biofilm formation using non-chemical treatments, plant extracts, and other 'waste' products. Interestingly, recent research in the literature explores how coffee grounds can disrupt the formation of pathogenic Listeria monocytogenes biofilms partly through the modulation of quorum sensing signaling.[1] Given Melbourne's passion for coffee, perhaps this local waste product is something they should also explore.

I first became interested in quorum sensing in bacteria in the early 2000s while conducting plant trials at Melbourne Water's Western Treatment Plant. We were investigating the dewatering of human biosolids at Werribee by growing Tasmanian/Southern Blue Gum (*Eucalyptus globulus*) seedlings in the new biosolids alongside 'paramagnetic' rock dust, sterile brown coal, and fish emulsion! I won't delve into paramagnetics, but the idea was that the bacteria in the fish emulsion used the coal as a food source, leading to a population boom among local bacteria that outcompeted the invading bacteria—perhaps quorum sensing played a key role. The growth results were remarkable and were later replicated in trials with Canola grown in tailings at the Fosterville gold mine in Bendigo.

The idea of "talking" to bacteria, leveraging quorum sensing rather than bombarding them with chemicals has been around for more than twenty years.[2]

RSV Transformation

The RSV Council has recently established a Transformation Taskforce to guide the Society to a securely funded role as a hub for enabling the science and technology economy in Victoria. I am convening the Taskforce as President of the RSV, the other members are Richard Blundell and Tony Clemenger from RSV Council, Steph Brady and Dylan Brady (Decibel Architecture), Rachel Alembakis (U Ethical Investors), Nigel Blair (Medical Products Hub) and Gordon Noble (UTS Institute for Sustainable Futures) is Secretary.

The Taskforce reports and recommends directly to the Executive of the RSV Council which will take proposed opportunities to the Council. The Taskforce will provide a report to members at our Annual General Meeting in May.

The RSV has the opportunity to play a pivotal role in promoting science and technology in Victoria but we need to enlist influential and expert individuals to assist in making the transition. In the last two years we have had the intent but have not had the capacity to make the progress needed.

The Taskforce is now exploring a range of new concepts and ideas which require an analysis of our brand, our products and programmes, our engagement strategy with members, governments and the community and our purpose. We're looking at new coalitions and alliances, drawing on expertise from the startup and impact investment sectors and investigating international models that the RSV might learn from or adopt in order to become a valuable hub for the enabling of the knowledge economy in Victoria.

If you wish to contribute to the Taskforce's thinking or if you would like to become involved please contact me at **president@rsv.org.au**.

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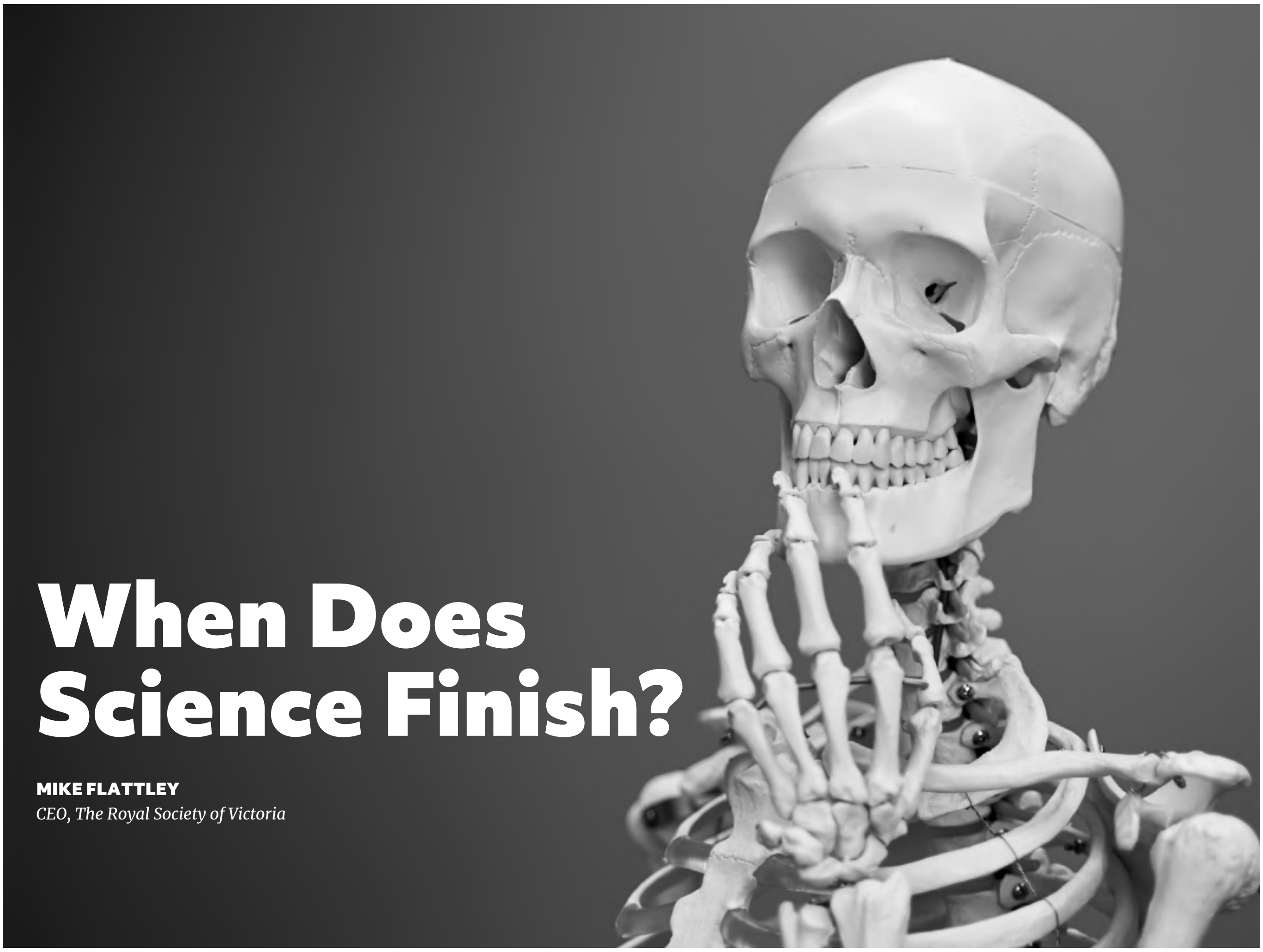
1. Spent coffee ground disrupts Listeria monocytogenes biofilm formation through inhibition of motility and adhesion via quorum sensing regulation, International Journal of Food Microbiology, Volume 430, 16 February 2025, 111066
2. Make peace not war, New Scientist vol 177 issue 2376 - 04 January 2003



Photograph: Mathew Schwartz via Unsplash.

When Does Science Finish?

MIKE FLATTLEY
CEO, The Royal Society of Victoria

My Aching Head

For the past ten years, I've organised presentations and report inputs from hundreds of scientists presenting their work for the Royal Society of Victoria, our many partners and, most importantly, our community. On emerging from this decade of frantically reading the 'zeitgeist' to anticipate the interest in and relevance of diverse scientific topics for a general audience, I find I have been immersed in what I've come to understand as 'deep time' – the ages and stages of our planet and its evidently unique home for the only known life detected in this infinite universe to date.

It's been a hot minute since the powerful ruling authorities of Europe last decreed the Earth to be the centre of the cosmos based on ancient philosophical and religious precepts – the heliocentric model of our solar system did not become the dominant cosmology taught in Western education until the early 19th century, despite centuries of work by remarkable (and courageous) scientists revealing that we're simply the "pale blue dot" circulating a small, yellow star, more recently revealed to be in a remote, outlying neighbourhood of the gigantic Milky Way galaxy, one of up to 2 trillion galaxies estimated in the vast, *observable* universe. The immensity of that picture is overwhelming to a simple little organism like a human being, and our infinitesimal stature within this infinite tapestry of existence is humbling beyond comparison - which is likely why it was resisted so fiercely by grandiose regimes clinging tightly to their political and moral power, as such regimes are wont to do.

There are other concepts in cosmology that are counter-intuitive to the way we imagine the universe based on the small scale of our existence here on planet Earth. Dark energy and dark matter are among these, but what I've found the most slippery to grasp is that, yes, the Earth is *not* the centre of the cosmos, sure, got it - but it appears there is *no* centre of the cosmos! This defies our imagining of the "Big Bang" as emanating from a fixed point into a void 13.7 billion years ago, "which must surely be the centre." We picture the moment of the Big Bang "from the outside," which does not exist. Instead, the Big Bang represents the rapid expansion of everything (that already existed) from a singularity - everything together in one place at one time - which then rapidly resolved into a vast soup of interactive matter and energy. This was not a small something expanding to fill a big nothing. It also follows that the universe is still not expanding into nothing – it's just expanding. There is no edge to the universe, no spreading puddle of existence into non-existence, no boundary between "something" and "nothing" – there is just "something." Energy. Matter. Spacetime.

My poor brain hurts! - but how amazing. I probably still have this wrong, but *la lucha continua*.

Big Ideas versus Fast Thinking

Let's come back to Earth. They say a week is a long time in politics, which is likely why science and politics are usually such awkward companions. Not only are the two spheres of concern often diametrically opposed in focus – one concerned with our species' best effort at overcoming personal or collective biases to secure certain proof of 'the nature of things,' the other more concerned with delivering short-term measures that support the fluid values of each society's dominant cultures and their economies – they are also concerned with entirely different scales of space and time.

Science can take centuries to establish a solid 'theory', this being the closest thing the scientific community can assert as being 'the truth.' The Big Bang. Relativity. Gravity. Quantum mechanics. These concepts are 'theories' (rather than 'hypotheses', which are closer to what most of us consider the word 'theory' to mean in lay terms) because they *work*, are accepted by a global collective of millions of highly trained scientists and, despite the valiant efforts of armchair philosophers like me all over the world, have not been disproven by qualified, scientifically literate people working hard to refute or refine them – yet.

Politics, meanwhile, is mercurial – programs and initiatives can be born, live and die within days, espoused by people with highly varying levels of actual expertise, dependent on the tactical currents of power and influence – although warring ideologies and the embodied expertise within the public service swing a dynamic pendulum overhead to effect short-term changes in the vehicle of government's trajectory that can have long-term impacts.

When all goes well, science and politics meet in the middle to interrogate 'an evidence base' to inform robust decision making.

From New Knowledge to General Knowledge

When the scientific community uncovers, tests and confirms new knowledge, the 'lag' to bringing that new knowledge to governments, classrooms and markets can be considerable. Compare this to times of war, famine and plague - moments when we suddenly need our experts to deliver radical new technologies and solutions to problems we either didn't anticipate or otherwise couldn't avoid. As with certain types of industries, a time of societal crisis often delivers a surge of investment in the translation of established science into new technologies and processes.

Between crises, the blame for a frustrating inertia in this scientific translation and an accompanying dearth of 'great leaps forward' is often allocated to a political class obsessed with quick wins and success at the ballot box; an extractive business class unwilling to change, innovate or collaborate; a failure of textbook writers to keep pace with advancements in fields of science between editions; or the subcurrents of anti-intellectualism alive within our broader culture.

However, we must also squarely allocate this blame to the scientific community. Back in 2013, the Chief Scientist for the United Kingdom of the day, Sir Mark Walport, told a meeting of the Centre for Science and Policy that "science isn't finished until it's communicated. The communication to wider audiences is part of the job of being a scientist, and so how you communicate is absolutely vital."[1] This followed much earlier recommendations from the world's oldest research institution, the Royal Society of London for the Improvement of Natural Knowledge, which claimed that "more than ever, people need some understanding of science, whether they are involved in decision-making at a national or local level, in managing industrial companies, in skilled or semi-skilled employment, in voting as private citizens or in making a wide range of personal decisions."[2]


Star trail over Melbourne. Photograph: Yong Chuan Tan via Unsplash.

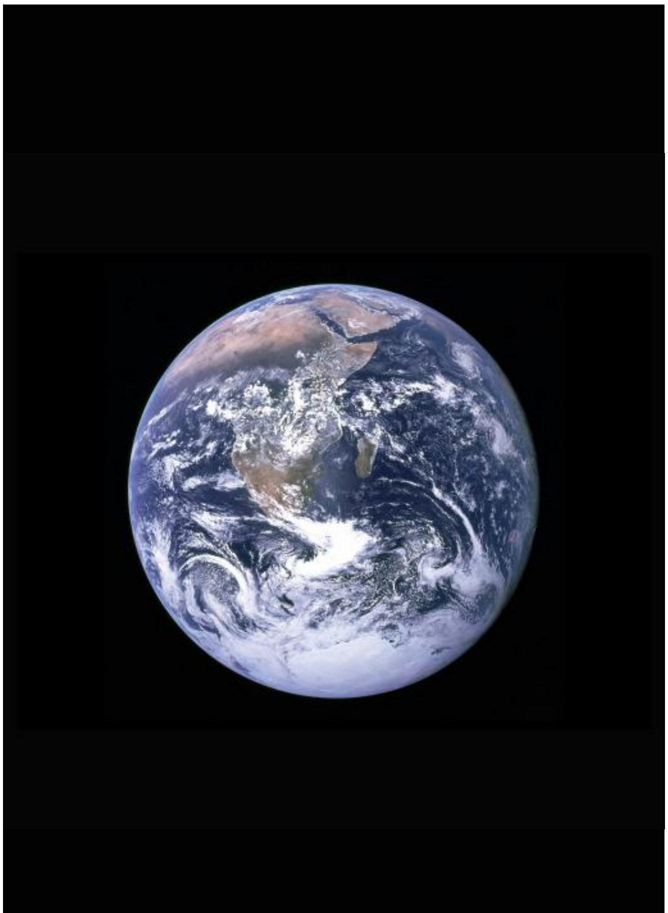
The Royal Society of Victoria has placed this work – 'sharing scientific intelligence' – at the centre of our mission for almost two centuries; locating, elevating and amplifying the voices of accomplished scientists committed to translating their life's work into useful knowledge for the balance of the Australian community. As a small, independent and overwhelmingly unfunded organisation committed to Open Science, we've tried a lot of things over the past ten years (and the preceding 160 years, naturally) – awards and competitions to celebrate high achieving scientists; public events, lectures and forums; symposia bringing scientists together with the public service to confront big issues; new video channels and livestreaming efforts; this most excellent magazine *Science Victoria*; small grants for local knowledge networks across the state to offer their communities science engagement events; and continuing our tradition of publishing scientists from our region in our open-access journal, the *Proceedings of the Royal Society of Victoria*.

Our capacities to deliver many of these engagement initiatives have been enabled by our management of the Inspiring Australia initiative in Victoria, one of the jewels of Australian policy making that has survived tumultuous changes in government since its inception in 2009 and features continued support for the nation's longest-running community festival, National Science Week. Without the staffing resource support from the Victorian Department of Education, and the program resource support from the Commonwealth Department of Industry, Science and Resources, this would not have been possible to deliver, and I would like to record my thanks and appreciation for this uncommon, sustained commitment to the translation of new knowledge to general knowledge from our political class!

Farewell

Sadly, this is my last communication as the CEO of the Royal Society of Victoria, as I finish up my role at the end of February 2025. Ten years is the blink of an eye in the long history of life on Earth, its geological ages, and the expansion of the universe, but it's a pretty long haul in a human lifetime and it feels like the moment has arrived for fresher eyes on the persistent challenges facing Victoria's venerable science society. I'd like to thank all of the wonderful scientists, colleagues, partners, supporters and RSV members who have worked with and beside me on a really interesting journey through both science and science translation over the past decade. Particular appreciation is reserved for my incredibly dedicated and hard-working colleagues James McArthur, Scott Reddiex and Catriona Nguyen-Robertson. Of course, none of this challenging work would have been possible without the enduring support of my wife Monica Parravicini and our sons Liam and Conor. Thank you.

I'd also like to encourage our colleagues leading the state's universities to financially support and partner with the Royal Society of Victoria, which has worked hard and long to support our state's scholars and the impact of their work beyond the reductive measures of citations and journal impact factors despite a chronic lack of investment from the sector. Understanding the perennial challenges confronting Australian tertiary education, I humbly suggest that it's time for Victoria's largest export industry to start turning up and contributing to a collective effort that transcends parochial institutional concerns for research rankings and international enrolments to elevate the status and utility of science at all levels of our community.



Our pale blue dot. Photograph: NASA via Unsplash.

The Centre of the Cosmos

A final, indulgent thought on departure! As physics has effectively declared the location of the "Centre of the Cosmos" up for grabs, and our tiny speck in the cosmic soup appears to be the only location where something as amazing as life is known to exist, I suggest that planet Earth reassumes the mantle. Not through the time-honoured device of anthropocentric conceit, but because our planet's biosphere is unique and precious in a universe that is overwhelmingly hostile to life as we know it beyond our island home's magnetosphere, which will frustrate attempts at humanity's exploration and colonisation of space for many years to come.

