The Royal Society OF VICTORIA

Inspiring AUSTRALIA Victoria

SCIENCE VICTORIA

DECEMBER 2023

PSILOCYBIN AND MDMA

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TREATING YOU BETTER

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EVERYBODY BE COOL

Helping Communities Escape Extreme Heat

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PLUS

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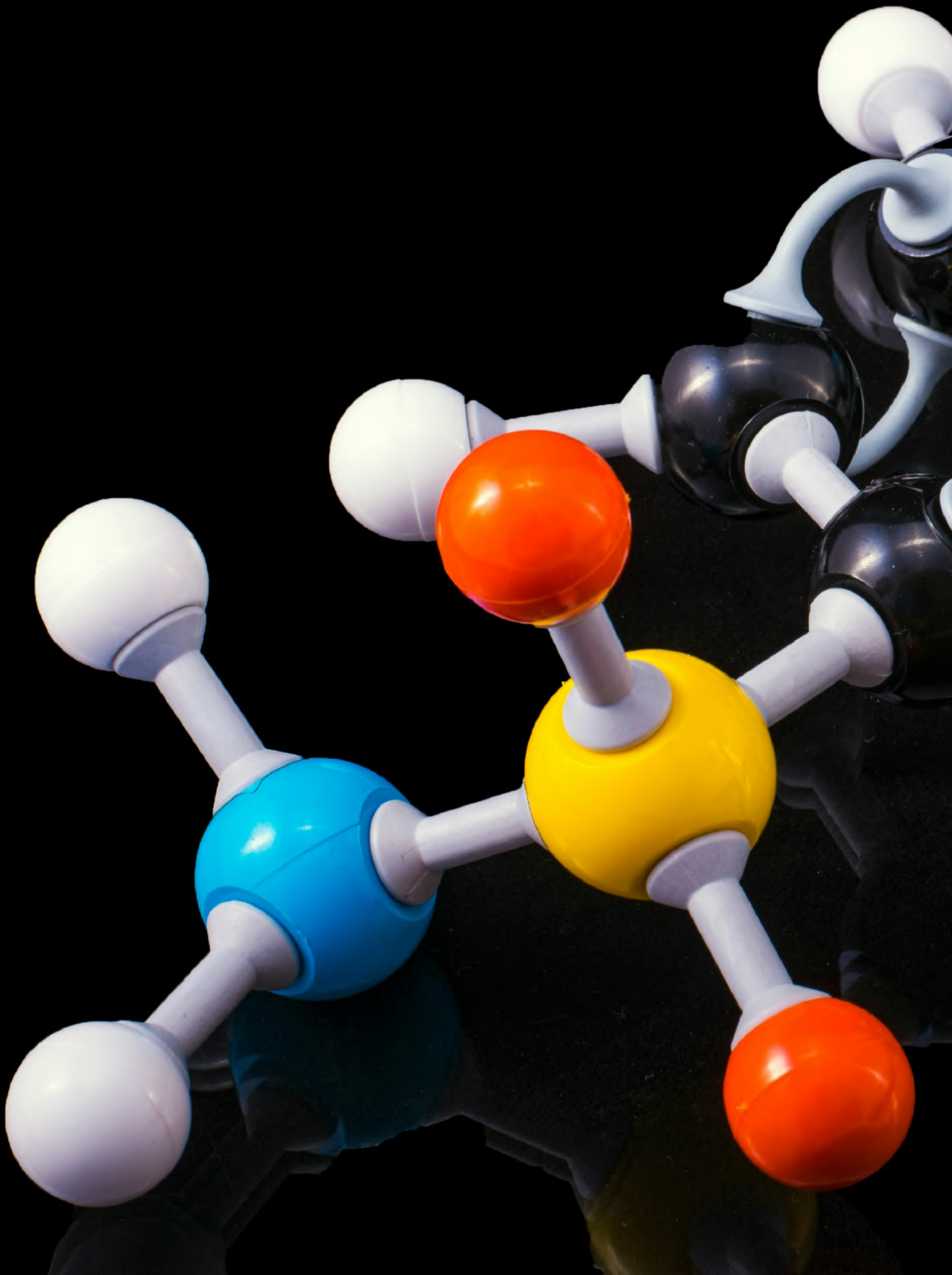
The chemical structure of the antibiotic sulfanilamide ($C^6H^8N^2O^2S$). While the original compound now has limited use, it spawned a class of antibiotics based on the sulfonamide functional group. Photograph: via Unsplash.



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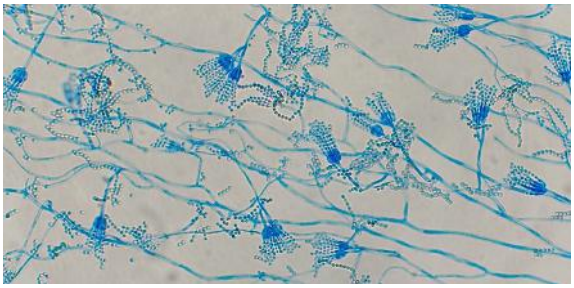
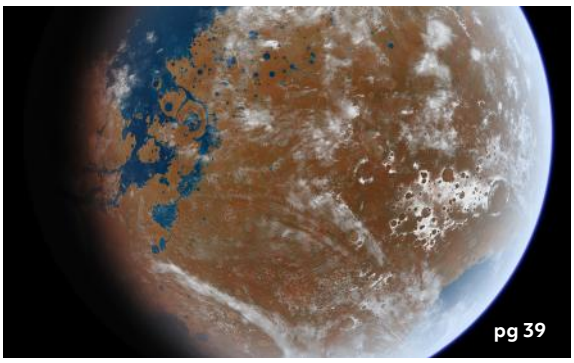


This Edition: The Future of Drug Discovery

The discovery and development of drugs is an integral part of humanity, and recent centuries have seen the discovery, refinement, and mass production of drugs to address all ailments (with mixed success). In this edition of *Science Victoria*, we take a look at some of the factors involved in the future of drug discovery and development, including work happening right here in Victoria.

On the Cover: Penicillin-producing *Penicillium spp.* mold, stained and visualised at 400X magnification. Photograph: Jirawan Muangnak via Shutterstock.



Please note the submission deadline for content to be included in upcoming editions:

February 2024 | Artificial Intelligence
5pm, Friday 19 January 2024.

A YEAR OF SCIENCE VICTORIA IN REVIEW

Scott Reddiex
Editor, *Science Victoria*

As we approach the end of 2023, I want to take a moment to share with you our plans for *Science Victoria*: what we set out to do, what we have achieved this year, and what the future holds.

Firstly, and most importantly, I want to thank you, wholeheartedly, for reading. Our aim is to connect relevant scientific thinking, with an interested readership, in an engaging way. I hope that you have found something interesting in each edition this year – even if it can be at times frustrating to learn more about particularly dire situations.

Secondly, I must thank all our contributors this year. The content that we produce each month comes courtesy of talented individuals and groups, who take time each month to write the pieces you read. We have had the pleasure of working with and learning from so many talented people this year, and I look forward to continuing this high standard.

This year, we redesigned the magazine, with huge thanks to our new designer, Ms Rosie Everett. *Science Victoria* is now available each month in both digital and printed formats, and will be supported by a long-overdue redesign of our website (due for completion in the coming months).

We have introduced themes for each edition, to focus on issues of importance to STEMM, Victoria, and the world. This will continue in 2024, tackling artificial intelligence, climate change, biodiversity loss, the rise of misinformation, Victoria's fauna, and more in the next year.

With each topic, we aim to both inform and advocate for meaningful, scientifically-supported action. Many of the issues have been known for decades, and the focus now needs to be on how to fix them. With that said, it is likely that our readership will have some of these answers, and I would love to hear from you. Instead of a Twitter thread or a LinkedIn post, send it to me at **editor@sciencevictoria.org.au** as a letter. Help us to connect these ideas with the people who need to hear and respond to them.

Finally, I want to thank Mr Mike Flattley and Dr Catriona Nguyen-Robertson. I am so proud of what our small team has achieved this year, and I am immensely grateful to have the support of their individual talents. *Science Victoria* has only been possible thanks to their countless hours of work and brilliant minds.

In our final edition for 2023, we look at the future of drug discovery and development.

Kade Huckstep takes us through the past, present, and future of psilocybin and MDMA in medical treatments, while Dr Amy Niselle and Zayne D'Crus from Melbourne Genomics explain how understanding your genes can allow for tailored and targeted treatments for a range of conditions.

Dr Catriona Nguyen-Robertson revisits a presentation by Dr Christopher Draper-Joyce on new approaches in drug development, and elsewhere tells us how students at Whittlesea Tech School are tackling the rise of antimicrobial resistance.

As Australia braces for a summer of extreme temperatures, Shirley Diez, Fran Macdonald, and Phani Harsha Yeggina present their findings on using community buildings to keep cool.

We hope you enjoy this edition of *Science Victoria*, and will see you again in February 2024 for our edition on artificial intelligence.

SCIENCE VICTORIA, VOLUME 3, NUMBER 11, DECEMBER 2023

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Hon. Treasurer Mr Siddharth Verma
CEO Mr Mike Flattley
Membership, Business & Facilities
Mr James McArthur

Membership
James McArthur
james.mcarthur@rsv.org.au

Events and Commercial
Mike Flattley
ceo@rsv.org.au

Editorial
Editor Mr Scott Reddiex
Associate Editor Dr Catriona Nguyen-Robertson
Layout Rosie Everett, *Brand Warrior Communications*

Contributors
Dr Catriona Nguyen-Robertson, Mr Scott Reddiex, Ms Shirley Diez, Ms Fran Macdonald, Mr Phani Harsha Yeggina, Mx Kade Huckstep, Ms Tejaswini Divanji, Dr Amy Niselle, Mr Zayne D'Crus, Dr Tanya Hill, Ms Sarah Mele, Ms Marina Yakou, Mr William Kwan

Letters
editor@sciencevictoria.org.au
Please note that letters may be edited for length and clarity

Advertising
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Contact Us
The Royal Society of Victoria
8 La Trobe Street, Melbourne,
VIC 3000
rsv@rsv.org.au
+61 3 9663 5259

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Acknowledgement of Country:

The Royal Society of Victoria acknowledges the many First Peoples of our continent, their vast history and connection to the lands and waters within and beyond the State of Victoria, and the valuable cultural and scientific knowledge held by the Elders to care for Country. We acknowledge our headquarters are located on Wurundjeri land, never ceded, and convey our respect to Elders past and present. The RSV welcomes all First Nations people, and seeks to support and celebrate their continued contributions to scientific knowledge.

SCIENTIFIC COLLABORATION: SOCIETIES AND SCIENTISTS

Rob Gell AM MRSV
President, The Royal Society of Victoria

Each state in Australia has long had a 'Royal Society', who exist for the advancement of science and knowledge. The Royal Societies of Australia (RSA) was established as a national organisation in 2007 to provide a mechanism for sharing ideas and operational practice among Australia's Royal Societies. It would unfortunately be fair to say that little has been achieved, apart from a series of three Stewardship of Country webinars in 2021. These were facilitated by the Royal Society of Victoria's (RSV) capability to deliver the series online and subsequent publication in The Proceedings of the Royal Society of Victoria.

The Governor-General, His Excellency, General the Honourable David Hurley AC DSC (Retd), has recently shown interest in the RSA. In response, a meeting of Australia's Royal Societies was recently held in Canberra to coincide with the Australian Academy of Science's (AAS) Annual Conference, the theme of which was International Scientific Collaborations in a Contested World.

The societies as a group have agreed to meet regularly to pursue the objectives of a national approach to the promotion of intellectual inquiry in Australia, with an emphasis on evidence-based knowledge. In the short term, the group has shared The Royal Society of NSW's Advocacy Guidelines and the RSV's Affiliation Agreement, which could allow the utilisation of our Deductible Gift Recipient status for the benefit of other societies.

Currently, the RSV is not a member of the RSA. Consideration of this in light of the recent meeting will be considered by the council at our December meeting.

The meeting provided an opportunity for the Australia's Royal Societies to meet and present to the Governor-General on the work of each society. His Excellency was particularly interested in our plans to update our site, and our 'One Victoria' building proposition.

The highlight of meeting Government House was undoubtedly our CEO Mike Flattley's piano accompaniment of Her Excellency Mrs Linda Hurley in four rousing choruses of the 1940 standard 'You are my Sunshine', which is apparently a favourite of Her Excellency.

Scientific Collaborations in a Contested World

The importance of the AAS's Annual Conference theme cannot be overstated. The conference programme can be found at **science.org.au/news-and-events/events/australian-academy-of-science-symposium-2023/symposium-2023-program**.

The conference underlined Australia's world leading contribution to international scientific research and the need to continue to build our capacity in the context of the recent Defence Strategic Review. The recommendations of the review in addressing national security risks have important implications for the science sector in international research collaboration and how current geopolitical tensions are affecting the productivity of scientists and the nature of their research. The implications of AUKUS have direct impacts on many areas of Australian research.