In this age of rapid climate change, runaway pollution and burgeoning mass extinction, we must place the health and preservation of our planet's rich biodiversity at the centre of who we are and what we do as human beings, or else lose all hope for continuing our forever-unfinished project of enlightenment and the meaning it confers to our otherwise fractious and self-involved existence as a global species.

Good luck everyone! Keep fighting the good fight, and I hope to see you again in a future role.

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1. Wolport, M. (2013) "Energy and climate change: challenges for science and policy" http://www.csap.cam.ac.uk/news/article-mark-walport-csap-lecture-on-climatechange/
2. [2] The Royal Society (1985) "The Public Understanding of Science," https://royalsociety.org/-/media/policy/publications/1985/10700.pdf

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LET'S CLEAN UP 2025

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CELEBRATING 35 YEARS

Dr Alastair Robinson (Manager Biodiversity Services at Royal Botanic Gardens Victoria) and Malaysian botanist Alviana Damit documenting a critically endangered carnivorous plant N. pongoides. Photograph: Adillah Yusof.

Dr Catriona Nguyen-Robertson, a Learning Facilitator at Scienceworks, experiments with an air cannon that blasts air out a hole at the end as a vortex. Photograph: Eugene Hyland/Museums Victoria.

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The Solutions of the Future

Join us online for a special, future-focussed panel discussion, broadcast from the Parliament of Victoria's Legislative Assembly, to mark the International Day of Women and Girls in Science!

This event will convene remarkable women leaders in the fields of science, technology, engineering, mathematics and medicine (STEMM) to discuss finding The Solutions of the Future.

Our secondary school students are the scientists and problem-solvers of tomorrow, and young women from across the State of Victoria are invited to explore the future problems facing our society - our climate, energy, and health - and discuss how the next generation can be prepared to find new solutions.

This engaging session will highlight the challenges facing our world and the innovative solutions that STEM can offer. Be part of the conversation, connect with inspiring role models, and discover how you can shape a better future through science. Don't miss this opportunity to ignite your passion for STEM and start your journey toward solving global challenges.

The discussion will be hosted by ABC Science journalist and presenter **Natasha Mitchell** with the support of Speaker of the Legislative Assembly, The Hon. **Maree Edwards** MP.

DATE/TIME:
Friday 21 February
12 - 1:30pm

PRICE:
Free

LOCATION:
Online

BROADCAST LINK:
vicparl.news/ broadcast

The Royal Society of Victoria · Inspiring Australia Victoria · Parliament of Victoria · Victoria State Government Department of Education

This event is presented by the Parliament of Victoria for the Inspiring Victoria program with the kind support of the Hon. Maree Edwards MP, Speaker of the Legislative Assembly.
The event is convened in partnership with the Royal Society of Victoria and the Victorian Tech Schools and Specialist Science Centres (Department of Education).

Future Climate

DR KIM REID

Dr Kim Reid completed her PhD at the University of Melbourne in 2022. Her thesis explored Atmospheric Rivers in Australia and New Zealand. Her research to date has focused on understanding rainfall, including its causes, future changes and how we can better predict it.

From 2022-2024, she worked as a postdoctoral researcher at Monash University. At the end of 2024, she started work as a research fellow at the University of Melbourne studying the impacts of fog and low cloud on transport and solar energy.
Kim is also a passionate science communicator who often appears in the media to explain climate and weather to broad audiences. She gave evidence for the New South Wales and Victorian Government inquiries into the 2022 floods and performed a stand-up comedy routine about climate science at the Melbourne International Comedy Festival.

Future Health

RUWINI COORAY

Ruwini Cooray is a scientist working at the intersection of neuroscience and genetics. With a BSc Hons in Biomedical Science and an MSc in Biotechnology from the UK, she has over eight years of experience as a lead research scientist and currently serves as an honorary scientist.

Having recently submitted her PhD thesis in Neurogenetics at Deakin University, Ruwini has founded Neurogen, a biotech startup developing advanced biological brain implants to treat neurological diseases such as Alzheimer's and Parkinson's. Her goal is to break through traditional barriers, harness innovation, and embrace diversity to address complex healthcare challenges associated with the brain.

Future Energy

DR MORLEY MUSE

Dr Morley Muse is a Chemical, Environmental, and Renewable Energy Engineer with expertise in waste-to-energy, wastewater treatment and energy transition technologies. She holds multiple leadership roles, including Board Director at Women in STEMM Australia and Co-chair of Science & Technology Australia's Equity, Diversity, and Inclusion Executive Committee.

Morley champions women in STEM and gender equity through her award-winning programs iSTEM Co. and DEIR.AI. She was previously an Elevate Advisory Panel member with the Australian Academy of Technology and Engineering and is a past ambassador of CSIRO's Innovation Catalyst Global, promoting women in STEM leadership. She also contributes to the RISE Expert Panel with Diversity Council Australia, and mentors senior women in STEM through Science and Technology Australia's "Superstars of STEM" Program. As an Energy Reference Group member with Jemena Energy, she supports renewable energy transition strategies.

Jonathan Borba via Unsplash.

Psychological Ill-Health in Healthcare Professionals

LECTURE BY PROFESSOR JILL MABEN, UNIVERSITY OF SURREY, UK

Providing high quality patient care requires healthy and motivated healthcare staff. Nurses, midwives and paramedics collectively comprise a high proportion of clinical staff with some of the highest prevalence of psychological ill-health.

Jill Maben, OBE, PhD, MSc, BA (Hons), RN, PGCE is a Professor of Health Services Research and Nursing at the University of Surrey, UK. Jill has undertaken national and internationally recognised nursing and health care research seeking to understand the links between staff wellbeing at work and patient experiences of care. Jill's work investigates the emotional costs of caring and staff psychological wellbeing at work.

DATE/TIME:
Friday 7 February, 2 - 4pm

PRICE:
Free

LOCATION:
Deakin Downtown
727 Collins Street
Melbourne, VIC 3008
(Simulcast on Zoom)

BOOKING LINK:
eventbrite.com.au/e/lecture-by-professor-jill-maben-university-of-surrey-uk-tickets-1145111913559

Graham Holtshausen via Unsplash.

Victorian Biodiversity Conference

The Victorian Biodiversity Conference (VicBioCon) is an annual scientific conference focused on highlighting biodiversity-related research and management projects based in the state of Victoria, Australia.

The conference is held over three days towards the beginning of each year and is organised by a dedicated team of post-graduate students and professionals from a number of Victorian universities and organisations.

In 2025, VicBioCon will be held at Monash University, Clayton campus from Tuesday 11th of February to Thursday 13th. For more information, and to book tickets, visit **www.vicbiocon.com**.

DATE/TIME:
11 - 13 February 2025

PRICE:
$40 - $100

LOCATION:
Monash University, Clayton Campus

BOOKING LINK:
www.vicbiocon.com/tickets

Pat Whelen via Unsplash.

Port Phillip Bay Marine Mammal Bioblitz

Become a citizen scientist by recording marine mammal sightings and contributing to the Marine Mammal Foundation's (MMF) understanding of marine mammals.This Bioblitz event is an opportunity for all members of the community to get involved in marine mammal science as citizen scientists to document marine mammals in Port Phillip Bay and contribute to our knowledge of marine mammal distribution and habitat use.

This event is a great opportunity to meet like-minded peers and get involved in marine mammal research!Once you've registered, you will receive an online training video in late February that will provide you with more information about how the Bioblitz event will run and what you can expect from the day. We will also host an online Q&A session before the event to answer any queries you may have about the day.

DATE/TIME:
Saturday, 1 March 9:30am - 12pm

PRICE:
Free

LOCATION:
Beaumaris Life Saving Club
Ricketts Point, Beach Road Beaumaris
VIC 3193

BOOKING LINK:
eventbrite.com.au/e/port-phillip-bay-marine-mammal-bioblitz-tickets-1111076061409

Markus Spiske via Unsplash.

Seed Propagation Workshop

Growing from seed is a great way to have a low-cost, productive garden. This seed propagation workshop includes a short presentation on the seed lifecycle, germination, looking after seedlings and preparing your vegetable bed as well as harvesting your produce and how to reduce your food waste. Includes a fun activity creating your own DIY seed propagation unit.

DATE/TIME:
Wednesday 26 March, 10 - 11am

PRICE:
Free

LOCATION:
The Homestead Community and Learning Centre
30 Whiltshire Drive
Roxburgh Park, VIC 3064

BOOKING LINK:
eventbrite.com.au/e/seed-propagation-workshop-tickets-1091854118059

Photograph: Clarissa Watson via Unsplash.

Using Life to Save Lives

Biotechnology and Healthcare

SCOTT REDDIEX
Editor-in-Chief, Science Victoria

The COVID-19 pandemic made many terms commonplace: mRNA vaccines, antibodies, antigens (in rapid antigen tests (RATs)), and antivirals would now be familiar to most.

Each of these was produced *en masse* to ensure that everyone had access to a RAT, a vaccine dose, or intensive therapies if their infection was severe. But how exactly are they made?

The answer, broadly, is biotechnology: the harnessing of biological organisms and systems to produce a substance or perform a task. Most often, these organisms are bacteria, fungi, or plants. While postgraduate students and research assistants do not fall under this definition of 'task-performing biological organisms', animals can also be utilised in biotechnology – for example, growing human organs in pigs.

There are many and varied applications of biotechnology in modern medicine, with several examples from the COVID-19 pandemic.

A Recent History of Biotechnology

As you will have noted from the above definition, biotechnology is nothing new. Humans have been using yeasts for baking and brewing for thousands of years, and many societies have utilised various plants in primitive remedies for injury and illness. Even the development of the lemon through the hybridisation of two different citrus species is an example of early biotechnology – life didn't give us lemons; humans brought them into existence.

The journey of penicillin, from observation to understanding and harnessing the organism that makes it, is a clear example of how biotechnology can transform natural processes into practical medical applications.

From the late 1800s, several scientists had observed that some moulds were able to inhibit the growth of bacteria, but wasn't until 1928 that Sir Alexander Fleming made his chance finding that *Penicillium notatum* could inhibit the growth of the bacterium *Staphylococcus aureus.*[1,2]

Fleming carefully studied the mould and its effects, but was unable to isolate and purify the molecule responsible for the observation, leaving penicillin unsuitable for use as a therapeutic drug. It wasn't until the work of Sir Howard Florey and others in the 1940s that the molecule was identified, the production was improved and scaled up, and the medical applications of the first commercial antibiotic were realised.[1,2]

Further research has allowed for massively increased yields in shorter time, as well as different forms of the antibiotic that have increased bioavailability (i.e., can be better used by the body), or are able to overcome bacterial resistance.

Research across multiple fields, as well as advancements in engineering, have not only allowed us to better understand how organisms have their observed effects, but also to harness, modify, and exponentially scale up those effects. While these processes are now commonplace in labs, they are rarely on display like they were during the COVID-19 pandemic.

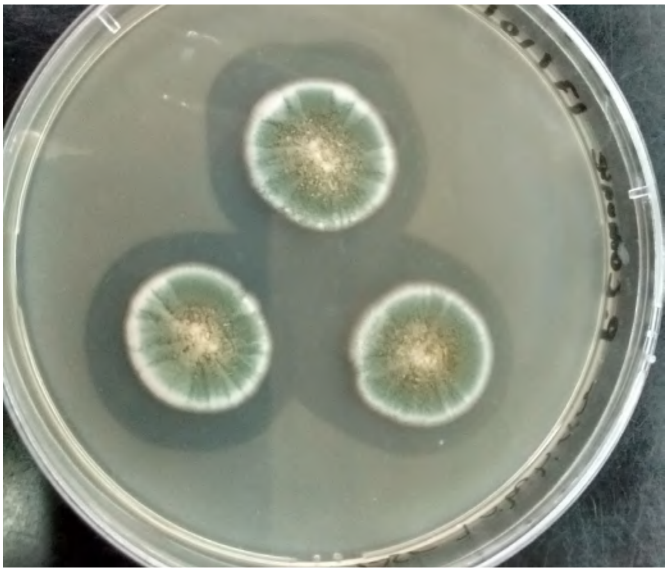
mRNA and other vaccines

Discussion of COVID-19 vaccines dominated the news of 2020 and 2021. As researchers and clinicians pivoted into COVID-19 research, and public and private money was thrown at the task, multiple vaccine candidates began to emerge.

At this point in time, we already had centuries of knowledge relating to vaccination, and how humans generate a protective immune response. At its core is the principle of showing the right parts of an invader to the right parts of the immune system so that a specific and protective memory is acquired.

Importantly, we don't want the patient to contract the illness in the process, and therefore need to carefully select what will be included in a vaccine. We also need to remember that not every part of the invader is able to generate a helpful immune response.

Vaccines typically address these requirements by combining key things in each dose: something that looks like the right part of the invader, and something to get it to the right place in the body. If all goes well, the next time we see that exact part of the invader, we'll be prepared.



Penicillium mould inhibiting bacterial growth. Photograph: Teresa María López via Wikimedia Commons (CC BY 4.0).

AstraZeneca, Moderna, and Pfizer

In the case of COVID-19 (the disease caused by the virus, SARS-CoV-2), the different vaccines that reached the arms of Australians were AstraZeneca's *Vaxzevria*, Moderna's *Spikevax*, and Pfizer-BioNTech's *Comirnaty*.[3,4,5]

AstraZeneca's vaccine used an adenovirus vector – the inactive shell from a different kind of virus – to get the payload into cells. In this case, that payload was a strand of DNA, which served as instructions for cells to make copies of the SARS-CoV-2 spike protein – the 'right part of the invader'.[3]

Pfizer and Moderna's vaccines are mRNA vaccines. In this case, lipid nanoparticles act as transporters to deliver mRNA instructions directly into the cells, without the need for a viral vector.[4,5]

Both the mRNA and the DNA vaccines provide instructions for the recipient cells to make the virus's spike protein, for the immune system to learn to recognise it. DNA is read to make mRNA, which is in turn read to make a protein, meaning that an mRNA vaccine has fewer steps before the goal is achieved.

Understanding what each of these vaccines contains makes it easier to see how biotechnology is involved in their production. For AstraZeneca, the DNA that encodes the adenovirus is modified to both make sure that it contains the DNA sequence of the SARS-CoV-2 spike protein, while also ensuring it can't replicate on its own – it is a virus itself, after all.[6]

This modified virus is then grown inside human cell lines – vats of 'immortalised' cells that reproduce like tumour cells – before being harvested, purified, and included in the vaccine formulation.[6]

In contrast, the production of mRNA vaccines doesn't involve cells or animal-derived raw materials. Instead, a DNA template is combined with the other ingredients and catalysts required for the mRNA to be produced. The process works using the same principles as mRNA production inside our cells, however it uses machinery derived from bacteriophages (viruses that infect bacteria).[7]

The mRNA production process is significantly quicker and produces milligrams of mRNA for every millilitre of reaction volume, which is a sizable yield. The mRNA is then purified, and encapsulated in lipid nanoparticles, ready for vaccine formulation.[7]

While these vaccines are great at reducing the chance and severity of infection, most of us by this stage have had COVID-19. Apart from the obvious and unpleasant symptoms, the main method for confirming a bout of COVID-19 is the use of a RAT.

Rapid Antigen Tests (RATs)

A "rapid antigen test" is exactly that – a test that rapidly determines if a given antigen is present in a sample. An antigen is anything that is recognised by the immune system – usually part of a protein.

While a RAT might seem more on the 'tech' side, it relies on a 'bio' component to work: antibodies. Antibodies are proteins produced by specific immune cells, with each cell producing unique clones with specificity for a single antigen.

It is this specificity of an antibody for an antigen that underpins how a RAT works, and is the same principle that a home pregnancy test uses (the antigen in those is a pregnancy-related hormone). The process occurs in stages:[8,9]

1. Viral proteins (antigens) present in nasal fluid are caught on the swab, and then rinsed into the provided buffer solution. The buffer solution releases any SARS-CoV-2 proteins from cells and mucus, optimises the pH, and forms the carrier solution for the test.
2. The sample solution is dripped onto, and begins to flow across, the test strip. As it passes through different sections of the strip, the solution encounters various components essential for detecting viral proteins.
3. The solution first passes through a section called the conjugate pad, which contains antibodies specific to SARS-CoV-2 antigens. These antibodies are labelled with small particles, such as gold, latex, carbon, or silver, so that a colour change can occur (the lines that appear).
4. If SARS-CoV-2 antigens are present, the antibodies bind to the antigens, forming a protein-antibody complex that continues flowing along the strip. If no antigens are present, the labelled antibodies flow alone.
5. At the "test" line, immobilised antibodies that bind specifically to the protein-antibody complex are present. If SARS-CoV-2 antigens are present, the complex binds to these antibodies, causing a visible coloured line to appear.
6. Finally, at the control line, a different set of immobilised antibodies bind to any unbound labelled antibodies. This ensures the test is functioning properly.

A virologist at the CDC examines a culture flask containing Madin-Darby Canine Kidney (MDCK) epithelial cells, looking for any signs of growth in a stock of Influenza virus. Photograph: CDC via Unsplash.

Producing the antibodies required for the RAT is the biotechnological part of the process. First, animals (like mice, rats, and goats) are injected with an antigen, like a protein from the surface of SARS-CoV-2. Over the next few weeks, the animal's immune system produces antibodies specific to that antigen.[10]

The animals producing the "best" antibodies are identified, and their antibody-producing cells are collected. These cells are then fused with cells that can grow indefinitely – derived from cancerous antibody-producing cells. The result is a "hybridoma", a type of cell that can both produce antibodies and reproduce continuously.[10]

These hybridomas are grown in bulk, with each one producing large quantities of the specific antibodies required for the RAT. The antibodies are then harvested, purified, and impregnated into the test strip at the appropriate section, ready for your next COVID-19 test.

However, hybridomas aren't the only way to produce antibodies used for treatments.

Antibody therapies

For COVID-19 patients who are very sick, antibody therapies are sometimes used to treat their infections.[11,12]

The primary function of these therapies is to neutralise the virus. When each virus particle is bound to a (relatively) large antibody, it is physically blocked from attaching to and infecting our cells. In other words, if we think of the virus as a key, and the patient's cells as a lock, then the antibody therapy is like supergluing a bell to the tip of the key – the key won't be able to fit in the lock, and it's going to make a lot of noise while trying.

The secondary function of these therapies is to make the virus visible to different parts of the immune system. That's the bell in the above analogy, signalling to other immune cells and defence molecules that this is a target to attack.

The antibodies used for this therapy have two sources: people, and immortalised cell lines. If someone has generated an immune response to COVID-19 (either through infection or vaccination), their blood will contain antibodies specific to parts of the SARS-CoV-2 virus. This means that blood can be donated, and their antibody-containing sera collected and then used to treat a patient – similar to how a blood transfusion works.[11]

Larger-scale and more specific antibody therapies are produced similarly to the antibodies used in RATs, but with some key differences. First, candidate antibodies are selected, their structure studied and optimised, and a gene encoding that protein created. Next, that gene is introduced into an immortalised cell line (such as Chinese Hamster Ovary (CHO) cells), and grown in large cultures.13 The output is a single type of highly specific antibody that can then be purified and administered to patients.

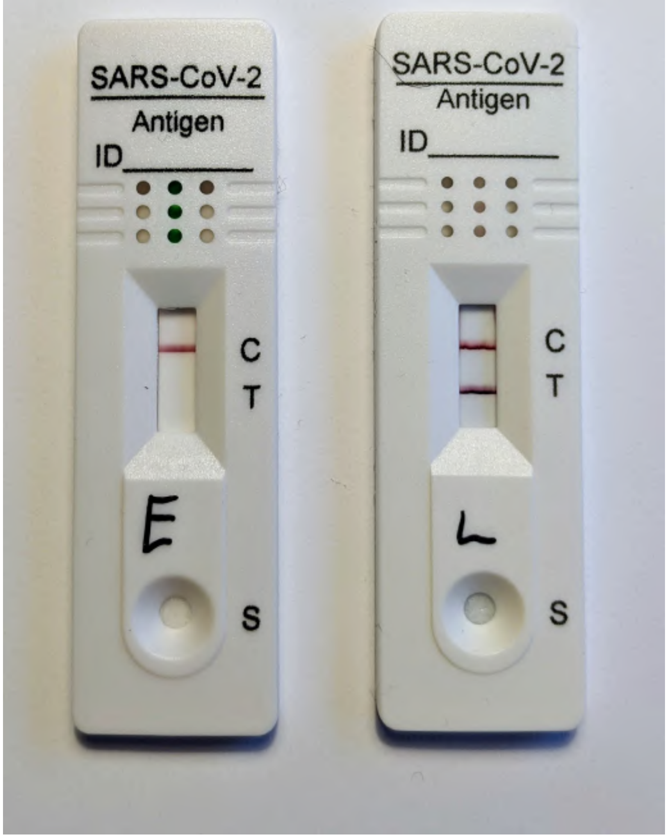
Biotechnology is a fundamental part of modern medicine

Processes and techniques that fall under the definition of 'biotechnology' are central to how we responded to COVID-19, from test kits, to vaccines, and therapies.

These methods aren't restricted to COVID-19, either. You've possibly seen RATs that test for multiple infections, or used a home pregnancy test. You've hopefully kept up-to-date with your vaccines, and you hopefully won't be needing antibody therapy for illnesses like rabies, Ebola, various cancers, some autoimmune diseases, or many others.

As biotechnological processes continue to improve, so too will our ability to rapidly and effectively respond to a wide range of diseases.

COVID-19 Rapid Antigen Tests (RATs). The left test is negative for the detection of SARS-CoV-2 antigens, while the right test is positive. Photograph: Boldie via Wikimedia Commons (CC BY-SA 4.0).



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A Sweet Solution to the Sugar Problem

The Discovery of Insulin to Treat Diabetes

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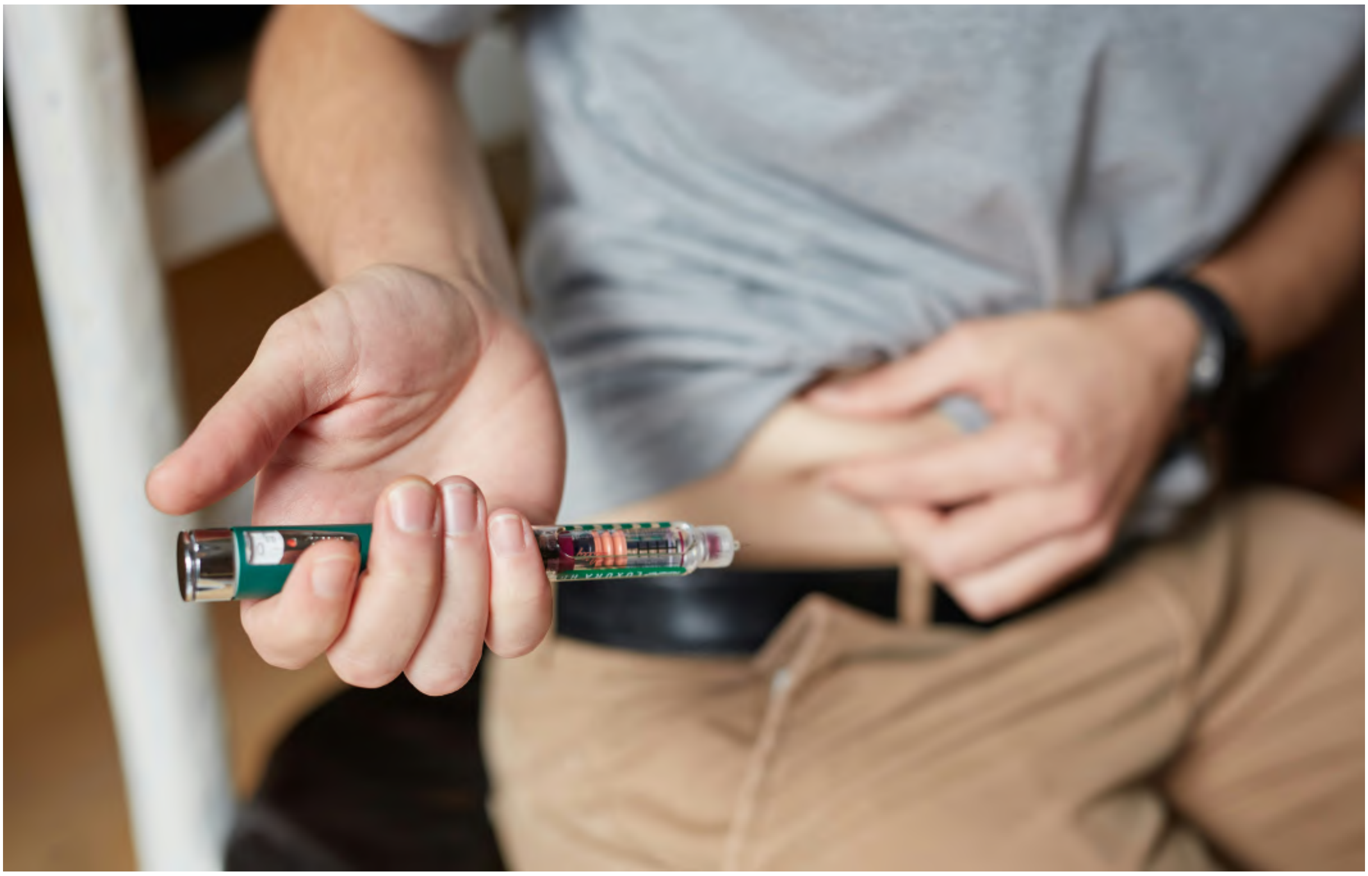
Photograph: Mae Mu via Unsplash.



Auto-injectors pre-filled with a required dose of insulin are an easier administration alternative for many people with type 1 diabetes. Photograph: Sweet Life via Unsplash.

Prior to the mid-20th century, a type 1 diabetes diagnosis was a death sentence.

Your only option was to starve yourself of carbohydrates to limit the amount of sugar in your blood, which bought you a few extra years at most. Some patients even died of starvation after being prescribed as few as 450 calories a day – just over a quarter of the recommended daily caloric intake.[1]

Although we still have no cure for diabetes, advancements in insulin therapy have meant that the lives of diabetics aren't cut tragically short. The discovery of insulin and its role in treating diabetes, and the development of ways to provide patients with regular doses of it were decades in the making.

Insulin and its discovery

Insulin is a hormone that controls blood sugar (glucose) levels – if the level is too high, insulin signals for cells throughout your body to take up glucose and for your liver cells to convert glucose to glycogen, a type of fat, for storage.

In 1889, two German researchers, Oskar Minkowski and Joseph von Mering, found that when the pancreas gland was removed from dogs, the dogs developed symptoms of diabetes.[2] This led to the idea that the pancreas was the site where "pancreatic substances" (what we now know as insulin) were produced, which was then narrowed down to specific clusters of specialised cells.

In 1910, Sir Edward Albert Sharpey-Shafer suggested that it was only one chemical that was missing from the pancreas in people with diabetes.[3] This chemical controlled blood sugar, which he called insulin, from the Latin *insula* ("island").[3]

We now understand that type 1 diabetes is an autoimmune condition in which a person's own immune system attacks and destroys the insulin-producing cells. Specialised immune cells – that usually do not enter the pancreas – gain access, and once they have destroyed enough of the insulin-producing cells, the pancreas no longer produces insulin.

Understanding the cause of the disease meant that researchers could now work out a way to treat the condition.

A lifesaving, murky concoction

Attempts were made to extract insulin from ground-up pancreas cells, but they all proved unsuccessful. The challenge was to find a way to extract insulin from the pancreas without it being destroyed in the process.

In 1921, Canadian surgeon Frederick Banting figured out how to extract insulin from a dog's pancreas *and* keep it intact. Banting had read an article suggesting that the insulin-producing cells are specifically slower to deteriorate than other pancreatic tissue, meaning that he could possibly break down the pancreas in a way that would leave them intact.

As Banting wasn't a scientist by training, he couldn't test his theory alone, and visited John Macleod, a professor at the University of Toronto.

Macleod was sceptical that a research novice would succeed when others had failed, but he saw the value in Banting's surgical skills to be able to test pancreas grafts and transplantation (an idea for treatment that had been floating around at the time).[4] He offered Banting dogs, lab space for

experiments, and a research assistant, Charles Best.

While many of their initial experiments failed, the three worked together to produce an extract.[5,6] They tied off the pancreatic duct of dogs to cause the pancreatic tissue to die – and extracted insulin from what was left behind to create a "thick, brown muck".[5,6]

With this murky concoction, Banting and Best kept another dog with severe diabetes (having completely removed its pancreas) alive for 70 days.[5,6] Thanks to their extract, they saw regular drops in blood sugar levels, with the dog only dying when there was no more of the extract available. [5,6]

Having seen success in dogs, the researchers, along with biochemist James Collip worked towards a more refined form of insulin, this time from the pancreases of cattle.

The very next year, in January 1922, a 14-year-old boy dying from type 1 diabetes received an insulin injection.[7] While the first try was unsuccessful, a second shot dropped his dangerously high blood sugar levels to near-normal levels.[7] He was the first person to be treated, and many have followed since.

Word of insulin's success spread, and in recognition of their life-saving discovery, Banting and Macleod were jointly awarded the 1923 Nobel Prize in Physiology or Medicine. Banting split his half of the Prize money with Best, and Macleod did the same with Collip.

Insulin on demand

With 830 million people worldwide currently living with diabetes,[8] and each of them requiring regular injections of insulin to keep their blood sugar in check, insulin needed to be produced on a large scale.

The medical company Eli Lilly started large-scale production of insulin isolated from cattle and pigs. Cow and pig insulin were used for many years to treat diabetes and saved millions of lives, but it wasn't perfect, as it caused allergic reactions in many patients.[9]

Instead, Eli Lilly turned to biotechnology. Not only would this mean that they could synthetically produce human insulin specifically, it also meant that production could be scaled up even further.

The first synthetic "human" insulin was produced in 1978 using genetically engineered *E. coli* bacteria. Scientists cut and paste the human insulin gene into a loop of bacterial DNA, which allows for the gene to be introduced into the bacteria. Bacteria that take up the DNA read the instructions from the inserted gene to make the insulin protein.

Insulin now comes in many forms, from regular human insulin identical to what the body produces on its own, to ultra-rapid and ultra-long-acting insulins. By tweaking the genetic instructions provided to bacteria, they can make different forms of insulin 24/7.

Insulin is predominately administered via manual self-injection. Photograph: Mykenzie Johnson via Unsplash

Who "owns" insulin?

If biotechnology means that insulin is incredibly cheap to produce, and it's the only thing that keeps type 1 diabetics alive, who should be profiting off it?

In the US, some diabetics struggle to purchase insulin and try to stretch out their doses to detrimental consequences. They simply cannot afford to live. Thankfully, in Australia, insulin is much more affordable.

Ironically, Banting, Collip, and Best were awarded a patent for insulin and sold it to the University of Toronto for a dollar each. At the time, Banting said, "Insulin does not belong to me, it belongs to the world."[10] He wanted it to be accessible to everyone who needed it.

As biotechnology increasingly solves more of our public health challenges (as well as agricultural and environmental challenges), we need to carefully consider how it is being used and ensure that everyone benefits. Synthetic insulin produced by bacteria in large vats may not be a cure for diabetes, but it is literally a lifesaver.

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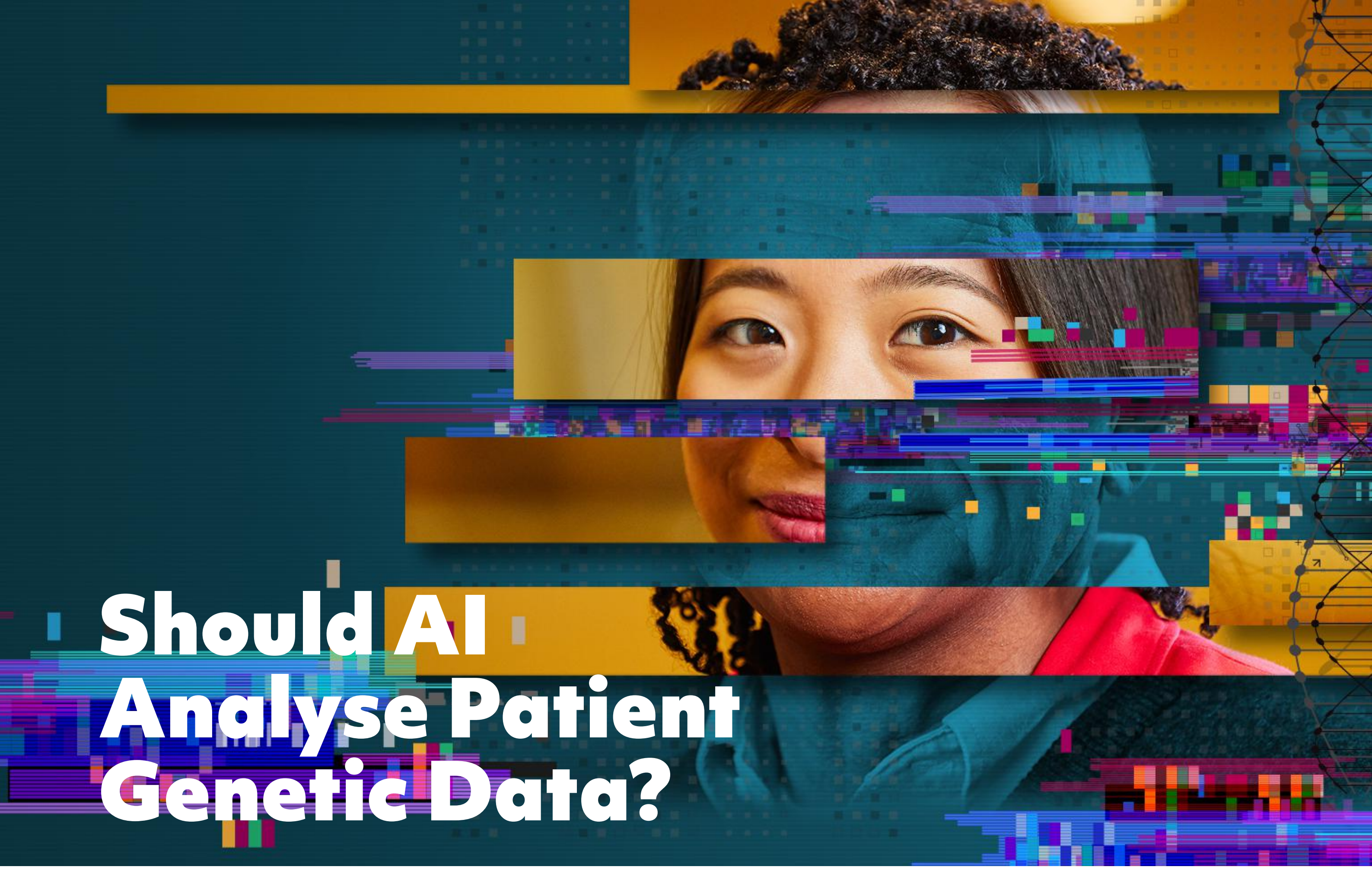

Should AI Analyse Patient Genetic Data?