In the Australian context, geopolitical competition is driving renewed recognition of a security dimension to international research collaboration. This is exemplified through evolving defence strategic policy settings and responses to counter foreign interference in the research sector.[1]

RSV CEO Mike Flattley and President Rob Gell attended the AAS symposium, 'International Scientific Collaborations in a Contested World'. Photograph: AAS

The range of presentations focussed on the new suite of critical advanced technology platforms and enabling platforms in areas such as quantum computing, semiconductors, Artificial Intelligence (AI), synthetic biology and cyber security. There is no doubt that the landscape has changed and that the AAS will play an important role in helping the Australian Government build an understanding of both the requirements and responsibilities of scientists – where they will play a role and where they will not.

I have no doubt you will find International Scientific Collaborations in a Contested World – A Discussion Paper, Australian Academy of Science 2023 Symposium of real interest.[1]

I highly recommend reading final remarks of AAS Conference Convenors Professors Steven Chown FAA and Frances Separovic AO FAA, and AAS President Professor Chennupati Jagadish AC PresAA FREng FTSE.[2,3] They can both be found at **science.org.au/news-and-events/news-and-media-releases**.

As usual, please use *Science Victoria* to communicate your ideas and comments to me at **president@rsv.org.au**.

May I take this opportunity to send all our members good wishes for 2024 and to thank the members of the RSV Council for their support through the year. In particular, on behalf of our council, I wish to offer our sincere thanks to our small, hard-working RSV team led by Mike Flattley for their considerable efforts this year.

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1. International Scientific Collaborations in a Contested World – A Discussion Paper, Australian Academy of Science 2023 Symposium science.org.au/supporting-science/science-policy-and-analysis/reports-and-publications/international-scientific-collaborations-in-a-contested-world-discussion-paper
2. Summary of 2023 Symposium: Professors Steven Chown and Frances Separovic | Australian Academy of Science. (2023, November 14). AAS. Retrieved November 15, 2023, from science.org.au/news-and-events/news-and-media-releases/summary-of-2023-symposium-professors-steven-chown-and-frances-separovic
3. 2023 Symposium closing remarks: Professor Chennupati Jagadish | Australian Academy of Science. (2023, November 14). AAS. Retrieved November 15, 2023, from science.org.au/news-and-events/news-and-media-releases/2023-symposium-closing-remarks-professor-chennupati-jagadish

SNAPSHOTS OF STEMM

Presenter Marie Kinsey in the Lightning Room at Scienceworks, demonstrating the effect of temperature on air.

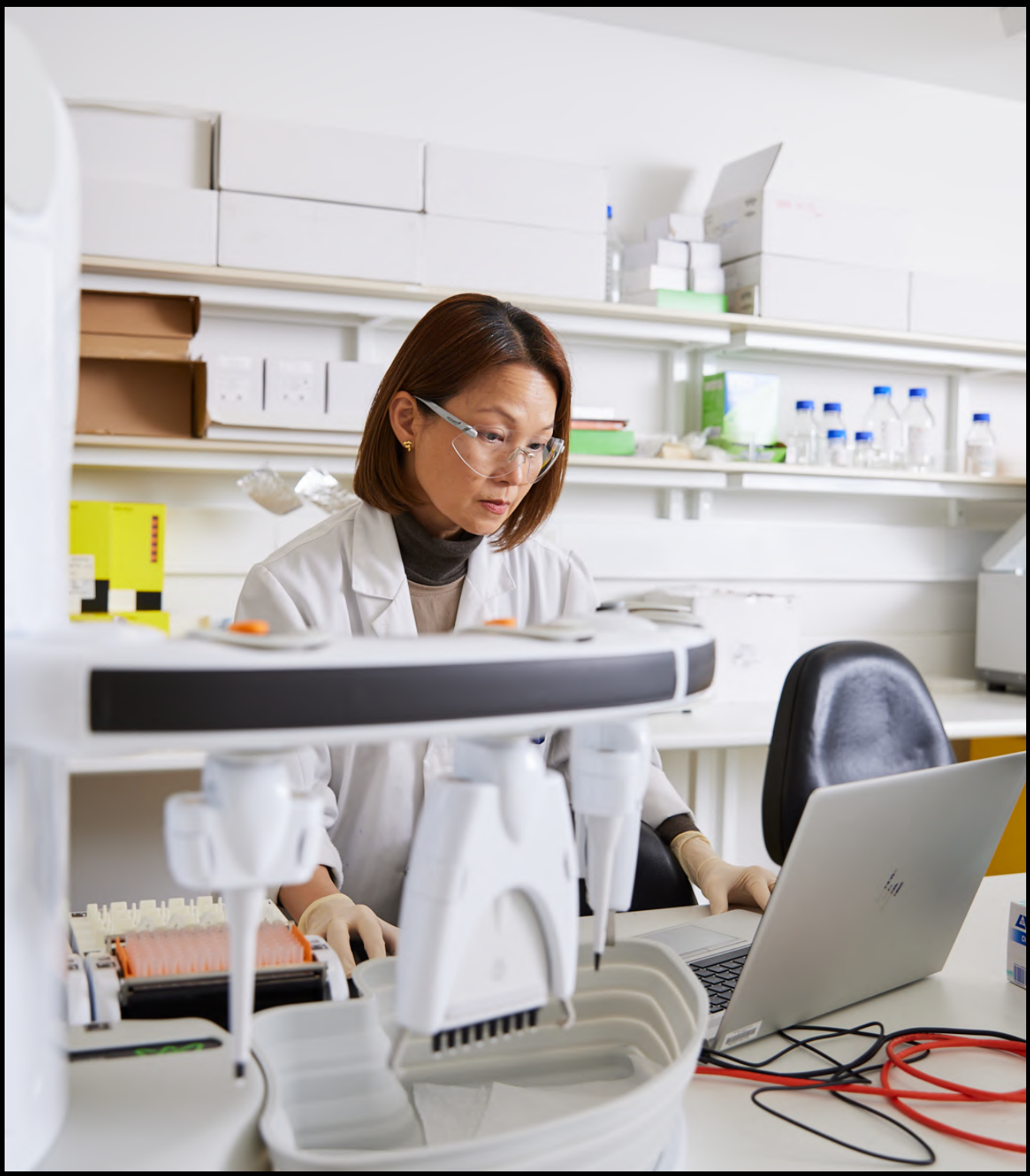
Photograph: Rodney Start/Museums Victoria

SNAPSHOTS OF STEMM

Members of Professor Christopher McDevitt's Lab at the Peter Doherty Institute for Infection and Immunity, working to develop a treatment for antibiotic-resistant community-acquired bacterial pneumonia.

Photograph: Cesar Nicolas/Doherty Institute.

SNAPSHOTS OF STEMM



Alice Ng, Senior Research Officer at the Centre for Drug Candidate Optimisation within the Monash Institute of Pharmaceutical Sciences, setting up a robot to run an assay testing novel drug candidates.

Photograph: Ryan Wheatley/Monash Institute of Pharmaceutical Sciences, Monash University

NEW RSV MEMBERS

INDIVIDUAL MEMBERS

Dr Guy Holdgate
Retired geologist

Mr Russell Tait
Chief Environmental Scientist, Tait & Associates Pty Ltd

Mr Abraham Alonzo Guiyab
Student, Melbourne Law School

Assoc. Professor Andrew Dowdy
Principal Research Fellow (Extreme Winds), The University of Melbourne

Mr Stephen Rando
Initiative Lead, ANZ Banking Group

Mr Mitchell de Vries
PhD Candidate, RMIT University

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Mrs Angelina Ross
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Ms Jenniy Gregory
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Dr Michael Smith
Senior Technical Specialist (Modelling & Analytics), The University of Melbourne

Mr Andrew Stuart-Smith
Student & Tutor, Monash University

Miss Jasmine Hendry
Student, Monash University

Miss Sophie Nolan
Student, Monash University

ORGANISATIONAL MEMBERS

Members of the Royal Society of Victoria are advised of our governing Council's intention to accept the following organisations as Affiliates of the Royal Society of Victoria, in accordance with Rule 8 (4) of our governing rules (**rsv.org.au/rules-bylaws/**).

Geography Victoria is a new not-for-profit bringing together people of all ages, from all walks of life, and with a broad range of interests, to share in a range of geographical experiences to develop a deeper understanding of the relationship between community and environment in our State.

geogvic.au

CALL FOR NOMINATIONS

Nominations for up to five Ordinary Members of Council for 2024 and 2025 are sought. If required due to more nominations being received than places are available, all nominees will be elected by postal ballot closing at **3.30pm on 1st March 2024**. The newly elected Councillors of the Society will take up office from the Annual General Meeting to be held in May 2024 - all current Ordinary Councillors of the Society appointed for the 2022-23 term will continue until that date. All current 2023-24 Councillors continue until the AGM to be held in May 2025.

Download the nomination form for more information: ***rsv.org.au/rsv-council-nomination-form-2024-25***

BECOME A MEMBER OF THE RSV

MEMBERSHIP BENEFITS	STUDENT $40/YEAR	FULL $120/YEAR	ORGANISATION $1000/YEAR	SCHOOL $1000/YEAR	AFFILIATE $500/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			
Science Victoria Digital Edition (Printed copy available for an additional fee).	✓	✓	✓	✓	✓
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.			✓	✓	✓

The Royal Society OF VICTORIA

For more information, visit **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.

UPCOMING RSV EVENTS

The RSV hosts many STEMM-related events, public lectures, and meetings throughout the year. These are predominantly held at the RSV Building at 8 La Trobe St, Melbourne (unless otherwise indicated), and simulcast online via YouTube.

Our public lectures comprise the "Scientists in Focus" component of the Inspiring Victoria program in 2023.

2023

10 DECEMBER

GEOGRAPHY VICTORIA'S MELBOURNE CHRISTMAS TREASURE HUNT

Save the date - the Melbourne Christmas Treasure Hunt is back for 2023. Developed by Geography Victoria as part of the City of Melbourne Christmas Festival, there will be three different events tailored for groups and individuals of all ages. You'll be given a map and clues, and begin your hunt for treasure!

For more information, visit: **rsv.org.au/events/melbourne-christmas-treasure-hunts-2023**

2024

RESCHEDULED

RSV PHILLIP LAW POSTDOCTORAL AWARD LECTURE

Please note that this event has been rescheduled from November 2023 to early 2024.

The winner of the RSV's Phillip Law Postdoctoral Award for 2023 will present their work to a special meeting of the RSV at a public lecture. This will be professionally filmed and shared online.

For more information, visit **rsv.org.au/awards-and-prizes/phillip-law-award/**

RESCHEDULED

RSV RESEARCH MEDALLIST LECTURE

Please note that this event has been rescheduled from December 2023 to early 2024.

The winner of the RSV Medal for Excellence in Scientific Research for 2023 will present a lecture to RSV members and guests, at which the Medal will be presented.

For more information, see visit **rsv.org.au/awards-and-prizes/research-medal/**

DISCOVERY EARLY CAREER RESEARCHER AWARD (DECRA)

Applications are currently for the Australian Research Council's Discovery Early Career Researcher Award (DECRA) scheme, for commencement in 2024.

The DECRA scheme provides focused research support for early career researchers (ECRs) in both teaching and research, and research-only positions.

The objectives of this scheme are to:

- support outstanding ECRs with demonstrated capacity for high-quality research and emerging capability for leadership and supervision
- foster collaboration, with national or international researchers
- support excellent and innovative research that addresses a significant problem or gap in knowledge and represents value for money
- create new or advanced knowledge resulting from the outcomes of the research with economic, commercial, environmental, social and/or cultural benefits for Australia
- advance promising ECRs and promote enhanced opportunities for diverse career pathways in high-quality and supportive environments.

Up to 200 three-year Discovery Early Career Researcher Awards, including up to $50,000 per annum in project funds, may be awarded each year.

Applications close at **5pm, 7 December 2023**.

For more information, visit: **arc.gov.au/funding-research/funding-schemes/discovery-program/discovery-early-career-researcher-award-decra**

SPONSORSHIP GRANTS FOR STUDENT SCIENCE

Applications open in January 2024 for the Sponsorship Grants for Student Science Engagement and International Competitions 2024.

Grants of between $1,500 and $15,000 are available for organisations, such as schools and community groups, to sponsor young Australians to take part in virtual or in-person STEM engagement events, activities, and competitions.

The maximum grant amount per student for Australian hosted events is $2,000, and $5,000 for events requiring international travel.

The intended outcomes of the grant opportunity is to:

- support Australian students to develop STEM skills
- increase the number of students applying to participate in domestic and international STEM competitions and events
- increase the number of students participating in STEM education and going on to a career in STEM
- increase engagement and participation in groups under-represented in STEM.

This initiative is part of the *Inspiring Australia - Science Engagement Program*.

Applications open at **9am, Monday 22 January 2024**.

Applications close at **5pm, Thursday 4 April 2024**.