Maybe the Public Has the Answer

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Artificial intelligence (AI) is a hot button issue for society. No longer confined to science fiction or data science, AI is now used everywhere from business to poorly written student essays. But what does it mean for medicine? And more specifically, what can it do for genomic medicine?

Personalised medicine

Genomic medicine refers to how a person's genes influence their health and their responses to medical treatments. By tailoring a person's treatments to their unique genetic make-up, we can personalise their medical care for a better outcome.

AI has the potential to revolutionise genomic analysis and get more informative results to patients faster than ever.[1] However, with the growing use of 'whole exome sequencing' – sequencing all of an individual's genes – the amount of data being generated is too great for existing IT infrastructure to handle.[2]

Automated tools are already being used in the genetic diagnostic setting, but the use of AI has new considerations. Public perspectives are imperative to ensuring the safe and equitable use of AI. Any medical field that wants to effectively incorporate AI needs to meaningfully engage with the public.

Public engagement

To learn more about public perspectives on AI in healthcare, we ran focus groups with Australians from all walks of life. By engaging a diverse range of participants in our focus groups, we were able to hear a more diverse range of perspectives on genomic AI.

During our sessions, participants were asked how they felt about having their own genetic data analysed by AI, as well as their thoughts on data security, and consenting to use of AI in the analysis process.

How are we feeling?

Pretty good actually! Polls from participants showed that the vast majority were comfortable with their own DNA being analysed by AI. In general, participants became even more comfortable with AI analysis after group discussions, which corroborates research on AI in other medical fields.[4]

There seems to be a general level of trust among the public, and this trust can be improved through education and open discourse about AI in medicine. Reasons given for trusting AI ranged from the potential benefits, like reduced risks associated with disease, to preferring AI analysis. Many participants related this to previous negative experiences with healthcare professionals.

But it's not all sunshine and rainbows. Most participants agreed that there should be some sort of human checking mechanism, and, when pressed further, many still expressed some level of distrust. This distrust wasn't always linked to the technology itself, but a general feeling of distrust about computer analysis. For others, they considered genomic data to be more personal or far-reaching than other medical data, and were less comfortable with the use of AI to analyse it.

Overall, participants strongly agreed on the potential benefits of AI in genomic medicine. They talked about how it could reduce wait times for patients, lead to new discoveries, reduce the workload for researchers and reduce bias and errors in analysis.

Should the results of your blood test be analysed by artificial intelligence? Photograph: Phillip Jeffrey via flickr (CC BY-SA 2.0).

Great! Time to steamroll ahead?

Not quite. In line with previous research, participants found that the potential effect of AI on error was a double-edged sword.[5]

AI has the potential to reduce human error, and lead to more accurate diagnoses for patients, but it also has the potential to introduce and reinforce bias against marginalised and underrepresented groups. This is a problem that we already see with AI in public discourse, such as with image generation unintentionally reaffirming racial and gender biases.[6]

While most participants were comfortable with AI analysing their data, they also strongly preferred to have a human professional check the results. Participants from marginalised backgrounds were also concerned that genomic AI tools could be used against them to justify discrimination.

These are just some of the potential issues that AI could introduce.

What happens when things do go wrong?

In short, there's no clear answer. But that's just another reason why engaging with the public is so important.

Like with any technology, if something goes wrong, there is a discussion to be had about who's at fault and who should be held accountable. If the doctor gives you inaccurate or incorrect results, are they at fault? Or is it the fault of the technology for giving the doctor those results in the first place?

AI may further muddy this discussion. Machine learning is a process through which an AI learns from its training data. It involves an AI model learning from existing data to make generalisations about unseen data, and adjusting based on any new information.[7] This allows for the creation of far more powerful tools than anything that could be coded manually.

Unfortunately, this process can make it difficult – or even impossible – to figure out how or why the AI model produces results.[8]

If an AI model produces a result that is outside of our current understanding of genomic medicine, but not necessarily in violation of it, can we trust it? Perhaps it can piece together information in a way that no human has – yet. Furthermore, should such results be shared with patients by medical professionals?

Focus group participants who were presented this scenario didn't always have a clear answer. For many participants, this generally reaffirmed the need for human oversight of these tools.

Clearly, this is a complicated space. More research is needed into the thoughts and preferences of the public and professionals alike. Guidelines also need to be developed for the building and use of AI.

▶ *Jack Harrison is completing a Master of Science in Genomics and Health at The University of Melbourne and Murdoch Children's Research Institute.*

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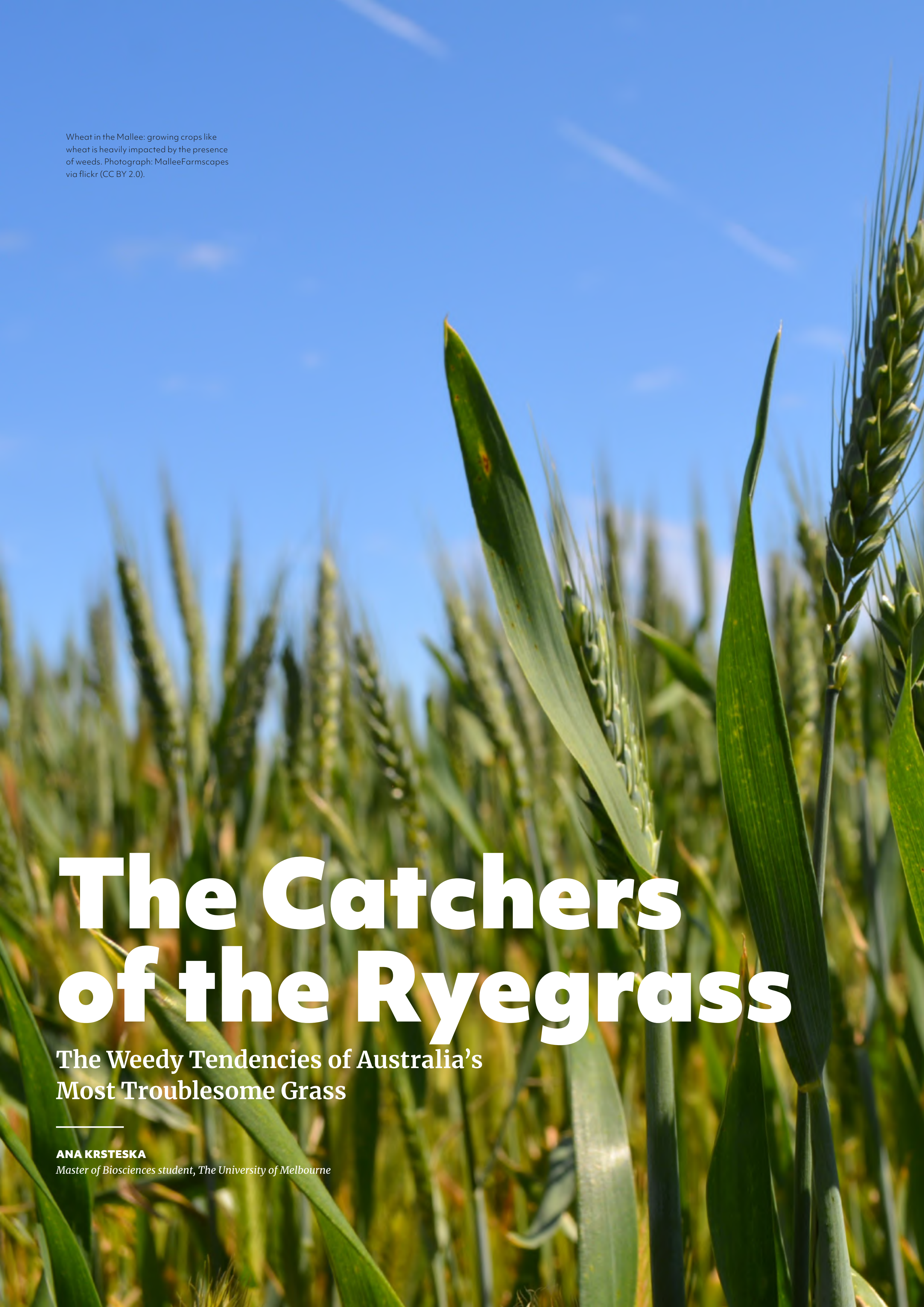

Wheat in the Mallee: growing crops like wheat is heavily impacted by the presence of weeds. Photograph: MalleeFarmscapes via flickr (CC BY 2.0).

The Catchers of the Ryegrass

The Weedy Tendencies of Australia's Most Troublesome Grass

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Weeds are any plants that are unwanted in a particular location. Most often non-native species, they pose a serious threat to Australia's environment.

The cost of weeds to the agricultural industries alone due to reduced farm productivity is estimated at about $4 billion per year.[1]

Herbicides were initially seen as an easy remedy to manage agricultural weeds, but over time they have unintentionally fuelled the rise of 'superweeds'—plant species that quickly evolve herbicide resistance, transforming a solution into a growing problem.[2]

Among the most noxious of herbicide-resistant weeds is annual ryegrass (*Lolium rigidum*), a persistent adversary for farmers. Decades of battling this resilient weed have raised pressing questions about whether poor herbicide stewardship is doing more damage than good.

Our research group, the Adaptive Evolution Lab at the University of Melbourne, is dedicated to uncovering the evolutionary mechanisms that allow ryegrass to adapt to agricultural interventions. By studying the physical and genetic traits behind its ecological responses, we aim to identify its strengths and weaknesses, providing farmers with valuable insights for more effective management.

A pain in the ryegrass

The grains industry is under increasing pressure to feed a growing global population, all while facing the challenges of a rapidly changing climate. Ryegrass, a persistent weed, is only adding to the burden. Competing fiercely with essential crops like wheat and barley for vital nutrients, it chokes yields and threatens crop profitability.[2] This, in turn, strains food supply chains, and makes it harder to meet the rising demand for staple foods.

The ability of ryegrass to adapt rapidly means that even well-rounded control programs might face diminishing effectiveness over time. In addition to developing resistance to multiple herbicides, it can also adapt to alternative weed control methods, such as tilling (soil turnover) and early crop sowing.[3] Even with the use of integrated weed management (IWM), which combines diverse and complementary strategies, the immense potential for ryegrass to adapt raises concerns about whether current methods can prevent it from becoming a larger problem in the future.

Historically, weed research has prioritised improving crop yields, often viewing weed control strategies solely through their impact on crops, while their direct effects on weeds like ryegrass were treated as an afterthought. Yet, it is equally important to investigate how these interventions impact ryegrass dynamics. Our understanding of ryegrass 'biotypes' — sub-types of plants that have adapted to specific conditions — is still limited, particularly in terms of how they evade or resist control efforts.

Adaptations stem from genetic changes that lead to distinct physical traits, raising an important question: how can we link ryegrass traits and their variants to specific conditions, across different environments?

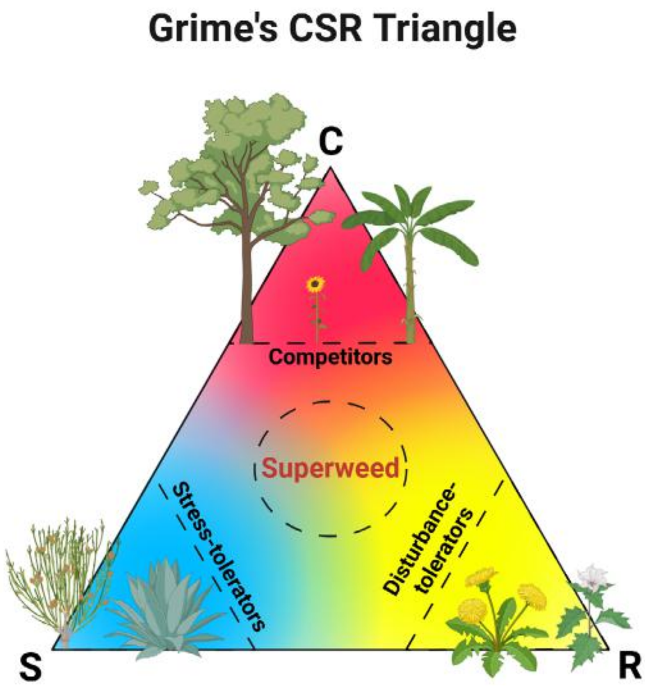

Image: Ana Krsteska via BioRender.

Weeding out the truth

This is where our research comes in. At the heart of our approach is Grime's CSR triangle, a cornerstone of plant evolutionary ecology.[4] This powerful framework categorises plant species into three key survival strategies: 'competitors' (C), 'stress-tolerators' (S), and 'ruderals' or 'disturbance-tolerators' (R).

While this framework has traditionally been used to classify differences between plant species, we are extending its application to characterise variation within a single species. In the context of agriculture, it provides a unique lens through which we can explore how ryegrass populations adapt their survival tactics in response to different weed control methods.

For example, 'competitors' excel in resource-rich environments, outcompeting crops for nutrients, while 'stress-tolerators' thrive in harsh conditions, like herbicide-treated soils. Meanwhile, 'ruderals', are quick to colonise disturbed areas, making them resilient to practices like tilling.[5]

By understanding how these strategies impact the weed's response in various agricultural settings, we can help farmers manage ryegrass more effectively and, quite literally, root out the problem.

We hypothesise that the potential rise of ryegrass 'superweeds' will be supported by one of two possible mechanisms. First, some individual plants might possess exceptional plasticity in their traits, making them what we would call our 'super biotype'. These plants could adapt and thrive in a variety of environments – whether it is in fields with competitive crops, under herbicide pressure, or in areas disturbed by tilling.[6,7]

Alternatively, survival could depend on diversity within the ryegrass population. Instead of relying on a single highly adaptable plant, the population might be made up of various biotypes, each specialised for different management challenges. Some plants might excel in competitive environments, while others are better equipped to handle herbicide stress or physical disruption from tilling. This diversity would ensure that, no matter what control method is used, a portion of the weed population would survive, continue to spread, and persist.[8]

We are conducting a field experiment that simulates different combinations of management strategies likely to elicit responses in every corner of the CSR triangle. In different growing plots, we observe how ryegrass responds to these conditions, measuring plant growth and biomass.

We are also taking genetic 'snapshots' of ryegrass populations at different stages, tracking how their genetic makeup changes over time. This helps us see whether genetic diversity changes in response to these management techniques. By doing so, we aim to pinpoint specific genes that may play a role in ryegrass' ability to resist these interventions.

Ultimately, by studying both the genetic (inherited changes in DNA) and plastic (flexible, non-genetic adaptations) responses, we aim to uncover just how adaptable ryegrass is—and answer a crucial question: is there a risk of annual ryegrass gaining a 'superweed' status?

Sowing the seeds of victory

So far, our research has revealed that ryegrass populations tend to favour certain survival strategies, particularly those that align with stress tolerance (S) and competitiveness (C). But adaptation is not simple — while a plant might develop resistance to a specific herbicide, it often comes with a biological cost, like slower growth or smaller biomass.[9] This means that it is tough for a single plant to thrive across all strategies, such as being both a top competitor and herbicide survivor at the same time. Based on these preliminary findings, we are leaning towards the second hypothesis of superweed evolution: that ryegrass populations are made up of different *biotypes*, enabling the population to persist under varying conditions.