For more information, visit: **business.gov.au/2024SGSEIC**

Photograph: Alexander Grey via Unsplash

THE THERAPEUTIC ODYSSEY OF PSILOCYBIN AND MDMA: A RETURN TO ROOTS

By Kade Huckstep, PhD Candidate in Addiction Neuroscience at The Florey Institute of Neuroscience and Mental Health

From ancient "magic" to modern medicine, psilocybin (the active ingredient in "magic mushrooms") and MDMA ("ecstasy") have had a riveting journey in healthcare. These drugs have gone from potential medicines to banned substances, and now – with Australia's world-leading reclassification of both this year – back to promising medical treatments. This tale of rediscovery and redemption is not just about two drugs: it's about an evolving understanding of mental healthcare and the reclamation of lost scientific knowledge.

A Historical Prelude

"Magic" psilocybin mushrooms have been used in spiritual practices, particularly in the Americas, for millennia. But American amateur mycologist Robert Gordon Wasson is credited with introducing them to the rest of the world in 1957 after participating in an indigenous Mazatec ceremony in Mexico and describing his experience.1 Psilocybin subsequently caught the attention of many scientists, including Swiss chemist (and famed LSD-discoverer) Albert Hofmann, who used *Psilocybe Mexicana* mushroom samples to isolate and artificially synthesise psilocybin.[2] This enabled more controlled drug dosing and launched a decade of research into potential medical applications for psilocybin.

Psilocybin was swept into the 1960s counterculture movement, which led to the 1970 United States Controlled Substances Act classifying it as "Schedule I". As a Schedule I substance, it was considered to have high abuse potential, no accepted medical use, and a lack of accepted safety. It wasn't long before other countries followed suit, with Australia soon classifying psilocybin as a Schedule 9 (our Schedule I equivalent) prohibited substance.

MDMA (3,4-methylenedioxymethamphetamine) was first synthesised in 1912 as an intermediate step in the synthesis of a drug to stop bleeding. The psychoactive properties of MDMA weren't discovered until the mid-1970s, however, when chemist Alexander Shulgin synthesised and self-tested the compound.[3] Upon experiencing the high brought on by MDMA, Shulgin realised the drug's therapeutic potential and shared it with psychologist Leo Zeff in 1976. Zeff, impressed with MDMA's ability to facilitate emotional insights, began using it in his practice with reportedly great safety and success.[4]

In the early 1980s, MDMA was referred to as "Empathy" by psychotherapists who used it for clinical and research purposes.[5] However, the substance was rebranded "Ecstasy" and its recreational use flourished. In 1984, the US Drug Enforcement Administration noted an increase in MDMA confiscations and moved to classify it as an illegal substance. The clinical research community sought to contest this, but given the lack of structured clinical trial data, MDMA was categorised as a US Schedule I drug in 1985 and Australian Schedule 9 drug in 1986.

The strict regulation of both psilocybin and MDMA created a host of new bureaucratic hurdles for researchers, such as increased licensing requirements and reduced funding, effectively halting decades of potential therapeutic research and use.[6]

From Counterculture to Clinical Care

Despite the legal barriers, a handful of researchers and clinicians continued to advocate for psilocybin and MDMA's potential clinical utility. The early 2000s saw a revival of research interest, and the establishment of various clinical trials investigating the use of these drugs in combination with psychotherapy.

Drug-assisted psychotherapy differs from conventional mental health drug treatments: these drugs are not intended to be taken daily, indefinitely, or unsupervised. Instead, patients receive several weeks of psychotherapy, during which time they receive 1-3 evenly spaced drug administrations. Both substances, though working differently, are thought to boost the impact of therapy and promote emotional breakthroughs. Unlike most antidepressant medications, which can take up to six weeks to begin working, these treatments start helping immediately.

Clinical Trial Triumphs

The modern era of psilocybin and MDMA research has been characterised by a cautious but enthusiastic exploration of their possibilities as treatments for a broad array of conditions.

The mood-boosting potential of psilocybin-assisted therapy has shown incredible promise for depression.[7] A study of people with moderate-to-severe depression compared only two doses of psilocybin with a six-week course of daily escitalopram, a common antidepressant medication. Not only was psilocybin just as effective at reducing depression scores, but the proportion of patients who no longer qualified as depressed after treatment was twice as high after psilocybin-assisted therapy.[8]

Psilocybin has also been shown to reduce both immediate and long-term anxiety in patients with terminal conditions such as cancer or HIV. [9] In addition, studies found that the treatment reduces drinking in people with alcohol use disorder[10] and

MDMA. Photograph: via Unsplash

smoking in nicotine-dependent smokers,[11] and a phase 1 feasibility study published this year concluded it would be a safe option for anorexia nervosa.[12]

Results from studies exploring MDMA-assisted therapy have been similarly encouraging, with research for this compound primarily focused on anxiety-based conditions. There have been studies demonstrating MDMA's potential to lessen social anxiety in autistic adults,[13] and psychological distress related to life-threatening illnesses.[14]

The most extensive exploration of MDMA-assisted therapy is undoubtedly for the treatment of PTSD. In addition to several small successful studies, a recent Phase III clinical trial people with moderate-to-severe PTSD found that following treatment, 71% of the people treated with MDMA no longer met the criteria for PTSD, compared to just 48% in the control group.[15] This follows a previous trial with similar results, which also tracked participants' alcohol use throughout the treatment, and found that the MDMA group drank less.[16] This finding is particularly promising, as many people reportedly use alcohol to self-medicate their PTSD, and subsequently develop alcohol use disorders. MDMA-assisted therapy may therefore assist patients with alcohol use disorder, as it appears to help decrease alcohol use post-detox.[17]

A Regulatory Renaissance

Australia's recent decision to reschedule MDMA and psilocybin for therapeutic use represents a seismic shift in drug policy. The Therapeutic Goods Administration (TGA) has approved the prescription of these substances for specific psychiatric conditions, acknowledging their potential therapeutic benefits and enabling their use in a controlled medical context. Specifically, as of 1 July 2023, psilocybin-assisted therapy is approved for treatment-resistant depression and MDMA-assisted therapy is approved to treat PTSD. Both drugs were also reclassified as Schedule 8, marking a significant shift in their legal status from prohibited to medicinal - the first instance of a national government recognising the therapeutic potential of psychedelic substances and integrating them into the medical system.

While the US Food Drug Administration (FDA) is yet to follow suit, it has previously awarded both treatments "breakthrough therapy" status: a designation reserved for drugs that may offer substantial improvements over existing treatments, intended to speed up their development and review. It has also been reported that, given the success of the PTSD clinical trials, an application for FDA approval of MDMA is set to be filed by the end of the year.

Risks and Considerations

Despite the promising data, there remain several important considerations in the legalisation of these medications. It is important to keep in mind that the TGA's decision was based on clinical trials which had very strict and numerous exclusion criteria. Conditions like PTSD and treatment-resistant depression frequently co-occur with other conditions, making it likely that many real-world patients won't match the subjects studied.

The TGA has also been criticised for an apparent lack of consultation with Australian researchers and experts in this space, and some clinicians fear that the regulatory framework governing access to these drugs may be insufficient. Clear guidelines relating to the psychotherapy component of this treatment are also lacking, and questions have arisen around the logistical and financial feasibility of psychiatrists delivering this treatment.

The previously illicit status of these drugs has led to stigma, but public perception is changing, and rapidly. As a result, these medications now sit at an interesting juncture between stigma and hype, and it will be important to manage both sides as either could damage the success of this rollout.

While the therapeutic potential is undoubtedly immense, there are hurdles to overcome. Regulatory, ethical, and logistical questions remain. The narrative of these substances is still being written, and it will be the task of scientists, policymakers, and society at large to ensure the next chapters are approached with care and consideration.

A Hopeful Horizon

As Australia steps into the therapeutic potential of psychedelics, the path is marked with caution signs. The general sentiment is that while these treatments could revolutionise mental healthcare, the journey must be measured, evidence-based, and patient-centric.

The renaissance of these compounds in therapy is a testament to the resilience of scientific curiosity, and the relentless pursuit of better mental health treatments. While there remain hurdles to overcome and risks to be mitigated, these substances could herald a new era in psychiatry - one where some of the most challenging mental health conditions could be treated more effectively than ever before.

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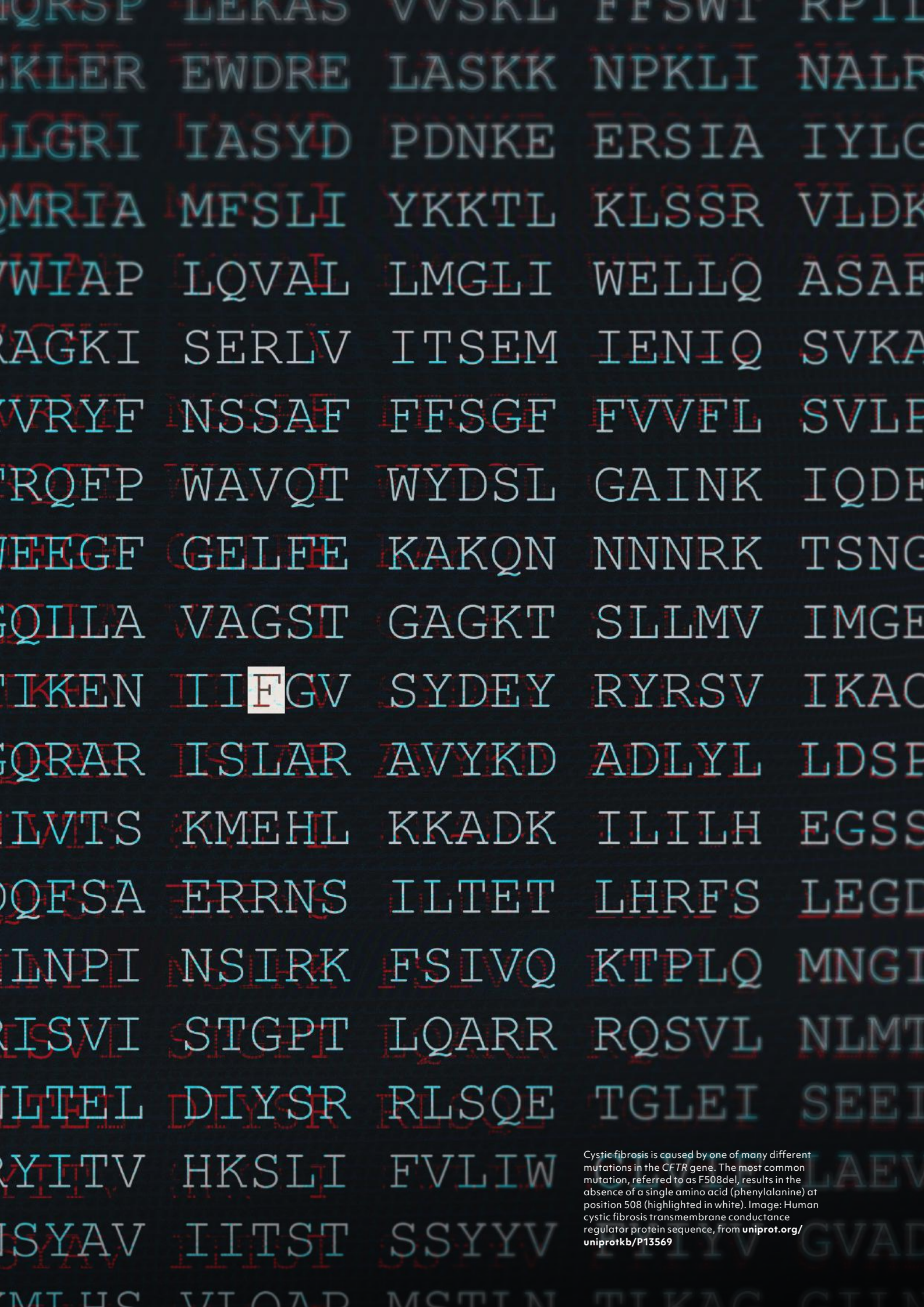
While there are over 150 species across 8 genera of fungus that produce psilocybin, ***Psilocybe cubensis*** (pictured) is one of the most commonly cultivated. Photograph: Goami via Shutterstock.



Cystic fibrosis is caused by one of many different mutations in the *CFTR* gene. The most common mutation, referred to as F508del, results in the absence of a single amino acid (phenylalanine) at position 508 (highlighted in white). Image: Human cystic fibrosis transmembrane conductance regulator protein sequence, from **uniprot.org/uniprotkb/P13569**

THE GENIUS OF GENOMICS

By Dr Amy Nisselle and Zayne D'Crus, Melbourne Genomics

Ten years ago, Victoria launched a concerted, world-leading effort to bring genomics into healthcare. Here's an update on how that's going, and what it will mean for you.

Imagine your body has an instruction manual. Something the size of a thousand copies of the *Lord of the Rings* trilogy.

Now imagine there's a spelling mistake in a single word, which changes its meaning. Perhaps the sentence containing that changed word no longer makes sense. In turn, a whole chapter might now read differently.