The CSR framework may serve as a valuable lens in linking specific physiological traits to survival strategies, allowing us to categorise ryegrass biotypes based on their traits and genetic makeup. This deeper understanding helps us pinpoint the exact type of 'superweed' we are dealing with. In agriculture, this could be game-changing. We could better assess weed populations' potential in crop fields —considering the land's management history — and provide farmers with a more individualised strategy for more sustainable weed control. However, we are still in the early stages of this research, and there is much more to explore. Future studies could push our hypothesis further, testing it in different climates or with other weed species.

Much like the ryegrass growing in our plots, the field of experimental evolution is gradually taking root. It could become a powerful tool in building more resilient food systems, ensuring we keep food on our tables.

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Flowering ryegrass amongst wheat, The University of Melbourne. Photograph: Ana Krsteska/ University of Melbourne

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From Ink to Organ

The Power of 3D Bioprinting

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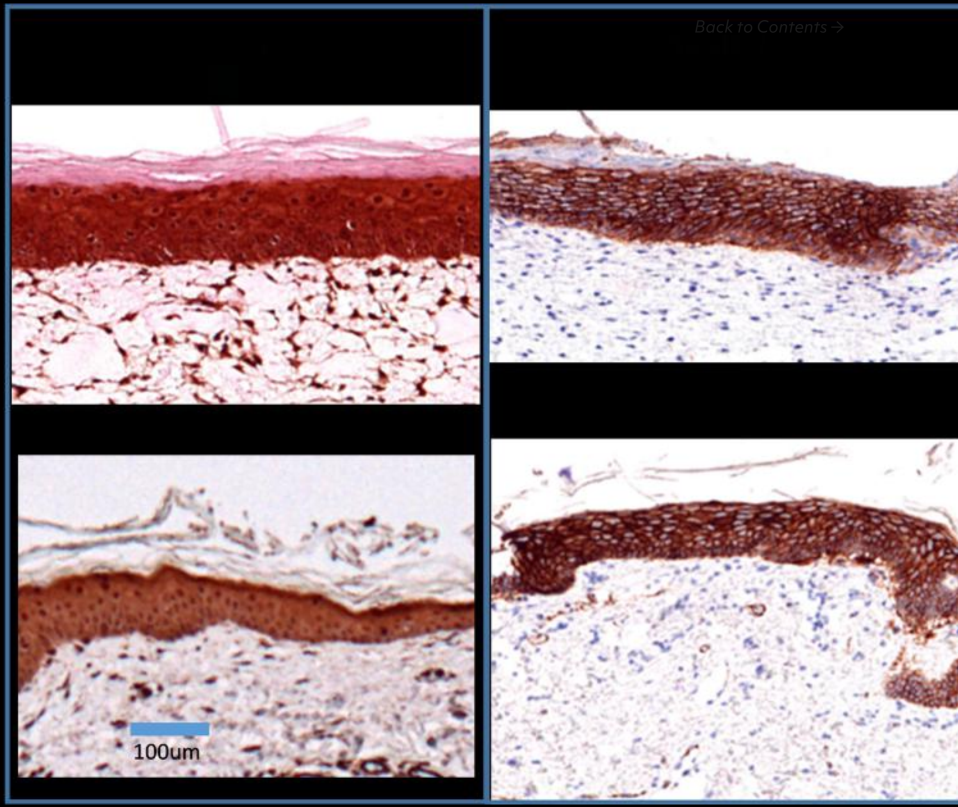


Lab Made vs. Home Made: histology sections of 3D bioprinted skin (top row) and native skin (bottom row). Image: National Center for Advancing Translational Sciences, Paige Derr and Kristy Derr, via flickr (Public Domain).

Imagine you could create any living structure with just a click. What would you create?

Thanks to advancements in technology, this isn't just imagination or science fiction – it's the reality of bioprinting.

Since 3D printing has become cheaper and more popular, it has been utilised across many fields: from small-scale customised jewellery to large-scale car and house manufacturing. Recently, it has started to attract biomedical researchers as they develop innovative solutions to address critical challenges in modern medicine.

Organic challenges

A chronic shortage of organ donors leaves patients on long transplant waiting lists, often with life-threatening consequences. Currently, there are around 1,800 Australians on the waitlist for an organ transplant, and an additional 14,000 on dialysis who would greatly benefit from a kidney transplant.[1] However, very few people die in a way that allows for their organs to be used, and the list of patients needing transplants is always longer.

For those patients who *do* receive a donated organ, they face a different challenge for the rest of their lives: tissue rejection. The immune system has elaborate and effective mechanisms to protect the host against anything it considers to be "non-self". Transplanted tissue often falls under this category, meaning that it is attacked by the recipient's immune system. Without a life-long regimen of immunosuppressive drugs to protect it, the transplanted organ can be destroyed.

Making "non-self" look more like "self"

By creating functional, lab-grown organs tailored to individual patients, bioprinting not only reduces reliance on donors but also mitigates the risks of rejection, so that transplant recipients need not remain on immunosuppressive medications for the rest of their lives.

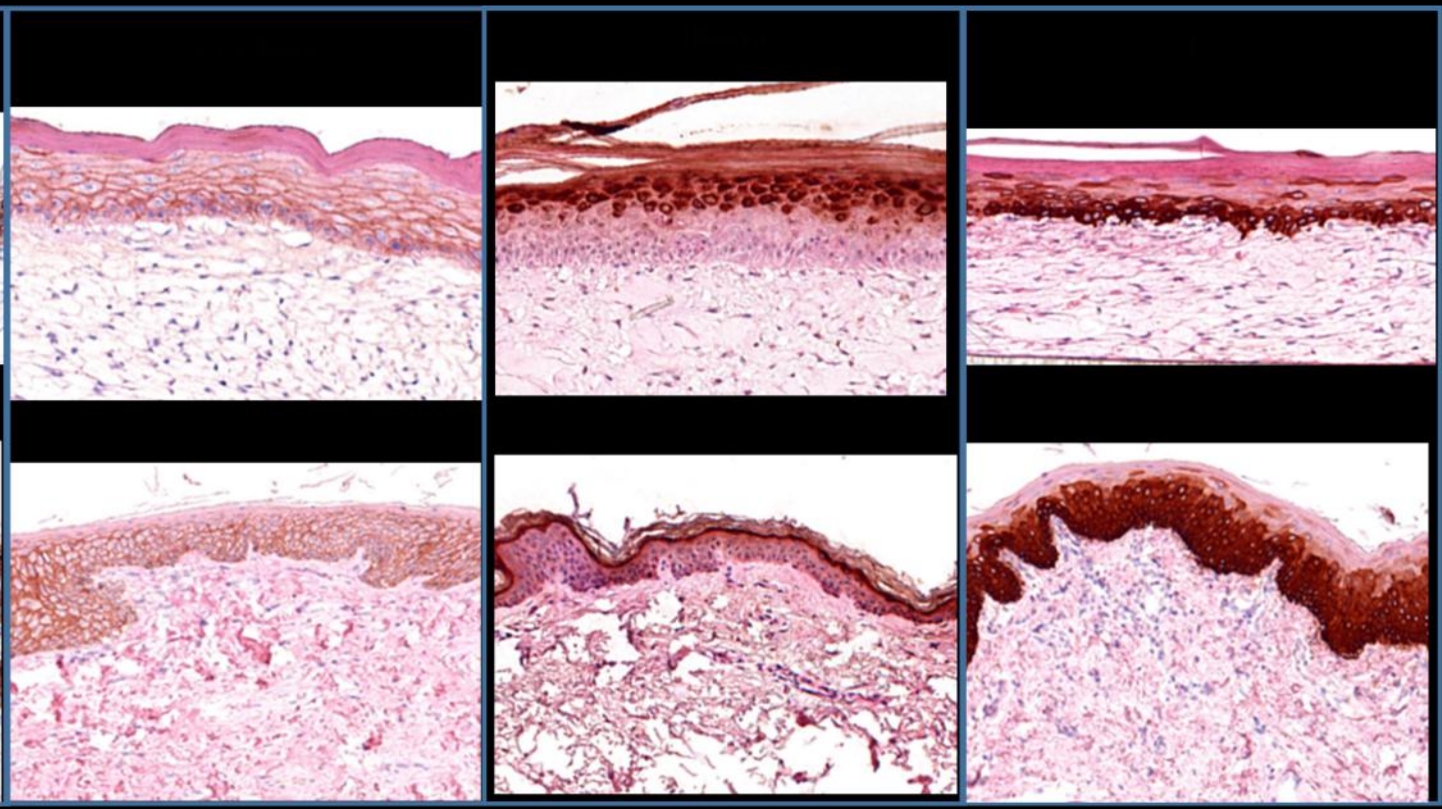
Another major application of bioprinting is testing patient samples to develop personalised treatments, as bioprinted organs can mimic the intricate structure and function of human tissues far better than traditional models. This can lead to safer and more effective therapies, particularly for complex conditions.

Successfully bioprinting organs is therefore a very appealing option.

What is 3D bioprinting?

3D bioprinting uses the same layer-by-layer printing technique as traditional 3D printing to construct three-dimensional structures from digital designs.[2] Instead of plastic, it uses 'bio-ink', made from living cells and various chemicals that support their survival, such as growth factors. The living cells can be sourced from either a donor or the patient themselves, allowing researchers to create patient-specific body parts like organs and other tissues.

There are several 3D bioprinting methods, but in essence, the bio-ink is loaded into a printing chamber and extruded through a moving nozzle to lay down cells in the correct formation. As each layer is added individually, the cells form tissue that (ideally) has all of the structural intricacies of the original organ, including empty channels for blood vessels.



The applications of 3D bioprinting

The use of 3D bioprinting is already well-established in technologies such as lab-grown organs and organ-on-a-chip devices for research. The latter involves labyrinths of tiny channels and tissues in which researchers experiment on the micro- and nano-metre scale. They can be personalised with patient samples, enabling experimentation with a patient's cells and tissues outside the body. This innovative technology allows them to create patient-specific customised body parts to maximise treatment outcomes. Moreover, bioprinted tissues can also be used for drug testing to reduce the current reliance on animal testing.

Researchers now aim to use 3D bioprinting technology to print organs for transplantation. Already, there has been successful use of 3D bioprinting technology to create a bladder (1999), prosthetic leg (2008), jaw (2012), and skin (2018).[3] One patient who received a 3D bioprinted bladder transplant reported that their bioprinted organ is still fully functional decades after their transplant.[4]

Two years ago, scientists performed the first transplantation of a 3D bioprinted ear. The 20-year-old patient was born with a small and misshapen right ear, with no externally connected ear canal. The bioprinted ear was grown in stages, starting with cells responsible for producing cartilage, and combining them with a collagen-based bio-ink. The bioprinted ear was then transplanted, successfully reconstructing the patient's external ear.[5]

As research continues to progress, the use of 3D bioprinting is extending to more and more organs and tissues.

Challenges of 3D bioprinting

Despite positive advancements in this technology, it is still difficult to build complex organs like heart, lungs or liver. Additionally, ensuring sufficient blood and oxygen supply to a full-sized bioprinted organ presents a significant challenge.

Maintaining the health of the cells in the bio-ink both before and after printing is equally challenging, since the cells can be physically destroyed if the nozzle of the tube is too small, or the printing pressure is too high. Careful consideration of a range of factors is therefore critical for successful bioprinting of any kind.

The future is bright

3D bioprinting is a revolutionary technology that provides us hope for addressing one of the trickiest problems in the medical field. Researchers aim to develop full-sized, complex organs in the future, as well as enhanced personalisation of treatments and transplants.[6]

Hopefully technologies like 3D bioprinting can help to ensure that anyone in need of an organ transplant isn't confined to the bottom of a long wait list.

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Welcome to the Fold

The Nobel Prize-winning AI driving scientific discovery

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Laptop overlaid with open source AlphaFold code (available from GitHub). Photograph modified from: Daniel Korpai via Unsplash.

> Imagine if you could use a sequence of letters to unlock the secrets of treating incurable diseases, conserving the environment, and countering antibiotic resistance. This may sound like science fiction, but a new artificial intelligence (AI) program is making it a reality.

For over 50 years scientists contended with the "protein folding problem": while DNA tells us the order of the amino acids in a protein, it's much harder to predict a protein's three-dimensional shape.[1] As a protein's structure is critical for its function, predicting a protein's shape is important for understanding its production and interactions.

In 2020, the AI program 'AlphaFold' was released. This program can predict the structures of proteins with high accuracy,[2] and its arrival is a potential revolution in various fields of research.

Nobel Prize? No surprise

Last year, the Nobel Prize in Chemistry was awarded to the creators of AlphaFold, Sir Demis Hassabis and Dr John Jumper at Google DeepMind, alongside Professor David Baker.[3] To many, this did not come as a surprise, as the significance of AlphaFold has been clear since its release. The technology is highly effective, freely accessible, saves significant resources, and is applicable to a wide range of scientific fields.

From drug discovery to the breakdown of plastic pollution, AlphaFold has made its mark. The AI program is designed to solve protein structures, but what does this mean and why is it important?

Life's machines called proteins

Proteins are involved in most natural and many industrial processes, from functions of the immune system to harnessing nature to break down plastic pollution. They consist of building blocks called amino acids, which can be visualised as a string of different beads forming three-dimensional shapes.

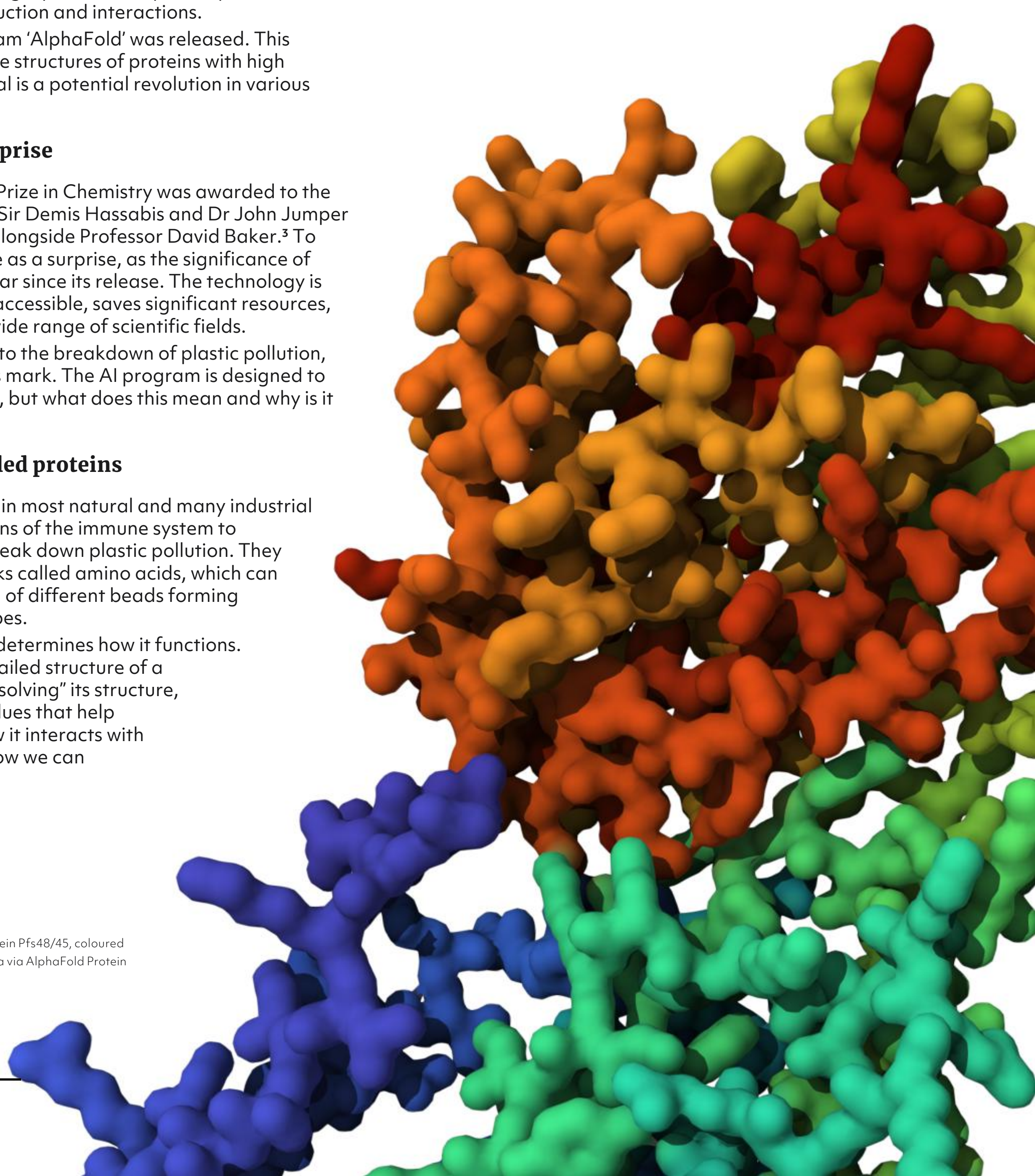
A protein's structure determines how it functions. Learning about the detailed structure of a protein is regarded as "solving" its structure, as this provides many clues that help understand its role, how it interacts with other molecules, and how we can manipulate it.