This is how genetics is often explained to people whose illnesses are caused by changes in their genes, which are the individual sentences that make up our vast instruction manual. Sometimes we inherit these changed genes from our parents; at other times, they occur spontaneously, like at conception, or when cancers form.

Genetics has long been studied in healthcare. Even before the 20th century, scientists were investigating how traits were inherited, and the earliest DNA tests began in the 1950s. Most genetic tests look at one or a few genes at a time – those that we know are linked to specific diseases. One example is cystic fibrosis, which is caused by mutations in the *CFTR* gene.

But now, every letter in your *genome* – your complete instruction manual – can be read and analysed. Not only can medical scientists detect single spelling errors, but they can also understand how these errors influence the wider text.

Sites like ancestry.com or *23andme* have made the term 'genomics' familiar. But genomics can do more than suggest where our families came from: it can transform our healthcare, too.

Today, medical specialists can look at your DNA to diagnose rare or complex conditions, assess your risk of developing particular illnesses, and even identify what treatments are likely to succeed or fail.

Welcome to the era of genomic healthcare.

Genomics can find answers

Thousands of Victorians have now received genomic tests, with life-changing results for many.[1]

Four years ago, a seemingly healthy baby suddenly stopped breathing and began to have seizures. She needed resuscitation multiple times, but countless tests failed to find a reason why. A genomic test finally pinpointed the cause – a genetic variant that made her cells unable to transport vitamin B around her body. With a small daily dose of riboflavin (vitamin B2), the child returned to full health.

In another case, two brothers, who had lived for years with a mystery mix of bowel disorders and respiratory infections, were finally diagnosed through a genomic test. With the cause identified, a stem cell transplant from donated bone marrow saw the boys' health rapidly improve.

A third example is Susan, who was diagnosed with terminal cancer in her fifties. Her tumours looked and behaved like sarcomas – but a genomic test determined they were actually melanomas. Susan received more appropriately targeted therapy, and is now cancer-free.

Professor Clara Gaff is Executive Director of the Melbourne Genomics Health Alliance, whose member hospitals provided care for the patients described above. As she explains: "Genomic testing can find answers too complex for other medical tests – all through a simple blood or saliva sample, without the need for invasive procedures like biopsies."

Genomic testing differs from other diagnostic tests in two significant ways. First, the test results can have implications for more than just the patient involved. "People who have a known genetic condition might be thinking about having children, and want to know if they will pass the condition on," says Professor Gaff. "Or perhaps their relatives may be able to get tested to see if they carry the same condition."

Second, genomic data can be reanalysed. Unlike a blood test, which gives a point-in-time result, a genomic sequence can be stored and examined again as new knowledge becomes available.

Yet genomic testing has its limits. Its diagnostic capability depends on a collective body of evidence about gene changes and their ability to cause disease. Much of this evidence comes from research in Europe and North America, with populations of European ancestry – meaning that genomic testing may not be as effective for people with other backgrounds.[2]

Despite its emerging benefits, genomic testing is not yet provided consistently across the health system. This is due to the complexity of the test, the technology involved, and the system-wide changes needed to bring genomics into every medical speciality where it can demonstrate improved outcomes for patients.

How the world is taking on genomics

By 2018, more than AU$6 billion had been invested worldwide in bringing genomics into healthcare.[3]

The United Kingdom launched a national research program called the 100,000 Genomes Project in 2012, and created the NHS Genomic Medicine Service in 2018. A national test directory for genomics was released in the same year and a genomics strategy was updated in 2022.[4,5]

Other countries are taking similar steps to build on population-scale research, such as the *All of Us* program in the United States,[6] and the *Human Heredity and Health in Africa (H3Africa)* consortium.[7]

National genomics programs have several common themes: establishing clinical utility and cost savings from genomics, ensuring equitable access, upgrading and standardising infrastructure, upskilling the health workforce, supporting patients to make informed decisions, and integrating the voice of consumers into service design and delivery.

Australia's federated healthcare system requires effort at both national and state levels. Several states have their own genomics initiatives, and the Australian Genomics Health Alliance was formed in 2016 to investigate a consistent approach across all states and territories.[4]

Bringing genomics to Victoria

Victoria was the first Australian state to explore how to bring genomics into mainstream medicine and led the world by demonstrating where genomics outperformed other diagnostic tests.[8]

Ten years ago, leading hospitals, research and academic institutions committed to working together to offer genomic healthcare to all Victorians who need it. Recognising that this commitment would require significant effort across the entire health system, they formed the Melbourne Genomics Health Alliance and committed to a multi-year program of change.[8]

The first step, of course, was establishing an evidence base. Melbourne Genomics members offered genomic testing to thousands of Victorians childhood illnesses to cancer, kidney disease, bone marrow failure, neurological conditions, deafness and more. Genomic tests were offered side-by-side with the usual diagnostic tests these patients would have received.[9]

Overall, these studies showed that 19 times more patients received an informative result from genomic testing than from their usual care – and around half of those who got an answer made a change in care because of it.[10] This work supported a case for nationwide Medicare funding for genomic tests for childhood syndromes, genetic kidney disease, deafness, and other conditions.[11]

"These studies did more than prove the benefits of genomic testing," says Professor Gaff. "They helped us understand what was needed to bring genomics into mainstream care."

Education was an immediate priority. Programs were designed to guide medical scientists in interpreting genetic variants, and to enable doctors to identify when and how to use a genomic test. Doctors and scientists were funded to work on genomics projects and offered fellowships in genomic medicine and research, thus creating a corps of 'genomics champions' across multiple specialties.[12,13] Graduate programs in genetic counselling and other aspects of genomic healthcare were updated or developed.

Data management was a critical barrier to overcome. The instruction manual for a human being contains vast amounts of data; too large to be stored in electronic medical records or other software currently used in health. Doctors and medical scientists need access to genomic data to inform current and future medical decisions, while patients need to decide who sees their data and for what purpose.Melbourne Genomics built a software platform that makes genomic data management easy, while enabling laboratories to store genomic data in the cloud. This data is stored securely, encrypted separately from any other identifying information, accessible only to the testing laboratory, and shareable with other health providers only if a patient gives their consent.[14]

Equitable access to genomics will be vital. Consumer representatives, including people with rare genetic conditions, provide advice on each Melbourne Genomics project.[15] Meanwhile, researchers from First Nations and culturally diverse backgrounds are leading efforts to improve equity in genomics research and healthcare.[16]

Perhaps the hardest challenge of all is to create change in the complex world of public healthcare.

Melbourne Genomics is currently developing a framework to help hospitals make decisions about genomics. It is also testing different models for 'mainstreaming' genomics – making it a routine part of oncology, nephrology, paediatrics and other disciplines. These findings will inform a roadmap for embedding genomics in the health system, led by the Victorian Government.

What will this mean for Victorians?

Associate Professor Cate Kelly, former chief medical officer at The Royal Melbourne Hospital, believes that genomic testing will become routine in healthcare.

"Victoria has come so far in the last 10 years," says A/Prof Kelly. "We have the evidence, the models, the education and the technology to embed genomics in our health system. What's needed now is the will and shared effort to translate evidence into action and make it happen."

The widespread availability and accessibility of genomic testing would change healthcare in many ways. Thousands of Victorians who live with unexplained medical conditions could get answers. Relatives of people with genetic conditions can find out if they are also at risk. Some childhood conditions can be detected and treated before they become life-altering. People could plan families with an informed understanding of inherited conditions.

Our health system – always under pressure to cut costs – would also benefit. Earlier diagnoses would mean patients spending less time in emergency wards and hospital beds.[17] Many invasive and expensive tests could be avoided.

"This is the kind of care we would want for our children, our parents, our siblings and our friends," says A/Prof Kelly. "Its use is only going to increase, and it's exciting to see what will happen next."

Susan was initially diagnosed with terminal cancer, with tumours that looked like sarcomas. Her oncologist, Dr Faisal, wanted to investigate further. Genomic testing revealed that Susan's tumours were actually melanomas, informing a targeted course of treatment that left her cancer-free. Photograph: Terry Hope/Melbourne Genomics

Dr Amy Nisselle is Genomics Workforce Lead, Melbourne Genomics, and an Honorary Senior Fellow at The University of Melbourne. Mr Zayne D'Crus is Communications and Engagement Manager, Melbourne Genomics.

Dr Nisselle's research and practice focus on genomics education for students, professionals and the public. She has a doctorate in multimedia genetic education and is a keen science communicator. Zayne D'Crus is a communications specialist for topics ranging from healthcare to international humanitarian law.

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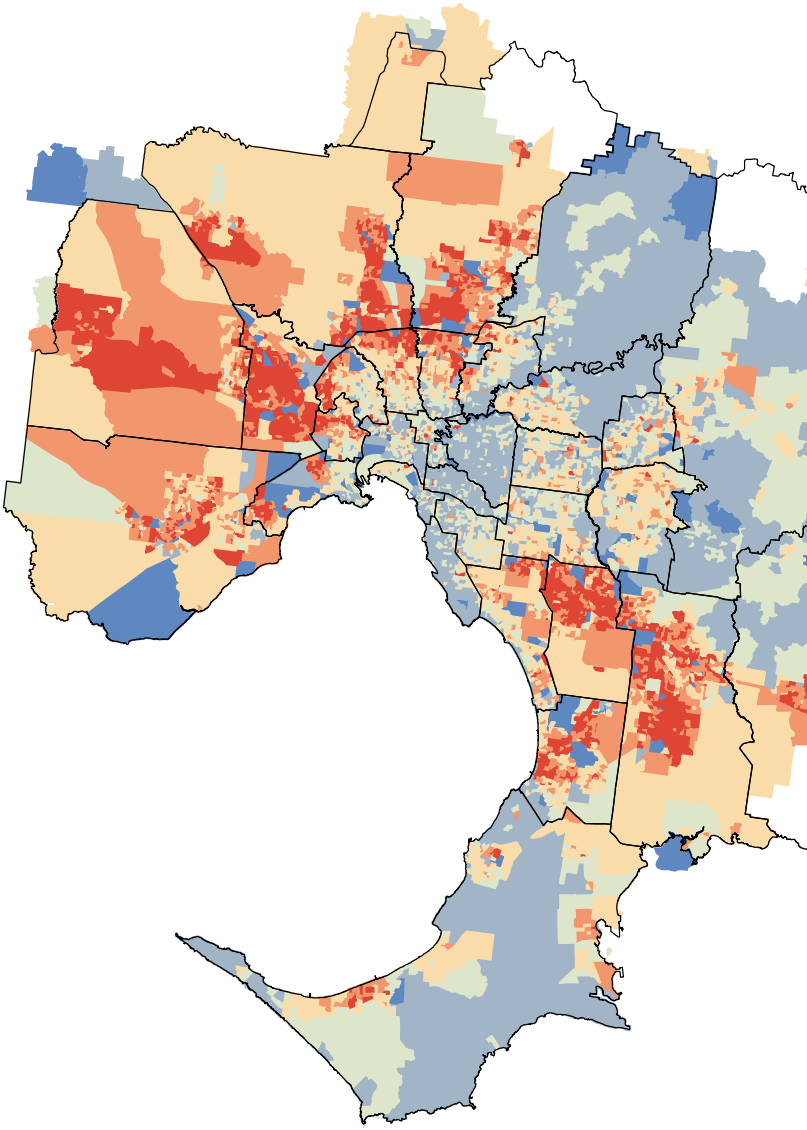
EVERYBODY BE COOL: USING COMMUNITY SPACES TO MANAGE HEATWAVES

By Shirley Diez, Fran Macdonald, and Phani Harsha Yeggina

This article provides an overview of work recently delivered by the Western Alliance for Greenhouse Action (WAGA), a partnership of councils in the west of Melbourne, with support from Department of Energy, Environment and Climate Action (DEECA) and Yarra Energy Foundation (YEF). The project included selection and assessment of a range of community buildings, views from the users of these spaces, and preliminary discussions about management of such spaces during heatwaves.



Coming into summer, how can we look after people who can't stay cool at home? Where can they go? What would be needed to ensure everyone stays safe in a heatwave? Greater Melbourne's Regional Climate Change Adaptation Strategy[1] funded a project called 'Creating a Network of Safe Spaces for Extreme Heat Events' to explore what is needed to make a network of heatwave safe community buildings for vulnerable people within the Greater Melbourne Region.

Record heat around the world

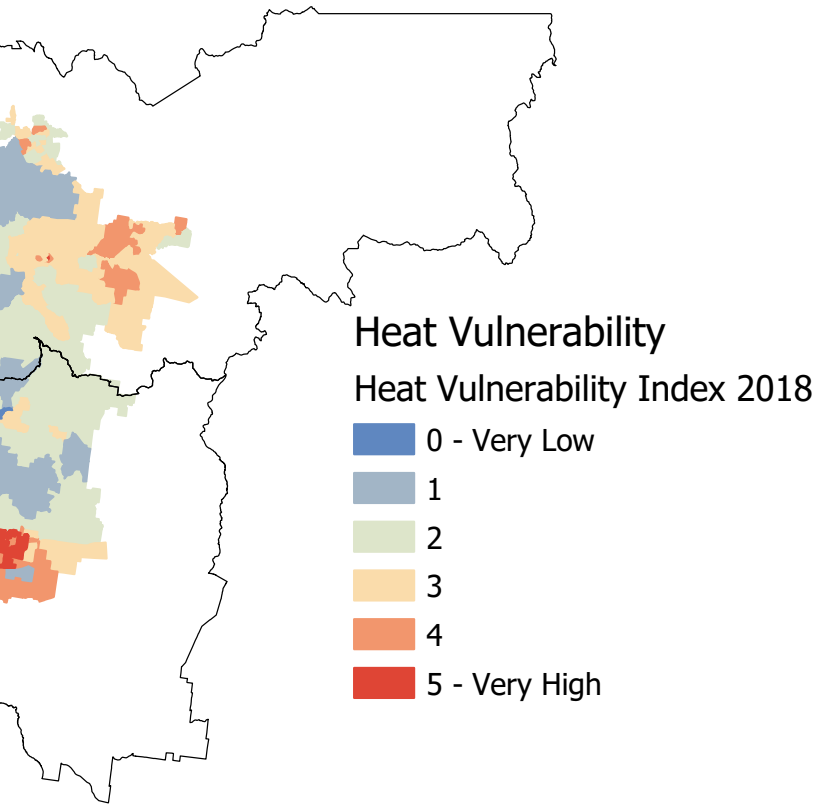
A quick news scan shows that the northern hemisphere has experienced record-breaking heat in summer this year, with built-up areas additionally impacted by the 'Urban Heat Island Effect'.[2,3]

In Australia, heatwaves are one of the most powerful and dangerous natural disasters that lead to increases in heat-related hospital admissions and deaths.[4,5,6] While extreme heat can cause physical illness and death, it can also contribute to mental illness, and increases the risk of violence.[7,8]

Some cohorts are particularly vulnerable, and so designing multi-faceted approaches to limit the impact of heatwaves on individuals and communities is vital.

Unlike floods and fire, there is limited practical, place-based experience around managing heatwave emergencies in Victoria. The guiding document is the State Extreme Heat Subplan, under the State Emergency Management Plan (SEMP), which outlines how agencies respond to the impacts and consequences of extreme heat and heatwaves. To test our preparedness, some organisations have started bringing together people from the health and community sectors, the emergency sector, state and local government, and industry.[9,10,11]

While there are many organisations involved,[12,13,14] our project's focus was on the most vulnerable and at-risk people and the role of local governments and community buildings in supporting these people in the event of an extreme heat event.



Heat vulnerability map of metropolitan Melbourne, produced using 2018 census data. An interactive version this map is available at mapshare.vic.gov.au/coolinggreening

The Melbourne Heatwave Disaster Scenario event in September 2023, held by Sweltering Cities. Photograph: Eric Ditloff.

Where do Melburnians go when it's hot? What do they need?

To understand where to focus attention in Melbourne, we can examine a heat vulnerability map, produced by the Victorian government by overlaying heat and census data.[15] The map shows that some parts of Melbourne are hotter and more likely to include at-risk people.

To find out what people do in hot weather, we collected the results of over 120 conversations with people on the street near libraries and visiting neighbourhood and community houses in Melbourne's west. While three quarters said it was easy for them to keep cool at home in summer, the other quarter found it difficult. On really hot days, roughly half of the respondents stayed home, while half went to places like shopping centres, swimming pools, libraries, and friend's homes.

The requirements of a 'cool space' were very simple: somewhere to sit, bathroom facilities, and cool water to drink. A range of other small comforts were identified as being useful, such as Wi-Fi or other entertainment, maybe some snacks, and tea/coffee. These are all things that could potentially be provided by community buildings.

How could community buildings play a role?

Community buildings play a crucial role in the day-to-day life of a community. Libraries, community centres, and recreation and leisure centres are the most frequently used public infrastructure within council areas. In times of extreme weather events, such as floods, bushfires, or other emergencies, these buildings commonly act as a safe haven for people. During heat waves, community buildings could similarly play a vital role in providing a cool space for people, especially for those who cannot avoid the heat at home. Importantly, some community buildings like libraries and neighbourhood houses have existing networks that could potentially support a coordinated response.

In 2022, our project assessed community buildings in Melbourne's west to identify heat-related vulnerabilities of buildings and collect information on the most common users of these buildings. Councils selected buildings based on factors such as the presence of air conditioning, accessibility to different transportation options, geographic location in relation to other buildings, and proximity to heat-vulnerable populations. Community centres, neighbourhood houses, and libraries were the top choices, followed by recreation centres, town halls, senior citizen centres, and one place of worship.

During early conversations with building managers, we learned that some of the buildings already serve as a cool space during extreme heat for people of all ages, with a higher proportion of seniors. Some buildings also provide a safe space for some of the most vulnerable people in the community, including those experiencing homelessness and domestic violence. It became clear that community buildings are already seen as cool spaces by many community members, and that they will play a larger role as communities adapt to climate change.

But each "safe haven" isn't perfect. The most common building vulnerabilities identified in our project include the absence of backup power, exposure of air conditioning systems to hot sun, absence of external shade trees, and the lack of building elements such as insulation. Costs to address the vulnerabilities range from inexpensive (e.g., draught sealing, shade cloth) to more capital intensive and complex upgrades (e.g., relocation of heat rejection equipment and improving structural condition of the building).

Key questions and challenges

As the project was led by local governments, an initial question was "What is the role of a local council in providing cool spaces?". We recognised that councils are front-line service providers and managers of community buildings, especially for vulnerable residents, but this role varies across internal departments or units. Sustainability units coordinate their councils' overall response to climate change impacts such as heatwaves; emergency management units coordinate responses and preparation for extreme weather events; health and community care units manage services on the ground; and facilities teams manage the maintenance and upgrade of buildings.

Our solution for the project was to set up a working group involving all the various teams, including managers of community centres themselves, such as neighbourhood houses and libraries.

The working group identified the following:

- Many types of community buildings could support the community in a heat emergency, but not all can be easily upgraded. The most suitable, such as libraries, are already being used by the community. These are often already set up to cope with heatwaves, at least to a certain extent; for example, by providing a cool environment for people to sit in for hours at a time.
- Some potentially suitable buildings require expensive upgrades to improve them, such as new air conditioning (HVAC) systems or insulation. These improvements may only be considered cost-effective as part of a more general upgrade, or when compared to the costs already associated with extreme weather events, such as increased hospital admissions. Heatwaves have a significant financial impact on built assets like community buildings, with damages projected to more than double by 2050.[16]
- There are many practical considerations for the operation and use of community centres during heatwaves. They include operating hours, staffing needs, transport and travel corridors to and from centres, whether to accommodate pets, and so on. Neighbourhood and community houses managers also mentioned increased energy costs that would be associated with running air conditioners for longer.
- Services across councils vary, so it is essential to create clear and accessible messages about what spaces may be available for people during heatwaves. There could be confusion if some councils or authorities advise people to stay home.
- A council could potentially coordinate messaging and services during heatwaves within their own municipality, but regional coordination (across municipalities) would be harder. This may require participating councils to set up a central coordinating mechanism or even shared services.

Insights

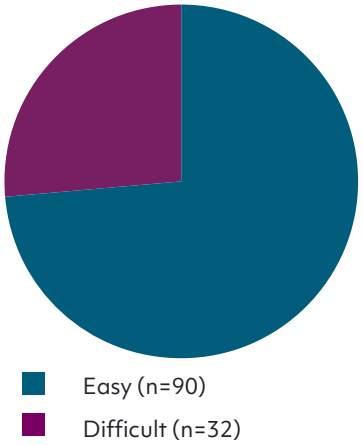
Despite the challenges, we have found that it is possible for community buildings to provide significant assistance during heatwaves to at-risk people, and some of the best solutions are not expensive. Some of the solutions involve modified operating hours, changes to staffing, and provision of heatwave safe kits for residents to take home. Following on from our project, the kits are already being produced by some councils and include items such as neck coolers, taxi vouchers, cooling towels and reusable drink bottles. Other actions involve adjustments to buildings like insulation, external shading, and 'cool-scaping'.

What next?

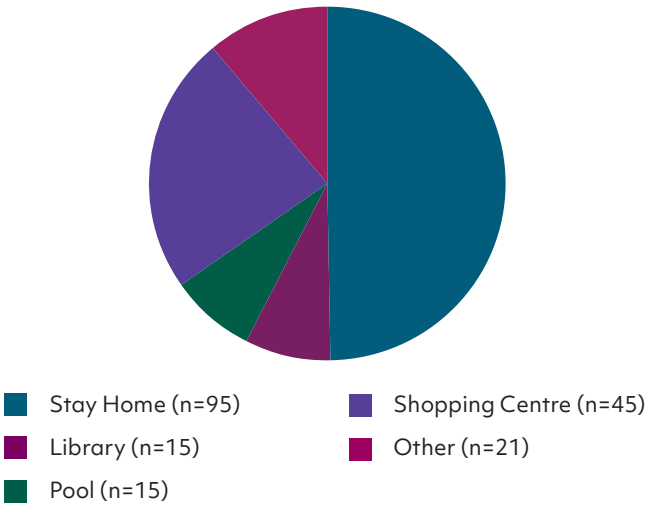
Addressing heatwaves is one of the most urgent climate change adaptation challenges for everyone, so it needs to be everyone's business.

Dwell Church has installed shading as a result of the project's building assessment. Photograph: Logan Shield, Moonee Valley Sustainability

HOW EASY IS IT FOR YOU TO KEEP COOL AT HOME?



WHERE DO YOU GO WHEN IT'S HOT?



Perspectives from people interviewed in Melbourne's west.

Understanding the places people go during extreme weather events and how they use them is critical, as it can inform the potential for surge capacity at these centres. Clarity about roles, responsibilities, communication, and local coordination is also important, and would support those who work with our community's most at-risk groups. We recommend that community service organisations consider developing heat plans for themselves, and explore how a heatwave might play out in their neighbourhood.

Our project has shown that it is possible for community buildings to provide significant assistance, for a relatively small cost. While there is still uncertainty about the roles of councils, other community support organisations, and community buildings during heatwaves, we feel confident that the findings of our work can inform future discussions. We've shown that at-risk people visit community buildings like libraries and neighbourhood houses during heatwaves, that some low-cost improvements can be made to those buildings and that there is a willingness to work together in situ to develop local heat approaches. It is important to keep advocating for these community buildings that provide many benefits to their community.

If you don't have a means of staying cool at home in the summer heat, consider seeking community buildings - a library, a recreation centre, a neighbourhood house, etc. They are typically already set up to be cool on a hot day, and they provide a space for recreation, to learn, to connect, or to "beat the heat".

Acknowledgements

We'd like to thank the team at Network West who assisted by collecting local views about heat, Northern Alliance for Greenhouse Action for extending the project to the north, the 16 local councils and their officers who contributed their ideas and time selecting buildings and discussing their use. We also extend our thanks to Sweltering Cities for their insights and for continuing the conversations nationally.

—

Shirley Diez is a Program Manager at Victorian Department of Energy, Environment and Climate Action. She has supported and coordinated the delivery of state government projects and discussions about environmental and climate-related issues for more than two decades.

Fran Macdonald is the Executive Officer of WAGA, which includes Brimbank, Hobsons Bay, Maribyrnong, Melton, Moonee Valley, Moorabool, and Wyndham Councils. WAGA is also leading a broader project called 'Victorian Climate Resilient Councils', to develop an ongoing program of support for councils to understand and embed climate change adaptation across all their services, operations, and assets.

Phani Harsha Yeggina worked as Building Resilience Project Officer at the Yarra Energy Foundation during the delivery of this project. He has deep knowledge of issues surrounding climate change and is passionate about finding equitable and just solutions to the problems.

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THE FUTURE OF PAIN MANAGEMENT DRUGS: MOVING AWAY FROM OPIOIDS

By Tejaswini Divanji, Master of Science (Pharmaceutical Sciences) student at Monash University

Everyone knows what pain feels like, even though our individual scales for it might be different. But what exactly is pain?

Understanding and addressing pain is one of the oldest challenges of medicine. Broadly, pain is an unpleasant sensation; a warning signal that something is damaged, prompting action to limit further harm. However, as many people know, this doesn't always work exactly as described.

Pain can be divided into two broad categories: acute and chronic. Acute pain is short, and resolves as the body heals itself from injury. As painful as a papercut can feel, you'll recover quickly, and the pain will go away. In contrast, chronic pain persists beyond the body's healing process following the initial injury, illness, or trauma. Chronic pain loses its protective function and can severely impact the patients' quality of life.