Scientists have dedicated decades to solving protein structures, allowing for the development of valuable new technologies, such as vaccines for COVID-19. Many would recall seeing the SARS-CoV-2 virus in the media: the surface of the virus dotted with spike proteins. Establishing the structure of this spike protein revealed key regions that could be targets for vaccine development.[4,5]

Traditional techniques have limits

Experimental methods for determining protein structure have existed for over half a century, enabling scientists to dip into the protein structure pool. The results of approximately 200,000 protein structures have been collated in an online database named the Protein Data Bank (PDB).[6] However, the number of proteins in the world is huge - in the billions. The techniques used to understand each individual protein can be time-consuming and resource-intensive, requiring intricate multi-step processes and years of expertise.

Other tools are needed to streamline this experimentation, speeding up our discovery and understanding of protein structures. This is where AlphaFold comes in.



Structural representation of the protein Pfs48/45, coloured by sequence ID. Image: Breana Galea via AlphaFold Protein Structure Database (CC-BY-4.0).

Paradigm-shifting predictions

The potential of the AI program AlphaFold was first realised at the fourteenth international Critical Assessment of Protein Structure Prediction conference, known as CASP14. This conference assesses how accurately different computational methods can predict protein structures. It has long been considered the benchmark for assessing these models against experimental methods.

At CASP14, AlphaFold vastly outperformed other computational methods and showed it could produce protein models that were accurate within the width of one atom. This is on par with experimental techniques.[7]

Entire PhD theses were once dedicated to solving a single protein's structure. Now, AlphaFold could predict the structure in a matter of hours, or even minutes. It does this through a unique computational approach called deep learning.

The algorithm behind the AI

Taking inspiration from the complex inner workings of the brain, 'deep learning' uses artificial neural networks to process huge amounts of data. AlphaFold works by starting with an amino acid sequence, the string of beads which forms three-dimensional shapes. It also factors in known information about other proteins, as families of proteins with similar functions tend to have conserved sections that appear similar.

The AI program then searches through various databases for similar sequences, and collects relevant information about the physical, geometric, and evolutionary properties of these proteins. AlphaFold integrates all this data into its algorithm to assemble a preliminary three-dimensional protein structure. This process is iterated several times over, and with each iteration improving upon the previous prediction. Ultimately, this allows AlphaFold to output highly accurate protein structures.[2,8]

With this kind of technology at people's fingertips, a wave of new scientific discoveries has been unleashed.

Invaluable impact

Access to AlphaFold has catalysed novel developments across science, technology, engineering, and mathematics (STEM), in areas like drug discovery, plastic pollution, and antibiotic resistance.

As one example, the AI program has been used to solve protein structures crucial to treating malaria. The structure of the protein Pfs48/45, which is involved in the development of the malaria parasite, was solved with the help of AlphaFold after many years of inconclusive experimentation by teams of researchers.[9] A vaccine has been developed based on this protein, which has already successfully completed a phase I clinical trial as of 2022.[10]

Proteins called enzymes serve a key role in countless biological and industrial processes, including breaking down plastic. Google DeepMind has partnered with the Centre for Enzyme Innovation at the University of Portsmouth to establish the protein structures of over 100 enzymes that could help break down chemicals in plastics, using AlphaFold. With this database, they aim to design enzymes that are cheaper, more structurally stable, and are faster acting to enhance plastic recycling.[11]

Antibiotic resistance is a growing healthcare crisis, and threatens our ability to effectively and safely treat a wide range of bacterial infections. The mechanism of resistance is often a bacterial protein that allows the organism to survive the drug, such as proteins that "pump" antibiotics out of the bacteria before they can be killed. One protein structure involved in a mechanism that causes bacterial resistance had evaded scientists for a decade. AlphaFold solved the protein structure in 30 minutes.[12]

This has accelerated research in this area and opened new possibilities for preventing deadly bacterial infections.[13]

A New Framework for the Future

For the most part, AlphaFold has solved the "protein folding problem". It has accelerated scientific discovery and propelled research ideas into reality, where vaccines are entering the clinic and enzymes are being created to potentially conserve the environment. The developers of the AI program have also compiled the AlphaFold Protein Structure Database, which now includes over 200 million predicted protein structures, compared to the previous 200,000 in the PDB.[14]

As for the future of AlphaFold, it has already expanded into other versions designed for protein interactions or mutations. Although the AI program is highly accurate, it is still best used alongside experimental methods. This helps ensure that the protein structures it predicts really do transfer into the real world. Nevertheless, AlphaFold is being continually pushed to grow – competitors like RoseTTAFold, developed by the other Nobel Prize winner Professor Baker, are catching up quickly.[15] With this ongoing progress, we are heading into an exciting future of important discoveries.

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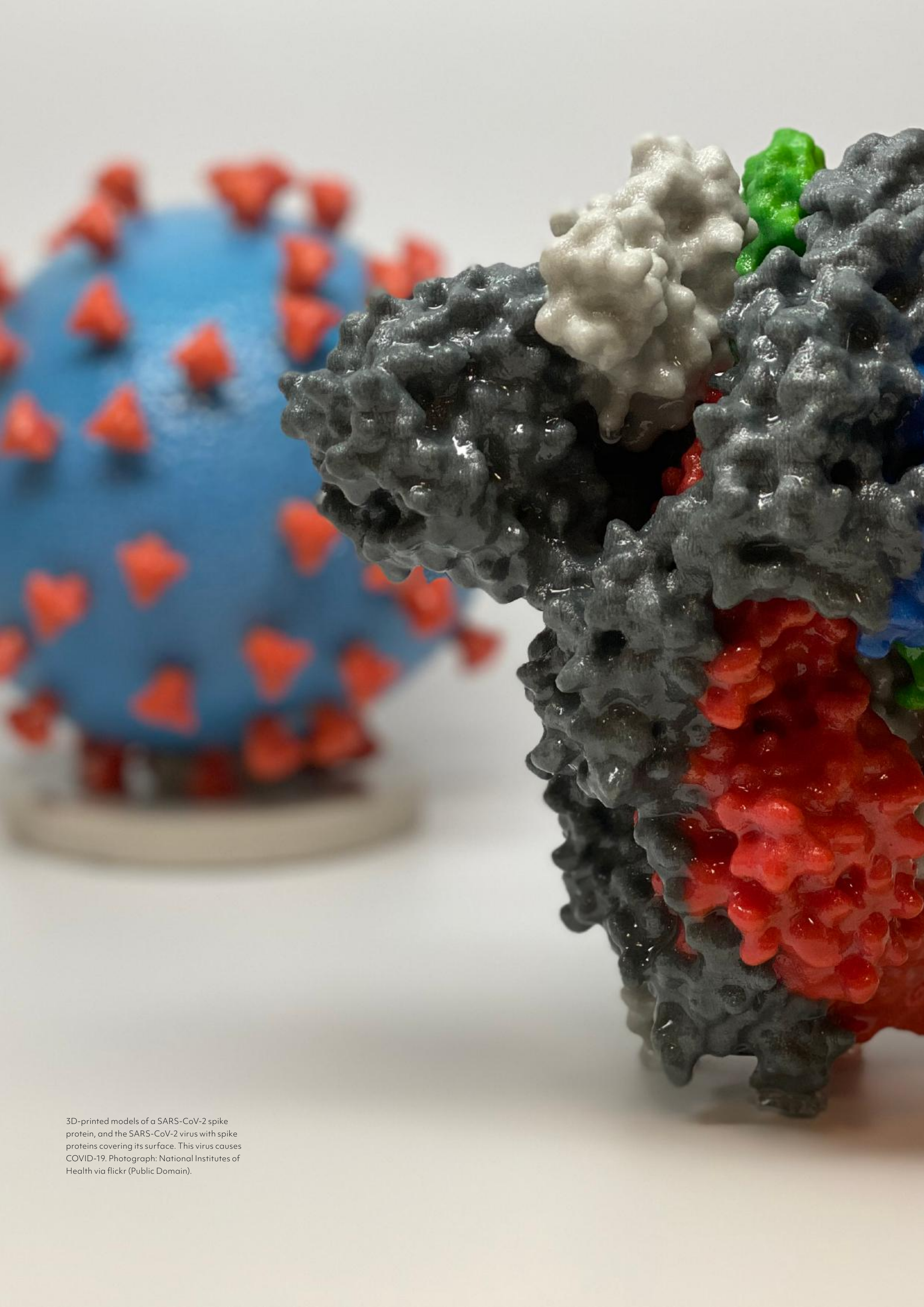

3D-printed models of a SARS-CoV-2 spike protein, and the SARS-CoV-2 virus with spike proteins covering its surface. This virus causes COVID-19. Photograph: National Institutes of Health via flickr (Public Domain).

1876

The State of Science in 1876

SCOTT REDDIEX MRSV
Editor-in-Chief, Science Victoria

The end of the 19th century found the world amid the second industrial revolution. Referred to as the 'technological revolution', it was a time marked with rapid progress in the discovery and application of science, with examples including radio (Hertz) and telephones (Bell) were invented, electricity harnessed (Edison, Tesla), microbiology and germ theory of disease emerged (Pasteur, Koch, Lister), Mendeleev's periodic table of the elements, and many more.

Rail, internal combustion engines, and the telegraph system connected cities and countries like never before. The rate of discovery and knowledge-sharing was increasing at an exponential rate, and many learned societies – like the Royal Society of Victoria – were being established around the world.

On the 10th of August 1876, President Robert L. J. Ellery presented his anniversary address to the society, in which he reflected on the current state of scientific discovery and application across a number of fields.

Astronomy

"In Astronomy there appears little of more than passing interest to arrest our attention; it almost seems as if a lull had fallen on this department of science after the unusual activity caused by the transit of Venus in December, 1874. This is apparent only, for nearly all the national observatories have been busily engaged, each in its own particular direction."

In addition to new or upgraded telescopes in Paris, Washington, and Vienna, Ellery predicted that "likely there will be more busy eyes and large telescopes occupied on the fainter celestial objects"

Preliminary results from the 1874 observations of the transit of Venus across the face of the sun indicated *"that the sun's distance, from these observations, will be found to be … somewhere between 91,580,000 and 91,240,000 miles."*

Additionally, the *"number of the planetoids (the small planets which occupy the gap between the orbits of Mars and Jupiter) already discovered is 161."*

"Most of these bodies are so minute that their detection among the myriads of small stars is a matter of considerable difficulty, even to accomplished observers; but, nevertheless, a systematic search for new members of this group with telescopes of adequate power, appears to be always rewarded by discovery."

Physical Sciences

"In Physical Science also there is nothing of more than ordinary interest to refer to."

"Some little sensation has been excited lately by the supposed discovery of a new force, allied to electricity, and called etheric force.

"There can be no doubt, however, that they are simply induction phenomena, perhaps not hitherto thoroughly investigated, although certainly known, but which with the present tendency to discover new forces have been precipitately put in that category."

Ellery was correct, as 'etheric force' was later determined to be high-frequency electromagnetic waves – i.e., radio waves.

Chemistry

Most of the elements on the periodic table have existed stably on Earth (in different quantities) since it first formed. While early scientists and philosophers the world over tried to understand the constituent components of matter, our understanding of each element is extremely recent by comparison.

"Although the science of Chemistry advances steadily from year to year, it is not quite always that discoveries of popular interest are included among its newer acquisitions; the newly-discovered metal "gallium" is, however, sufficiently remarkable to demand a brief notice on this occasion."

It was thanks to the *"much more delicate … method of spectrum analysis [that] has enabled us to discover – first, rubidium and caesium, then thallium, afterwards indium, and now by its means gallium has been recognised."*

"All these are elements; they are all metals, each possessing definite chemical and other properties."

FROM:
Transactions and Proceedings of the Royal Society of Victoria, Volume XIII, 1877.

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The Melbourne Observatory in 1873. Located in King's Domain, it operated as Victoria's central astronomical institution from 1863 until 1945, by which time light pollution hindered its scientific use. Today, the site is preserved, with its telescopes occasionally utilised for educational activities and amateur astronomy. Photograph: Charles Bayliss, taken from Government House Tower. Source: State Library of New South Wales via Wikimedia Commons (Public Domain).

TOP: Rubidium (back) and Caesium (front) crystals sealed in vacuum ampoules. Photograph: ErpingWu via Wikimedia Commons (CC BY-SA 4.0).

LEFT: Professor Tyndall demonstrating a fog-horn to Queen Victoria and her entourage, 13 May 1876. Wood engraving by T. B. Wirgman, n.d. c.1876. Illustration for The Graphic: An Illustrated Weekly Newspaper, 27 May 1876, Sat. Page 8. (Public Domain)

Biomedical Sciences

The recent medical breakthrough discussed by Ellery – injection of ammonia to treat a snakebite – would not stand the test of time. However, he followed this with discussion of a very important subject that was *"exciting some considerable attention in England just now"*.

The subject was *"the movement against vivisection"* – that is, live animal experiments. Concerns that the inhumane practice was extensively performed without any scientific purpose had prompted a Royal Commission on the matter, which had in turn resulted in proposed legislation:

"The provisions of the bill are categorically given in Nature, and are as follow: -

1. *Experiments must be performed with a view only to the advancement, by new discovery, of knowledge which will be useful for saving or prolonging human life, or alleviating human suffering;*
2. *In a registered place;*
3. *By a person holding a licence from one of Her Majesty's principal Secretaries of State;*
4. *The animal must, during the whole experiment, be under the complete influence of some anæsthetic, not urari [curare]; and*
5. *Must be killed before it recovers from the influence of the anæsthetic;*
6. *The experiment shall not be performed for demonstrational purposes;*
7. *Nor for the purpose of attaining manual skill."*

Climate Science

The climate of 1876 had not yet been ravaged by humanity, and the primary concerns were water scarcity and weather forecasting.

"To us in Australia the value of a better knowledge of the laws that govern the weather can scarcely be overrated, as our prosperity depends so largely on the amount and period of rainfall."

Ellery noted that it may become *"possible, by systematic investigation, to foresee the approach of great disturbances of the atmosphere, or even critical seasons, and to be forewarned is to be forearmed."*

However, he did not consider in this piece that any forewarnings would fall on the deaf ears of those with the power to arm us.

Science Education

Public engagement with science was predictably different in 1876, however one similarity is that nothing compares to seeing things in-person.

The 1876 "Special Loan Collection of Scientific Apparatus" in London was a crowd-sourced exhibition, comprising ~20,000 scientific instruments loaned from around 1,200 private individuals, universities, learned societies, companies, and state departments around the world.1

Ellery briefly addressed the nature of the exhibits that visitors had the chance to see:

"The Astrolabe of Tycho Brahe, the telescope of Galileo, will be seen together with the magnificent astronomical instruments of the present day, prominent among which are models of the great Melbourne reflector and the gigantic Vienna refractor of 27 inches aperture.

The various sections are so arranged that, in many cases, the history of the progress in the respective sciences is more plainly shown than could be done by a written book; while throughout can be contrasted specimens of the earliest apparatus used in any branch of science with the refined appliances of the present day – Newton's simple optical apparatus with the exquisite prisms and spectroscopes of today; Dalton's crude balance with the magnificent weighing machines of the present time, with the unimpeachable weights of pure quartz.

It would occupy too much time to speak of this subject with any justice to its importance."

On the affairs of the Society, and the future

Ellery ended his anniversary address with some reflections on the current state of the society's purpose, and how they should approach the future.

"The fields of investigation are only too numerous; the further we advance in knowledge the wider they become; the more science contributes to the welfare, convenience, or luxury of the community, the more is demanded of it. So our young scientists have no lack of scope for their inquiries."

He also made an observation that remains true today: the idea of what is or isn't worth sharing.

"I have often found that most interesting and valuable information has been withheld because of a fear that it was of too trivial a nature, not original, or not sufficiently scientific."

"If we each do our best for the advancement of knowledge we shall all do something, and I am sure the result will redound to the credit of this Society, as well as of the country we now belong to."

Inspiring Victoria

inspiringvictoria.org.au

The Inspiring Australia strategy was developed by the Australian Government to increase general engagement and interest in the sciences by Australians. The *Inspiring Victoria* program is jointly funded by the Australian and Victorian governments with the Royal Society of Victoria (**rsv.org.au**).