Opioids: the opium of the people

Opium has been used to relieve pain for millennia. Opium poppies (predominantly *Papaver somniferum*) contain several pain-relieving compounds including morphine and codeine, and evidence of medical prescriptions of the opium poppy is found in ancient Sumerian clay tablets from 2100 BC.[1]

By the 20th century, opioids were increasingly the preferred drug for the treatment of severe pain. Claims that patients would not become addicted to opioid painkillers led healthcare providers to prescribe these drugs freely, but, as we now know, these claims were false.[2,3] The over prescription of opioids set the stage for an 'opioid epidemic', beginning in the 1990s and contributing to upwards of 630,000 deaths between 1999 and 2016 in the United States alone.[2] In 2017, the US Department of Health declared the opioid crisis a public health emergency due to increased misuse of opioids.[4]

Australia currently ranks eighth in the world in opioid use (daily doses of prescription per million people), at about 40% of the level of the US.[5] The number of annual opioid-related deaths spiked in 1999 (1,245 deaths), and while there was a drop in the early 2000's, the number climbed again to 1,385 and 1,355 deaths in 2017 and 2018 respectively.[6] Over the last five years, the problem hasn't slowed. Opioids continue to be the most common drug class present in drug-induced deaths in Australia (3.8 per 100,000 population in 2021),[6] and prescription opioid overdose remains a significant problem on a global scale.

Non-opioid alternatives for pain management

To date, it has not been possible to simply halt opioid use altogether. Opioid painkillers are still in use, despite their high addiction potential and side effects of respiratory depression, nausea, physical dependence, and tolerance. Their continued prescription is owed to their effectiveness as treatments for acute postsurgical and postprocedural pain, as well as neuropathic pain, cancer-related pain, and vascular pain.[7]

But while their utility as a therapy for acute pain is well-established, there is very little evidence to justify their continued use for chronic pain, which affects 3.4 million Australians every year.[7] A clinical study of 26,000 patients showed that opioids do not provide clinically significant relief from pain in patients with chronic non-cancer pain. Additionally, opioid painkillers were associated with less pain relief in longer clinical trials, because opioid-tolerance patients stopped responding to it as well.[8] Overuse of opioids, ironically, causes more pain in patients, and

ceasing the use of opioids after long-term use results in devastating withdrawal symptoms.[7] The opioid crisis in the US showed that opioid use is surrounded by stigmas driven by stereotypes, prejudice, discrimination, and social devaluation of patients which further hinders the implementation of measures to address the crisis.[9] Together, it highlights the need at both a clinical and societal level to identify better options for pain management.

With our thorough understanding of the risks vs benefits, opioids no longer need to be regarded as the first choice for managing chronic pain. Several non-opioid drugs already exist that can alleviate pain in a more targeted manner and with fewer negative side-effects.[10]

In addition to existing drugs, the pharmaceutical industry is also developing new non-opioid alternatives for pain. There are currently 546 painkillers in development, with cannabinoid receptors emerging as the most popular drug targets, as they modulate a variety of physiological processes (including pain).[11] Given the high priority of ensuring access to non-addictive painkillers, pharmaceutical companies and regulators have begun to fast-track novel drugs through the clinical trial process, such as tanezumab for chronic pain and osteoarthritis and Vertex Pharmaceuticals' novel drug VX-548 for postoperative pain.[12]

Outside of the pharmaceutical industry, academic researchers are also developing painkillers. A new type of opioid molecule developed at the University of Bath and Wake Forest University has shown promising results in rhesus monkeys without impacting breathing or causing addiction.[13] While it shows early promise in animals, it is still a long way to being developed for human use.[13]

Drugs alone cannot sufficiently alleviate chronic pain, and other treatments and therapies are needed as part of a holistic approach. Healthcare providers can use a combination of treatments such as exercise, physical therapy, and talk therapy to reduce the severity of the pain. The emergence of novel drugs and increasing use of behavioural interventions show the future direction of pain management. They provide hope for a future without opioid addiction, and a potential end to the epidemic.

LEFT: Diamorphine - better known as Heroin - was first synthesised by English chemist C. R. Alder Wright in 1874. It would be a few decades later, in the midst of rising levels of morphine addiction, that Bayer would mass produce the drug and label it as 'Heroin'. It was marketed as an 'excellent substitute for Codeine' with fewer side-effects than morphine, and sold primarily as a cough suppressant.[14] Photograph: Wikimedia Commons (Public Domain)

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IMPROVING DRUG DISCOVERY: ALL G WITH G-PROTEIN COUPLED RECEPTORS

By Dr Catriona Nguyen-Robertson MRSV

*This article revisits Dr Christopher Draper-Joyce's presentation to the Royal Society of Victoria in September 2021 as the recipient of the **2021 Phillip Law Postdoctoral Award.***

The human body is composed of trillions of cells. Each individual cell communicates with others, and performs certain tasks within the collective to keep our bodies working. Their ability to send and receive signals is vital. When communication is disrupted, disease often ensues.

Many therapeutic drugs used to treat a range of diseases target specific cell receptors – proteins on the cell surface that receive messages. Restore the communication, and you can restore normal function.

Using an interdisciplinary approach, Dr Christopher Draper-Joyce is exploring new approaches of safer and much improved options for therapeutics.

Cell communication (sans a mobile phone)

Numerous protein receptors in the body recognise a variety of signals to control cell behaviour. A message in the form of a signal molecule will bind to a receptor to elicit a response. The largest cell surface receptor family is G protein-coupled receptors (GPCRs). They are a large, diverse group of receptors that sit on cell membranes to respond to stimuli outside the cell.

Humans have more than 1,000 different types of GPCRs, and each has a unique function. When they bind to their appropriate signal - neurotransmitters, hormones, metabolites, and even light photons – they trigger a cascade of molecular events within the cell, broadcasting the signal via effector proteins.

Importantly, because GPCRs are involved in so many cellular responses, they are excellent drug targets. These receptors regulate numerous diverse physiological processes and are easily accessed by drugs at the cell surface, making them of particular interest as pharmacological targets. In fact, GPCR targets comprise around 35% of all medicines currently approved by the USA's Food and Drug Administration.[1,2]

Targeting GPCRs as therapeutics

Traditional drug discovery approaches focus on the point that a signal molecule contacts the receptor, either aiming to block or enhance signalling. The challenge with this approach, however, is designing a drug that selectively only targets the particular GPCR you want, while avoiding similar-looking ones as all GPCRs have a similar structure. . For example, the places where dopamine, serotonin, acetylcholine, and adrenaline bind their respective receptors overlap in structure. If a drug is designed to block the location where one of these molecules binds, then there is a high chance it will block all of the different molecules from binding to their own GPCRs, resulting in unwanted side effects.

Another challenge in drug discovery is that receptor signalling is often quite complicated. Because each GPCR triggers a cascade of signals in a cell when switched on, by manipulating one receptor, you are manipulating many signals at once.

Using a drug to either completely switch or switch off a receptor could therefore result in negative impacts in addition to achieving the desired outcome. As an alternative approach, Christopher and other researchers design drugs that bind to the receptor in such a way that they modulate the signal rather than completely switching it on or off. Rather than designing a drug that fits snugly into the spot where the signal molecule usually binds its receptor, if the drug binds to a different part of the GPCR, it could act as a dimmer switch without completely disrupting signals.

Christopher's team have recently unlocked the key that could lead to the development of alternative painkillers. With chronic pain affecting more than 3.2 million Australians and the costs of chronic pain expected to increase in the coming decades,[3] there is an urgent need for new, non-opioid painkillers. The adenosine A1 receptor protein (a GPCR) has long been recognised as a promising therapeutic target, as it plays a role in sensing pain. However, because adenosine can bind to four different receptors to either enhance or inhibit pain, previous attempts to target it without off-target effects have failed.

Using a multidisciplinary approach with preclinical models and microscopy, Christopher and team produced a detailed visualisation of the A1 receptor protein structure. They achieved the first atomic-level snapshot of the pocket where drugs bind, and could therefore design a drug that enhances the ability of adenosine to bind the A1 receptor – without also binding to a region conserved across multiple GPCRs. His work also shows that it is possible to design drugs for specific diseases by better understanding the interplay between a signal molecule and its receptor, and exploiting their structural interactions.

While most traditional drugs are small molecules that somehow interfere with the binding of signal molecules to a receptor, Christopher is now also exploring the use of nanobodies in therapeutics. Antibodies are proteins that bind tightly and specifically to their target cells, and nanobodies are the versions found in camelid animals (camels, llamas, alpacas, etc.). The different structure of nanobodies allow them to bind to different parts of a receptor, while also being cheaper to produce and less sensitive to temperature fluctuations (which is a particularly important consideration for transport). Furthermore, the structure of nanobodies is such that they tend to have finger-like parts that can help them better reach into the grooves of their target receptors, which may aid researchers like Christopher to design drugs to modulate a receptor rather than completely switch it on or off. He is currently producing nanobodies that target various GCPRs in alpacas in the hope that they become viable therapies for cancer and other diseases.

Receptors, particularly GPCRs, are implicated in a plethora of diseases. Through a molecular understanding of how ligands and receptors interact, and how a drug can modulate the interaction, is greatly advancing drug discovery programs. These new protein visualisation technologies will pave the way for safer and more effective GPCR therapeutics.

*Watch Dr Christopher Draper-Joyce's presentation to the RSV in full at **youtu.be/kDynzPYP5XU** (or a 10-minute version at **youtu.be/_6JmG-NcRU8**).*

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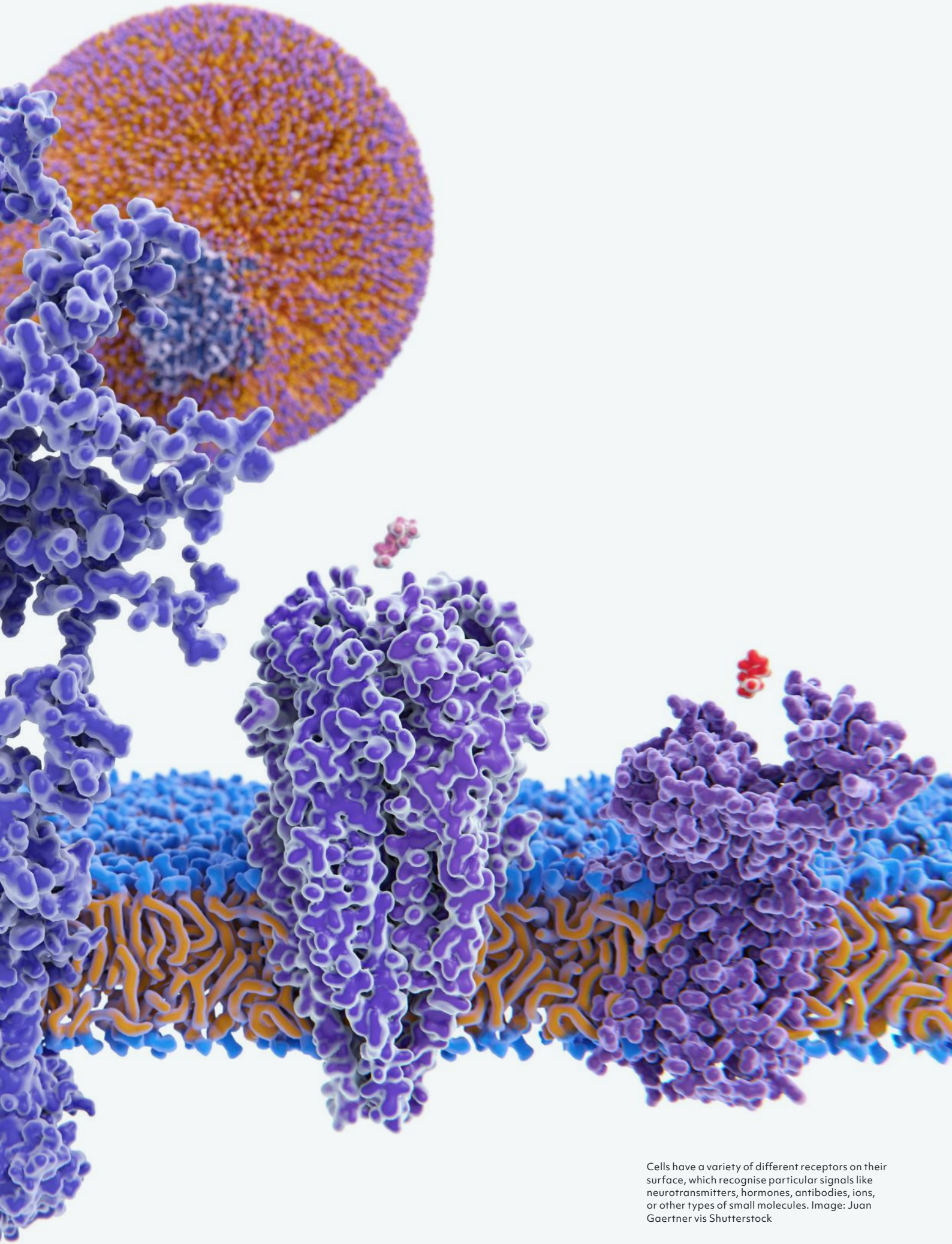
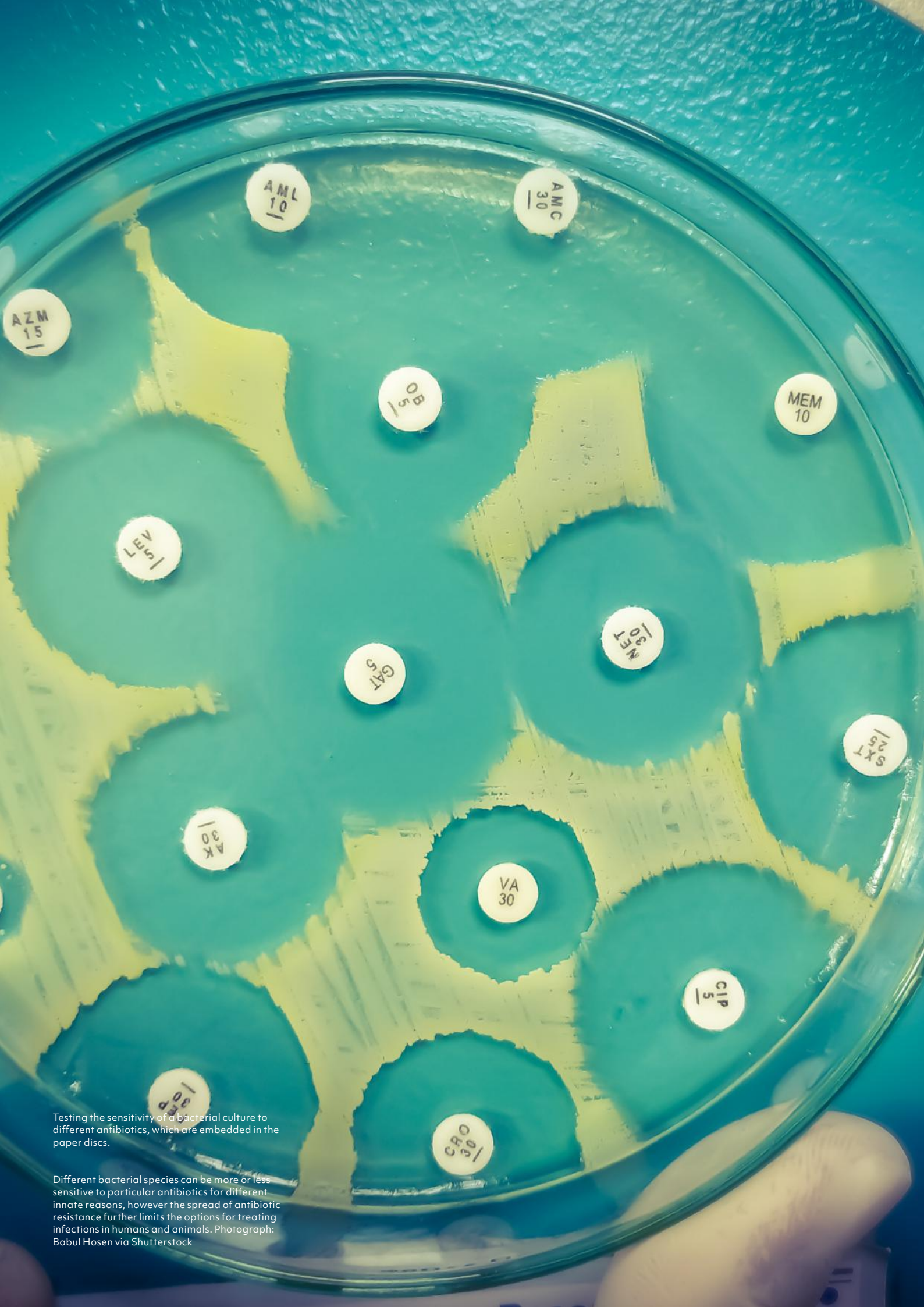


Cells have a variety of different receptors on their surface, which recognise particular signals like neurotransmitters, hormones, antibodies, ions, or other types of small molecules. Image: Juan Gaertner vis Shutterstock



Testing the sensitivity of a bacterial culture to different antibiotics, which are embedded in the paper discs.

Different bacterial species can be more or less sensitive to particular antibiotics for different innate reasons, however the spread of antibiotic resistance further limits the options for treating infections in humans and animals. Photograph: Babul Hosen via Shutterstock

RSV YOUNG SCIENTIST RESEARCH PRIZE FINALISTS

The Royal Society of Victoria annually awards four competitive prizes to final year PhD students in all areas of the Biomedical & Health Sciences, Biological Sciences (Non-human), Earth Sciences, and Physical Sciences. In September 2023, we heard from this year's eight finalists about their brilliant work in these fields. Over the coming months, they will share a written summary of their presentations in Science Victoria.

For more information about the RSV's Young Scientist Research Prize, visit ***rsv.org.au/young-scientist-research-prizes***

2023 RSV Young Scientist Research Prizes (Biological Sciences) - 1st place winner.

GETTING BACK ON TRACK

By Sarah Mele MRSV

Metabolism – it's how the food we eat gets turned into energy, and surprisingly it's a lot like a train network.

Your metabolism is a series of interconnected chemical reactions that have a beginning and a destination. At each "stop", a reaction is carried out by an enzyme, the chemical catalysts of the body, to allow the process to keep moving along the path.

But much like a train network, it doesn't always run.

The amino acid train line

Amino acids are the building blocks of proteins. Every time you eat protein, it is broken down into amino acids which then embark on their journey to be mixed and matched, and rebuilt as different proteins.

But what if there's an obstruction on the track — a malfunctioning enzyme? That can lead to an amino acid disorder. Not only is there a dangerous pile-up behind the obstruction, but there's also a deficit at the end of the track.

My project is focused on one small track of the network to do with an amino acid called valine. The metabolism of valine involves at least seven stages and a deficiency of the appropriate enzyme at any of these stages means that the train comes to a halt, leading to a disorder of varying severity and rarity. The resulting disease makes it hard for infants to learn to walk and talk.

There are ways we can try to fix this by changing their diet:

1. **Restrict:** By limiting the number of amino acids that are coming down the line to avoid congestion on the train line, in this case, valine.
2. **Resupply:** By starting new trains after the obstruction.
3. **Reroute:** By diverting trains down an alternate track that might not get you to your original destination - but at least you're not stranded.

Together these changes help to address the underlying problem.

Patients with amino acid disorders usually have to restrict protein in their diet and replace it with medical food substitutes. This can be constraining, but life-saving. Despite this, many amino acid disorders lack treatments because they are very rare, occurring in roughly 1 in 6500 births, making them difficult to study.[1]

One of the disorders I studied in my PhD is HIBCH (3-hydroxyisobutyryl-CoA deacylase) deficiency. It is currently not fully understood whether changes in diet can effectively treat this disorder. I therefore tested some treatments on a model organism: the fruit fly, Drosophila (these flies share 70% of disease-causing genes with humans, who knew!?)[2]. Flies with HIBCH deficiency don't move or develop as well as their healthy counterparts.

First, I tried to **restrict** – I reduced valine in the diet and saw that flies were not much better off. Second, I tried to **resupply** – I added a compound to the diet that valine is normally broken down into if HIBCH enzymes were functioning as normal. This didn't help much either. Third, I tried to **reroute** – a compound called carnitine can combine with one of the molecules that builds up with this disorder, altering it and allowing it to be transported elsewhere or excreted. I added carnitine to the diet and saw that more of the flies with the disorder were able to develop, and faster too.

This is the first model organism for HIBCH deficiency and other valine metabolic disorders. Now that these model organisms have been established, they can be used for large-scale diet and drug screens to bring us closer to finding treatments for individuals with these rare metabolic disorders.

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Sarah Mele, PhD candidate at Monash University. Photograph: Karey Shandler, Verse Photography

RSV Young Scientist Research Prizes (Biomedical & Health Sciences) - 2nd place winner.

HARNESSING IMMUNE CELLS IN THE BOWEL TO FIGHT CANCER

By Marina Yakou MRSV

Bowel cancer claims the lives of over 15,500 Australians each year, ranking as the second leading cause of cancer-related deaths in Victoria and the whole country.[1] The risk of developing bowel cancer rises sharply from age 50, but the number of diagnosed younger Australians has been increasing steadily, and 1 in 15 Australians will develop the disease in their lifetime.[2] We therefore need innovative approaches for bowel cancer treatment.

Immunotherapy has emerged as a beacon of hope. This cutting-edge approach involves enhancing the immune system's capacity to identify and eliminate cancer cells. As part of their normal function, immune cells detect and destroy abnormal cells - like cancer cells to prevent or slow cancer growth. But cancer cells have ways to avoid destruction by displaying proteins on their surface that turn off immune cells, having genetic changes that make them less visible to the immune system, or interfering with how the immune system responds to these cancer cells in other ways. Immunotherapy helps the immune system overcome these hurdles to better fight cancer.

However, the current reality is that fewer than 10% of bowel cancer patients respond positively to existing immunotherapies. This limitation underscores the critical need for groundbreaking research to unlock the full potential of immunotherapy in the fight against bowel cancer.

A part of my PhD research, I explored the gut microbiome, a complex ecosystem within the large bowel consisting of trillions of bacteria, viruses, and fungi. This diverse microbial community plays a pivotal role in modulating the immune system. Everyone has a different profile of microbial species in their bowels, and the microbes that are present determine the education that immune cells receive and regulate the immune system. Within this intricate web, gamma delta T cells, a vital group of immune cells in the large bowel, emerged as key players in preventing bowel cancer.[3]

Gamma delta T cells act as frontline defenders in the bowel. In the Mucosal Immunity and Cancer Lab at the Olivia Newton-John Cancer Research Institute, we found that the abundance and diversity of a person's microbiome increased the number of gamma delta T cells. When we analysed bowel cancer patient samples, we found that when more gamma delta T cells were present in the tumours, the patients had better outcomes.

The gut microbiome also influenced the ability of gamma delta T cells to fight the cancer. The microbiome strongly influenced gamma delta T cells' expression of a molecule called TCF-1, and we found that TCF-1 suppressed the natural immune response that gamma delta T cells can normally exert against bowel cancer. Furthermore, when we genetically deleted TCF-1 from gamma delta T cells, there was a significant reduction in the size of tumours.

By targeting gamma delta T cells and their TCF-1 expression, we may be able to develop targeted combination immunotherapies to treat bowel cancer patients more effectively. This newfound understanding of the intricate interplay between the microbiome and immune cells in the large bowel could open new avenues for intervention in the battle against bowel cancer.

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Marina Yakou, PhD candidate at La Trobe University, discussing the need for new cancer immunotherapy targets. Photograph: Karey Shandler, Verse Photography

RSV Young Scientist Research Prizes (Biomedical & Health Sciences) - 1st place winner.

THE LIGHTER SIDE OF BUILDING BIONIC EYES

By William Kwan MRSV

Over 100 million adults worldwide will be affected by mild to severe visual impairment in their lifetime. Sight begins with light. Visual processing begins with light inputs to photoreceptors in the retina, which signal to specialised neurons, and the signal is sent along a pathway to finally reach the brain. Many cases of visual impairment are due to photoreceptor loss, which could be due to genetics (e.g. retinitis pigmentosa) or ageing (e.g. macular degeneration). In addition to the physical and mental health toll that the visually impaired face, the global economic burden exceeds AUD$600b. As such, there is a concerted effort globally to address this health issue.

At the dawn of the 21st century, bionic eyes were being developed as a treatment strategy. They work by electrically stimulating the remaining healthy retinal tissue to evoke signal transmission between retinal cells and the brain. As our knowledge of retinal biology and engineering progressed, some devices have provided a degree of visual recovery in patients, allowing them to perceive objects and large letters. While this is a remarkable achievement, these devices do not provide patients with enough visual acuity to mean that they are no longer regarded as legally blind. Considerable research is still required to develop implants that provide more substantial vision restoration.

One of the issues with current devices is off-target stimulation. The electrical stimulation used to activate cells in the retina tends to spread, leading to inadvertent broad activation and poor visual acuity. As such, developing alternative stimulation methods that deliver greater spatial precision would be invaluable for vision restoration.

A stimulation method that shows promise as a viable alternative is optogenetics, a technique where cells of interest are genetically modified to express light sensitive proteins called opsins so that they can be activated by light. By specifically targeting opsin expressing cells, optogenetics improves spatial resolution in cochlear implants, provides greater control in regulating irregular heart rhythms, and recently has been tested in vision restoration. However, optogenetics also has a limitation: its poor temporal kinetics. The most frequently used opsins are unable to reliably activate neurons at frequencies typical in a healthy retina.

As part of my PhD, I am investigating methods to improve the temporal bandwidth of optogenetics so that it could, potentially, be used in bionic eyes. One approach my lab has adopted is a hybrid strategy of both optogenetic and electrical stimulation. We stimulate optogenetically and deliver a level of electricity low enough that we don't evoke off-target stimulation but enough to leverage the high temporal fidelity of electrical stimulation. In animal models, my preliminary results are promising, however, this hybrid approach still requires further investigation to determine whether translation to clinical trials is possible.