Inspiring Victoria encourages involvement in STEM through initiatives (such as National Science Week Victoria - **scienceweek.net.au/your-state/vic**) that are governed and delivered by the RSV's program partners:

PUBLIC LIBRARIES VICTORIA
plv.org.au

NEIGHBOURHOOD HOUSES VICTORIA
www.nhvic.org.au

PARLIAMENT OF VICTORIA
parliament.vic.gov.au

MUSEUMS VICTORIA
museumsvictoria.com.au

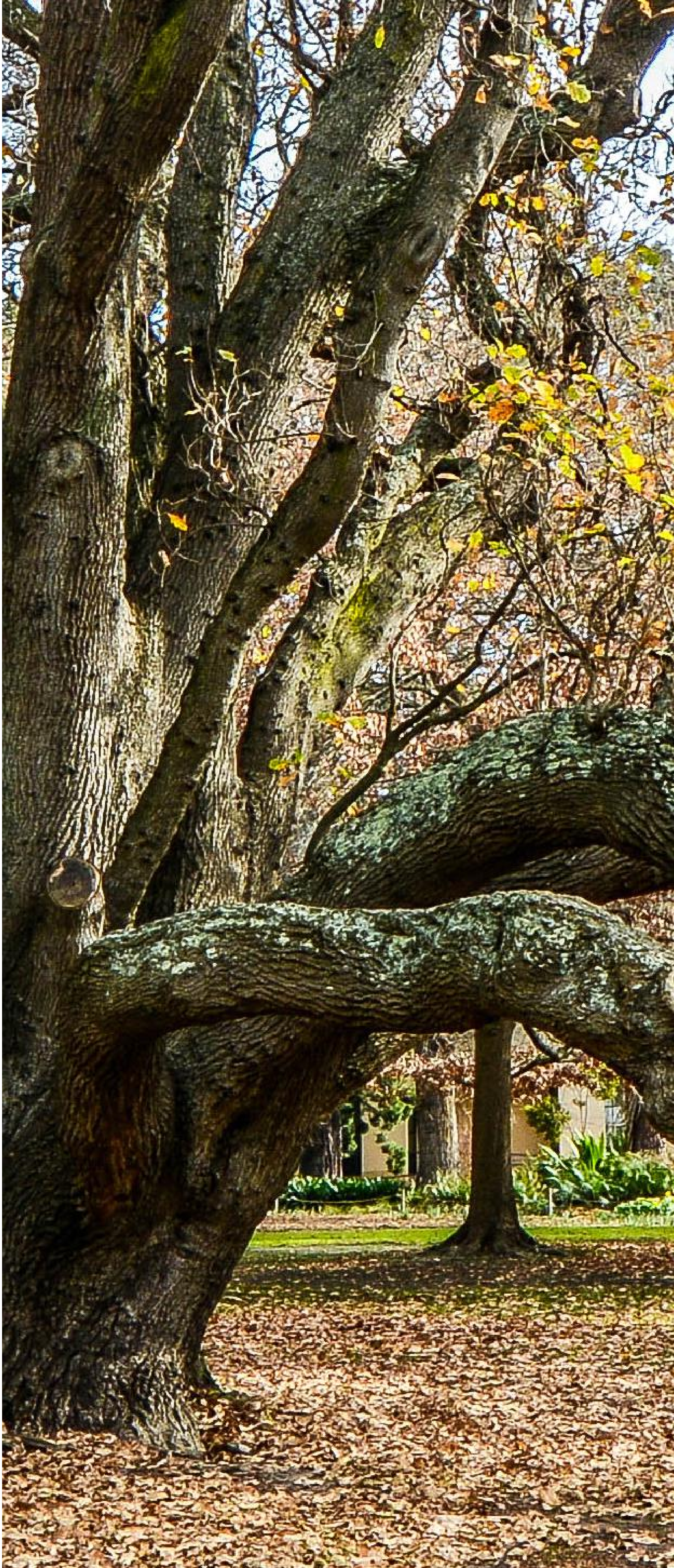
ROYAL BOTANIC GARDENS VICTORIA
rbg.vic.gov.au

ZOOS VICTORIA
zoo.vic.gov.au

QUESTACON
questacon.edu.au

SCIENCE TEACHERS ASSOCIATION OF VICTORIA (STAV)
stav.org.au

RIGHT: Royal Botanic Gardens Victoria, Melbourne.
Photograph: Goran Has via flickr (cropped, CC BY 2.0).



Call for Scientific Papers

AVAILABLE ONLINE AT PUBLISH.CSIRO.AU/RS

The Proceedings of the Royal Society of Victoria is our refereed journal, published twice annually by CSIRO Publishing.

The Society invites contributions for the *Proceedings* from authors across the various disciplines of biological, physical and earth sciences, including multidisciplinary research, and on issues concerning technology and the applied sciences.

Contributions on topics that are relevant to Victoria and the south-eastern Australian region are encouraged. The journal also publishes Special Issues and themed collections of papers commissioned by the Council of the Royal Society of Victoria. It is published online in May and November, with two issues constituting a volume.

The *Proceedings* is one of Australia's oldest and longest-running science journals, a terrific platform for establishing an individual research presence, grouping papers derived from symposia on specific subjects, or simply joining a distinguished tradition of science published in or about our region that stretches back to the 1850s.

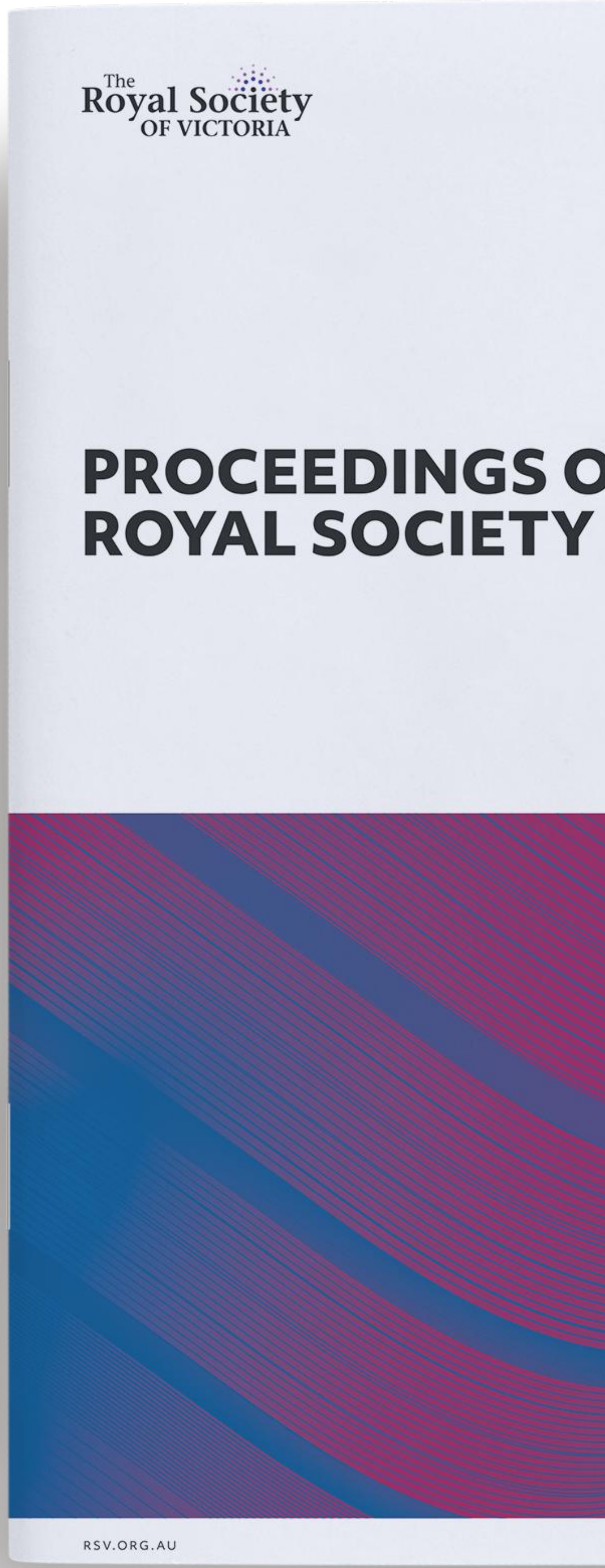
The journal began in 1855 as an irregular publication under the title *Transactions of the Philosophical Society of Victoria,* with the present name adopted in 1889. Since then, volumes of the journal have been published annually, often across one or more parts.

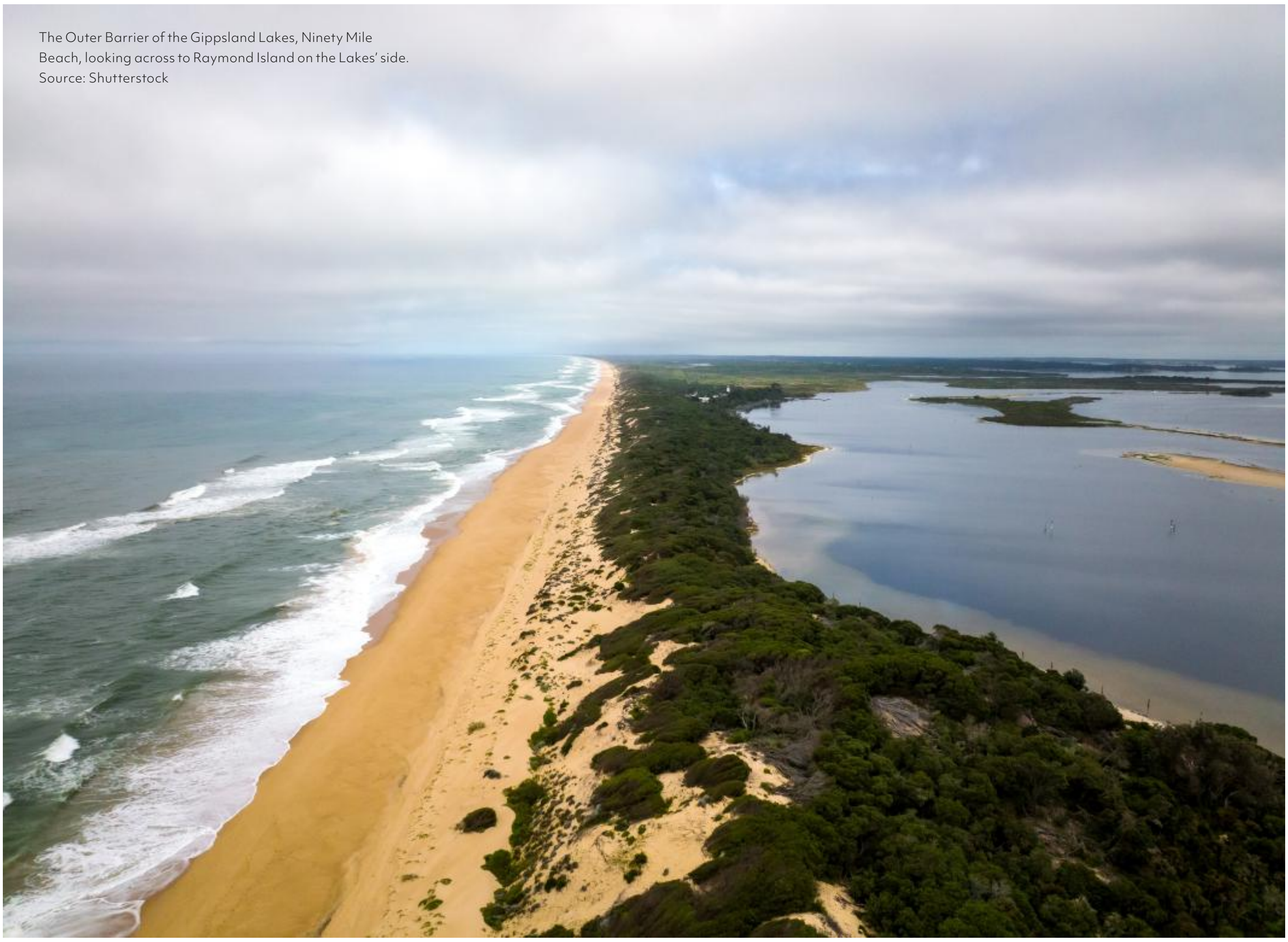
The online content published by CSIRO Publishing extends back to Volume 118, 2006, and is available at **publish.csiro.au/rs**.

All volumes of the *Proceedings* and its predecessors from 1854 to 2006 are also available free online at **biodiversitylibrary.org/creator/6984**.

Submissions

Those interested in submitting papers should review the Author Instructions at **publish.csiro.au/rs/forauthors/AuthorInstructions**. Manuscript submissions for the Proceedings are now made using the ScholarOne platform. Any enquiries regarding submission can be made to **editor@rsv.org.au**





The Outer Barrier of the Gippsland Lakes, Ninety Mile Beach, looking across to Raymond Island on the Lakes' side. Source: Shutterstock

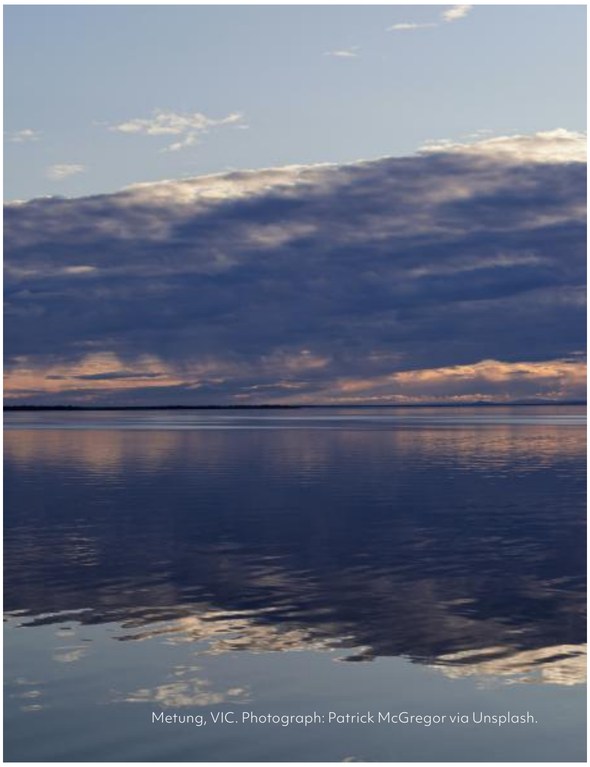
The Future of the Gippsland Lakes

PROCEEDINGS OF THE ROYAL SOCIETY OF VICTORIA, VOLUME 136

The first papers from Volume 136 of the *Proceedings of the Royal Society of Victoria* are now available online, open access from CSIRO Publishing, hosted at **publish.csiro.au/rs/collection/12070**. This volume is the first to be released under CSIRO Publishing's new 'publish-as-you-go' model, progressively collecting the volume over the course of the year.

This collection on the Gippsland Lakes compiles papers commissioned following the roundtable held at the Royal Society of Victoria on 26 May 2023, involving research expertise along with First Nations (Gunaikurnai) representation. It summarises the geomorphological character of the Lakes system, the current state of estuarine health, and anticipates the impacts of intensified human activities, a drying regional climate and rising sea levels on the interaction of the marine and freshwater ecological conditions.

The Society's report from the roundtable, titled 'Securing the Future of the Gippsland Lakes,' is also available at **rsv.org.au/gippsland-lakes**.



Metung, VIC. Photograph: Patrick McGregor via Unsplash.

Securing the future of the Gippsland Lakes

Photograph: eutrophication&hypoxia via flickr (CC BY 2.0)

A Foreword to Volume 136

ROB GELL

Estuaries provide us with a suite of resources, benefits and services providing critical habitat in parallel with sites for public infrastructure. They are among the most productive environments on Earth.

Australia possesses a wide variety of estuarine types exhibiting a wide range of physico-chemical conditions, some are less than a square kilometre in area. Each faces compound threats to their ecological condition assets through poor catchment management. Human settlements are frequently located on estuaries as they provide transport access, food and other resources for development.

Evidence of poorly regulated development is manifest in historical instances of fish kills due to reduced freshwater flows and unregulated pesticide use highlighting the longstanding challenges in balancing public and private interests in estuarine management. Sydney Harbour, for example, continues to grapple with the consequences of industrial pollution, impacting commercial fishing. As climate change intensifies, these challenges will multiply, endangering significant estuaries like the Gippsland Lakes.

The Gippsland Lakes comprise the largest estuarine lagoon system on the Australian continent and the largest coastal wetland complex in southeastern Australia, encompassing linked and isolated lagoons, swamps, active and abandoned river and tidal channels within the Gippsland Basin. The Lakes are 1 of 12 wetland systems in Victoria currently listed under the Ramsar Convention on Wetlands, an international agreement for the conservation of wetlands. The Lakes have been listed as a Ramsar site since 1982, covering over 600 km^2. Once the entire terrestrial catchment area is taken into consideration, the area of concern takes in 20,000 km^2.

A comprehensive natural capital accounting programme should be undertaken for the Gippsland Lakes to facilitate improved future decision-making and consistent monitoring of both conditions and outcomes over time. The Australian Government has undertaken such assessments of the Murray-Darling Basin and other regional ecosystems in recent years.[1]

In May 2023 The Royal Society of Victoria convened a roundtable discussion of scholars and catchment managers to consider the Victorian Government's review of the Gippsland Lakes Ramsar Site Management Plan over the course of 2023–2024. The roundtable presenters and participants reviewed a range of concerns, and provided an evidence base in support of these concerns with the intention of conveying these for consideration of informed actions by decision makers. This resulted in the compilation of a presentation program, a series of abstracts (provided as Attachment A in the report 'Securing the Future of the Gippsland Lakes') with further papers commissioned and presented in this collection of papers of the *Proceedings of the Royal Society of Victoria in 2024.*

▶ You can read this open access paper in the *Proceedings of the Royal Society of Victoria* via CSIRO Publishing at **publish.csiro.au/rs/RS24007**.

REFERENCES:

1. Past work on national capital accounts. (2024, September 2). DCCEEW. www.dcceew.gov.au/environment/environmental-information-data/natural-capital-accounts/past-work

Current Government Consultations of Interest to Victoria's Science Community

Projects open for consultation from ***engage.vic.gov.au/project***

KWON JUNHO via Unsplash

CONSULTATION CLOSES 07 FEBRUARY 2025

Victoria's Renewable Gas Directions Paper

We are seeking your input to help design policy that could best support the efficient and effective use of renewable gas in Victoria.

engage.vic.gov.au/victorias-renewable-gas-future

Ed Dunens via flickr (CC BY 2.0)

CONSULTATION CLOSES 14 FEBRUARY 2025

Dyurrite Cultural Landscape Management

Parks Victoria is seeking feedback about the draft Dyurrite Cultural Landscape (Mount Arapiles-Tooan State Park) Management Plan Amendment.

engage.vic.gov.au/dyurrite

Gonz DDL via Unsplash

CONSULTATION CLOSES 16 FEBRUARY 2025

Managing the biodiversity impacts of renewable energy

Have your say on Victoria's guidance to protect biodiversity as we transition to 95% renewable energy by 2035.

engage.vic.gov.au/a-better-approach-to-managing-the-biodiversity-impacts-of-renewable-energy

Anthony Indraus via Unsplash

CONSULTATION CLOSES 28 FEBRUARY 2025

Building Electrification – Regulatory Impact Statement

Have your say on proposed options to progressively electrify residential and commercial buildings across Victoria.

engage.vic.gov.au/building-electrification

Submission Guidelines

Pitch it to us!

Have an idea for an article? We want to hear from you!

Briefly outline your key message, why it should be shared in *Science Victoria*, and the proposed article type. Pitches can be submitted at any time, but check submission deadlines if you're interested in publishing in a particular edition.

All pieces will be reviewed prior to publishing, and may be edited for length and clarity (although we will not alter the message or context of your work).

Send pitches and any questions to **editor@ScienceVictoria.org.au**.

We welcome your pitches relating to current sci entific research in Victoria, recent scientific discoveries, social and policy issues, technical innovations, and overviews of impactful research.

Science Victoria's articles are written in plain, non-academic language, and thoroughly referenced (see: References).This is not a platform for scientific journal articles or media pieces. For more information on what we're looking for, see below.

Style Guide

All pieces should have readability in mind. A good litmus test is knowing that most people have read a piece or been to a presentation that managed to make the most interesting topics incredibly boring and/or confusing. This is what you want to avoid.

A general guide for readability is that it should be understood by an educated 16-year-old – or ask a friend or family member to proofread!

Feature Articles

Recommended length: 600 - 1,800 words

Feature articles are more in-depth pieces on a specific topic related to STEMM. A key aspect of feature articles is the narrative – this isn't a journal article, so think about the story that your article is trying to tell.

Avoid using jargon, as it will quickly alienate anyone who isn't an expert in that field. Explaining one or two otherwise irreplaceable terms is fine.

Use of sub-headings and figures to break up longer pieces is strongly encouraged.

Not quite sure about the tone for your piece? Have a look at articles published in previous editions of *Science Victoria*, or in other scientific publications for a general audience, like *The Conversation, Cosmos, New Scientist, or Scientific American.*

Opinion Articles

Recommended length: 600 - 1,800 words

In contrast to a feature article, an opinion piece conveys your informed opinion on, or experiences with, a particular topic. Clearly state your argument, outlining the details of the problem you are addressing, and build to a strong conclusion.

For greatest impact, your choice of topic should be one that is broadly relevant to STEMM-related fields in Victoria. Examples of possible topics include how to address a climate-change related problem in Victoria; successes and failures common to STEMM engagement initiatives; ethical problems related to scientific projects or careers in STEMM; your experiences of a career in STEMM and thoughts on how to better support the next generation of researchers; existing STEMM-related studies or approaches that you believe could be applied in Victoria.

We welcome well-informed opinion articles from all authors, particularly from those with significant expertise in a given area. Articles may reference your own work; however, these are not promotional fluff pieces.

Letters

Recommended length: 200 – 1,000 words

Letters have minimal restrictions on style, structure, or subject matter. You are encouraged to submit your thoughts/questions/comments that broadly relate to STEMM in Victoria. Potential subject areas include responses to articles in previous editions of *Science Victoria*, seminars at scientific events, science-related issues and policies, or topics you'd like to see in future editions.

Letters are also the best format to share current or recent news relating to science, with an emphasis on science in Victoria or news that impacts Victoria's scientific community. News could relate to funding announcements/grant outcomes, new STEMM-related projects, high-impact publications relevant to Victoria, successes of Victorian scientists, or relevant STEMM-related policy news.

Where a specific question is asked, we will try to have the appropriate person respond to your letter.

What I've Been Reading

Recommended length: 600 - 1,800 words

This is a column for you to tell us about a book broadly relating to STEMM that you've read. These pieces typically include a summary of the book and its ideas, as well as your interpretations or conclusions. Possible questions to consider: Do you think the author was correct in any assumptions? Was the author's style of writing approachable? Did they do the subject matter justice? Who would you recommend this particular book to? What did it mean to you? What did you learn?

Images and Figures

Images are strongly encouraged, however please only provide files that are either completely original, in the Public Domain, or covered by an appropriate Creative Commons license. Images must include details of the source, license, and any relevant descriptions.

If suitable images are not provided, we may include relevant Public Domain/Creative Commons images.

All images must be of sufficient size and quality – as a rough guide, aim for >1.3 MB in file size.

References

Please reference primary sources/journal articles for any non-trivial scientific claims, or for publications that prompted your writing of the article. If references aren't provided, we will request them for specific statements.

References for all articles should use a modified APA 7th edition format: reference list in author-year format, with numbered in-text citations. Refer to articles in previous editions for examples. Please do not submit pieces that use MS Word's References/Footnote/Endnotes feature, as it forces us to manually re-write your references.

2025 Editions & Deadlines

JANUARY & FEBRUARY 2025 — **DUE DATE**
Biotech in Victoria — *17 January*

Harnessing biological organisms.

MARCH & APRIL 2025 — **DUE DATE**
Preventing Future Problems — *7 March*

Identifying and preventing problems that threaten our planet in the future.

MAY & JUNE 2025 — **DUE DATE**
Fighting 21st Century Diseases — *9 May*

Tackling the leading causes of morbidity and mortality.

JULY & AUGUST 2025 — **DUE DATE**
Future Science & Tech — *4 July*

Opportunities, barriers, and risks of emerging fields in science and technology.

SEPTEMBER & OCTOBER 2025 — **DUE DATE**
Science Engagement — *5 September*

Meaningful connection of STEMM with everyone.

NOVEMBER & DECEMBER 2025 — **DUE DATE**
Knowledge Systems — *5 September*

Acknowledging, understanding, and Integrating the science of different knowledge systems.

Hold Your Next Event at the Royal Society of Victoria

The RSV engages communities with scientific knowledge through aligned partnerships, events, festivals, conferences, and education programs.

Services Available

We also provide a number of services to ensure your event is a success. Some of the services we provide are:

- Event management
- Meeting venues
- Grants and awards administration
- Social media campaign management
- Broadcasting and video production
- Recruitment of scientific panels
- Convening community engagement and deliberation processes where scientific work contributes to social, environmental, and economic impacts and benefits.

The Facilities

The RSV's facilities are available for hire to organisations, companies, or private groups.

Audio-visual and seminar equipment is available for use, including videoconferencing facilities for hybrid Zoom/MS Teams meetings.

There is a commercial kitchen on the ground floor, suitable for your own use or by a caterer.Limited parking is available on-site, and a commercial parking operator is adjacent on La Trobe Street.

Take a Virtual Tour

Take a Virtual Tour of the building at: **matterport.com/discover/space/royal-society-victoria**

The Burke and Wills Room

The beginning and end of the ill-fated Victorian Exploring Expedition of 1860-61 is a beautiful, multi-function space with an adjoining kitchen, suitable for a range of events.

SUITABLE FOR

Workshops, roundtables, luncheons, dinners, seminars, and functions.

CAPACITY

Workshops	*≤30 people*
Dinners	*≤60 people*
Catered Functions	*≤80 people*

The Ellery Lecture Theatre

First-floor lecture theatre, with raked seating, speaker's podium, and audio/visual equipment. Perfect for lectures, presentations, and conferences.

SUITABLE FOR

Presentations, seminars, lectures.

CAPACITY

Any Booking	*≤90 people*

← Back to Contents

Support the RSV

Book online for your meeting, conference, or a larger event.

Just visit **rsv.org.au/facility-hire** to explore our rooms, check availability, and secure the perfect space for your needs. Book now to ensure your date!

The Cudmore Library

The Cudmore Library A picturesque room with videoconferencing and projection equipment. Great for larger meetings and seminars, with in-person or hybrid attendees.

SUITABLE FOR
Meetings, seminars, and videoconferencing.

CAPACITY
Any Booking *≤15 people*

The Von Mueller Room

A light-filled room on the first floor, perfect for smaller meetings and seminars, or group/individual work.

SUITABLE FOR
Meetings, seminars, and videoconferencing.

CAPACITY
Any Booking *≤15 people*

Support Victoria's Science Society in 2025 and help us to engage individuals and communities with STEMM

WHO WE ARE

Founded in 1854, the Royal Society of Victoria (RSV) is our state's science society.

We are a membership based, non-government organisation, advocating for the importance of science, technology, innovation, and building the skills for Victoria's future industries, governments, community leaders, and research superstars.

WHAT WE DO

We manage the Inspiring Australia program in Victoria (inspiringvictoria.org.au), meaningfully engaging communities with science.

We encourage, profile, and celebrate the achievements of Victorian scientists through public lectures, awards, and prizes, which are supported by the donations and bequests to the RSV Science Foundation.

WHERE YOUR DONATIONS GO

Your donations allow us to continue the work we have been doing for Victoria for more than 160 years. This includes hosting organising/hosting/running STEMM events, running a public lecture series (in-person and online), producing the magazine *Science Victoria*, celebrating Victorian scientists through awards and prizes, publishing Victorian science in our academic journal (the Proceedings of the Royal Society of Victoria), and empowering the next generation of scientists.

HOW TO SUPPORT

We also support a number of smaller organisations, which are listed at **rsv.org.au**.

You can donate online now at **rsv.org.au/support-the-rsv**, or alternatively contact us at **rsv@rsv.org.au** for information about other payment methods.

Become a Member of the RSV

We bring together an independent community of science practitioners, educators, industrialists, and enthusiasts to promote an understanding and utilisation of scientific knowledge for the benefit of the state of Victoria.

	STUDENT $40 PER YEAR	FULL $120 PER YEAR	ORG. $1000 PER YEAR	SCHOOL $1000 PER YEAR	AFFILIATE $500 PER YEAR
Special Membership rates at RSV and affiliate events.	√	√			
Networking opportunities – national and local.	√	√	√	√	√
Recognition of membership through use of post-nominal affix	MRSV	MRSV			
Each edition of *Science Victoria* mailed for free		√			
Free monthly printed copies of *Science Victoria* for school libraries.				√	
Recognition of achievements through awards programs.	√	√			
Discounted advertising in *Science Victoria*			√	√	√
Discounted facility hire at 8 La Trobe Street, Melbourne.			√	√	√
Discounted membership rate for eligible full-time students.	√				
Discount on purchases from CSIRO Publishing	√	√			
'Schools Supporting Schools' Membership Program*				√	
Listing of membership on the RSV.org.au website.			√	√	√

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Professor of Mathematics, Uzbekistan

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Director, CSL Building - Biotechnology

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PhD Candidate, The University of Melbourne

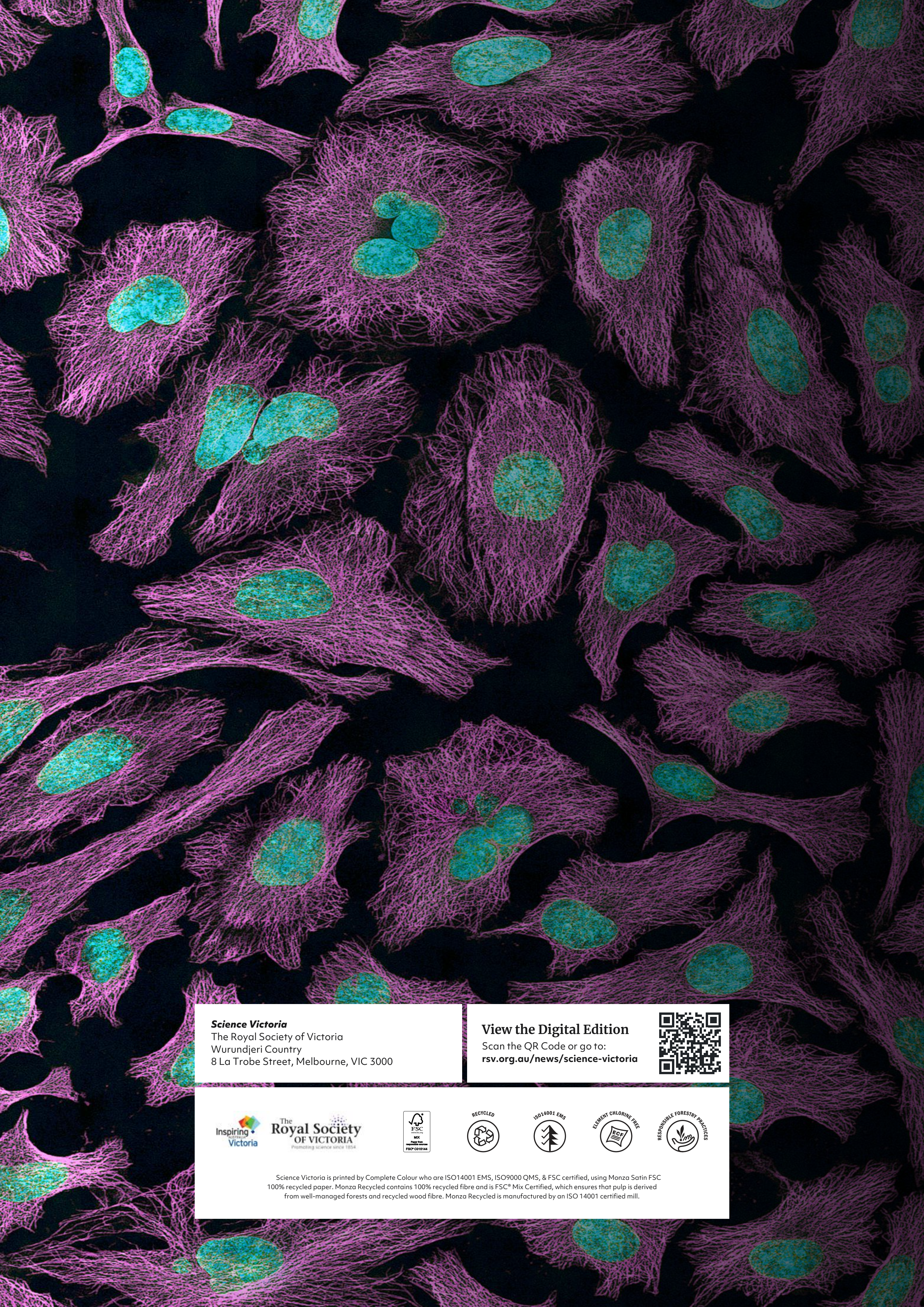
MR WARSAMA BULHAN
Student, Victoria University

How to Join

For more information:
rsv.org.au/how-to-join

* The 'Schools Supporting Schools' membership program allows a school to sponsor the membership of one or more schools at a discounted rate of $750/year, allowing less-resourced schools the same benefits and opportunities of RSV membership.

Humans have used yeast as a leavening agent for millennia. Photograph: EU-Ukraine Cooperation via flickr (CC BY-SA 2.0).



Science Victoria
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