We hope that by resolving the temporal limitations of optogenetics, crossing the threshold of legal blindness will be possible for future bionic eyes. Furthermore, as bionic devices such as cochlear, heart or limb implants still predominantly use electricity to stimulate neurons, we envisage that hybrid stimulation could potentially enhance the way these devices interface with neural tissue. Achieving this will ultimately provide greater functional recovery and ultimately improve the quality of life for patients who receive them.

WIlliam Kwan, PhD candidate at Monash University. Photograph: Karey Shandler, Verse Photography

Neerim District Timber Mill, Victoria, circa 1910. Source: Museums Victoria Collections (MM5825) (Public Domain).

1970

ASHES TO ASHES...AND PULP, AND MILLING

By Scott Reddiex MRSV

Last month, From the Archives covered a presentation at the RSV's West Gippsland Symposium in 1970 on coal. This month, we take a look at a second presentation to the symposium that discusses another vital resource in the history of Victoria: ash type eucalypts. It was authored by Mr S. C. Butler, who was Chief of the Forest Operations Division at the Forests Commission of Victoria at the time.

It is staggering to consider how different the area now known as Victoria was prior to the arrival of Europeans. In 1869, 88% of Victoria was covered by forests.[1] By 1972, only 36% of the state remained forested.[1] At that time in West Gippsland, almost a fifth of that forest was classified as 'ash country', dominated by ash-type eucalypts – mountain ash, alpine ash, and shining gum trees.

These ash type eucalypts, and particularly the mountain ash, can grow extremely tall. Butler reported that in 1921, there were listed "*a number of mountain ash trees well over 300 ft high, including 342 ft to a broken top in the Dandenongs, 319 ft in the Otways, and 326 ft at Mt. Baw Baw. However these trees are no longer standing, and possibly there are no trees left in West Gippsland exceeding 300 ft.*"

The ash forests of West Gippsland were reduced considerably through settlement, fires, and utilisation of the timber resource.

On the impacts of settlement by Europeans, Butler writes that "*from 1880 to about 1900 extensive mountain ash areas north of Noojee and in the Strzelecki Ranges of South Gippsland were sub-divided and made available for settlement. In an astonishingly short time tens of thousands of acres were cleared: the timber was considered a nuisance by the settlers and destroyed, generally by burning. Much of this ash country was later abandoned since problems of scrub, vermin, difficult topography, fire and isolation proved too much for the pioneers.*"

Many catastrophic fires ravaged Gippsland between the 1800s and the 1970s. One of the most extreme events was the Black Friday bushfires in 1939, which claimed the lives of 71 people and burned 2.5 million acres of forest. While earlier bushfires had resulted in "*excellent ash regeneration*", most of these areas were destroyed by the intensity and extent of the 1939 fires.

On utilisation, the ash timbers were initially not widely used for milling, as the sawn timber tended to "*collapse and distort during drying and seasoning*". This changed in the early 1900s with the development of technologies to address this shortcoming, resulting in the commencement of large-scale milling operations in West Gippsland. By the late 1960s ash sawlog output was in decline, while the amount of ash sent to pulp mills remained three times higher.

As for thoughts on the future of the West Gippsland ash forests in 1970, the policies and plans generally aimed to maximise the economic potential of this resource. This was to be achieved through regeneration of felled areas, reforestation of scrub and bracken areas, thinning of regrowth strands (i.e., removing the 'poorer trees' for the benefit of the 'better quality' trees), and protecting forests from bushfires. While the value of these forests for domestic and industrial water supply catchments is recognised, there is no mention of any other plant or animal in these ecosystems by Butler in this article.

Victoria's forests would continue to decline through the subsequent decades, with only 33% coverage in 1998.[2] This number has since returned to 1972 numbers (36%) by 2013,[3] however the 2018 State of the Forests report has seen only a 0.1% increase on that number.[4]

Whatever the future holds for Victoria's forests, we can be sadly confident that it will never reach 88% coverage again.

From:

Proceedings of the Royal Society of Victoria, Vol 83 (New Series), 1970. Article 7 - The Eucalypt Ash Resource of West Gippsland. By S. C Butler.

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The Beckman Model M pH Meter, first sold in 1937, was the fourth version of Beckman's pH meters to reach the market. Source: Science History Institute (Public Domain).

1920

POTENTIAL MEASURES OF POTENTIAL

By Scott Reddiex MRSV

The pH of a solution reflects its concentration of hydrogen ions. Generally speaking, more H+ than OH- means a solution is acidic, and more OH- than H+ means it's basic/alkaline. Testing and controlling the pH of a solution is vital in many different settings, whether it be in food preparation, drinking water and wastewater treatment, medical testing, scientific research, or keeping your swimming pool safe.

On the 9th of December 1920, a paper by James Monahan Lewis was read to the RSV discussing how to determine the pH of a solution. In his paper, Lewis covers the three methods *"available for the determination of the acidity or basicity of solutions":*

(1) The use of a "ladder" of indicators.

(2) The hydrolysis of esters.

(3) The electrometric method.

The first method is something that anyone who has owned a swimming pool, spa, or fish tank will be very familiar with. Indicator solutions have long and widely been used to determine pH, as they visibly change colour depending on the concentration of hydrogen ions. For example, to test the pH of a swimming pool, phenol red is the most widely used indicator, as it changes gradually from bright yellow below pH 6.8 to a bright fuchsia at a pH over 8.2. If your sample of pool water turns orange-red when you add phenol red, then it has a pH around 7.2-7.6, and you're safe to swim.

As the many different indicators change colour over different ranges of pH, indicators are selected based on the requirements of the task. Different indicators can also be combined to create a universal indicator, which moves through red, orange, yellow, green, blue, to violet as the pH of a solution goes from < 3 to > 11.

The second method for measuring pH discussed by Lewis is the 'hydrolysis of esters', which he says, *"must be regarded as more or less cumbersome… and may be set aside as not fulfilling the necessary requirements for routine use in the laboratory".* It is perhaps for this reason that he does not go into detail about the precise methodology.

In contrast, much more detail (24 pages) is provided for the third method. Described as *"the final court of appeal"* due to its (at the time) laborious setup and high sensitivity, the electrometric method forms the foundation of modern electronic pH probes used routinely in various industries. This method traditionally calculates the pH using two electrodes - a measurement probe and a reference probe - or a single combination electrode.

In 1920, this new electrometric method of measuring pH with high accuracy was groundbreaking. It would be another 14 years before Arnold Orville Beckman (founder of Beckman Instruments, later Beckman Coulter Inc.) would invent the pH meter based on these principles, revolutionising the study of chemistry.

From:

Proceedings of the Royal Society of Victoria, Vol XXXIII. (New Series), 1921. Art. XV - The Estimation of Acidity. By J. M. Lewis, D.D.Sc..

The Intercolonial Exhibition, held at the Melbourne Public Library in 1866, at which the Reverend Bleasdale presented a collection of gems found around Melbourne. Source: State Library of Victoria (Public Domain).

1868

MELBOURNE: WHERE THE CREEKS WERE LINED WITH GEMS

By Scott Reddiex MRSV

The Victorian gold rush brought hundreds of thousands of people from around the world to 'Marvellous Melbourne', on the chance they would become rich.[1] However, the almost 2,000 tonnes of mined gold weren't the only valuable to be found in Victoria during the 1800s.[2]

On the 25th of June 1868, the Rev. J. J. Bleasdale read his paper "*On Colonial Gems*" to the society, and accompanied this with the exhibition of "*several rubies found near Berwick*".

These particular gems were provided to Bleasdale by "*my friend, Mr Crisp, of Queen-street. He got them from Mr. Henty, who really owns them, and in the vicinity of whose station, below Dandenong, they were found*". The aforementioned Mr Crisp was the very same who apparently held the honour of finding "*the first blue sapphire ever found in Victoria … out of the gizzard of a wild duck, bought in Melbourne*".

On the veracity of this story, Bleasdale writes that "*This was told me by him a dozen years ago*". He goes on to say that over the next few years, there were no reports of rubies or sapphires found within a hundred miles of Melbourne. This changed when "*Mr. Ulrich informed me he had found a ruby, when examining sands from the creeks about Mount Martha and Mount Eliza*". Realising there were likely more gems to be found, and while preparing a collection for the Intercolonial Exhibition in 1866, Bleasdale examined "*in a cursory way the Dandenong, Berwick, Tubba Rubba, and other creeks to the south-east of Melbourne". His assumption held true, as he found "very pretty crystals of blue and greyish blue sapphire and a few small zircons*".

With these findings and the reports of other precious gems found near Berwick, Bleasdale determined that Mr. Crisp had likely been telling the truth: "*There is no wonder, then, at Mr. Crisp having met with a specimen in the gizzard of a wild duck; especially after what we know of the district, and when we recollect that at the time the supply of wild fowl was derived almost wholly from the Mordialloc and Dandenong country.*"

The variety of different gems found around Victoria appear to have very much impressed the Reverend, who goes on at length about how proud he is of Victoria, mostly because "*as yet no one country on the broad earth has yielded such an assemblage of varieties of rare and precious gems as Victoria*".

From:

Transactions and Proceedings of the Royal Society of Victoria, Volume IX, 1868. Article X – On Colonial Gems. By Rev. J. J. Bleasdale, D.D.

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2. GOLD PRODUCTION OF VICTORIA. (1907, June 6). Examiner (Launceston, Tas. : 1900 - 1954), p. 2 (DAILY). Retrieved November 2, 2023, from nla.gov.au/nla.news-article45816609

Students were excited to see "behind the scenes" of the biotech industry at CSL. Photograph: Sandra McKechnie, Whittlesea Tech School

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**
- **Neighbourhood Houses Victoria**
- **Parliament of Victoria**
- **Museums Victoria**
- **Royal Botanic Gardens Victoria**
- **The Commissioner for Environmental Sustainability**
- **Questacon**
- **The Arthur Rylah Institute for Environmental Research**
- **Zoos Victoria**
- **Science Teachers Association of Victoria (STAV)**

STUDENT SUPERHEROES FIGHTING SUPERBUGS AT WHITTLESEA TECH SCHOOL

By Dr Catriona Nguyen-Robertson MRSV

Antimicrobial resistance (AMR) threatens the effective treatment of a growing range of infectious diseases.

Without effective antimicrobials, the success of modern medicine in treating infections will be drastically reduced. Over one million people die each year due to drug-resistant infections because their diseases are untreatable,[1] and this could rise to as many as 10 million by 2050 if AMR is not addressed.[2] In response, the World Health Organization (WHO) has declared AMR as one of the top ten global public health threats that we face.[3]

Whittlesea Tech School calls on superheroes to fight superbugs. In this case, the superheroes are Victorian secondary school students. Students are invited to undertake an investigation: to develop antimicrobial products that kill harmful bacteria while keeping the good ones safe.

Not all bacteria and viruses are out to get us. Each of us houses a thriving ecosystem of microbes, including bacteria, viruses, and fungi, which is referred to as our microbiome. Although they are microscopic, these microbes have a mutually beneficial relationship with us, and contribute immensely to our health. They live on our skin, in our airways, and especially in our gut. In fact, the average human has an estimated 38 trillion bacterial cells, outnumbering their 30 trillion human cells.[4] Whittlesea Tech School's *Biotechnology in Focus* program teaches students about the relationships we have with microbes – both good and bad.

Our microbiome is one of the first lines of defence against pathogens. By occupying space and taking up nutrients along our barriers, harmful "invaders" (pathogens) have fewer resources with which to grow and hence cause disease. Our microbiome also fine-tunes the immune system: it plays a role in immune system training and development and there is constant cross-talk between the two.[5] In addition, Beneficial bacteria also can perform tasks that our own cells cannot, such as metabolising nutrients that we cannot digest (such as fibre) into usable molecules for our cells.

Whittlesea Tech School encourages students to consider the importance of our microbiome, as it can be harmful to wipe out bacteria that keep us healthy. Without good bacteria present, the immune system becomes dysregulated, and disease-causing bacteria are given a chance to flourish. The result can be infections and autoimmune diseases, such as inflammatory bowel disease. Courses of antibiotics affect our gut microbes, which can allow pathogenic bacteria to colonise the gut, and is why probiotics are often recommended following antibiotics. *Clostridioides difficile* (formerly known as *Clostridium difficile*) is an example of an opportunistic pathogen that causes disease following antibiotic treatment, and is the leading cause of hospital-acquired infectious diarrhoea.[6] It is therefore important when designing new antimicrobial agents to consider only targeting disease-causing microbes – otherwise they could make things worse.

Adding to the AMR crisis is shortage of new antibiotics; pharmaceutical companies do not want to invest in drugs that are complex to develop and might not work several years down the track. Because of this, no new classes of antibiotics have been invented for decades – any new antibiotic is simply a variant of existing compounds discovered prior to 1984. Over the course of a term, students are guided through a design thinking process to create and market a new antimicrobial product.

As students – or any scientists – investigate solutions to the AMR crisis, many turn to nature. Over the years, nature has given us many valuable medicines, including most of the

antibiotics we use today. Antibiotics are produced by soil bacteria and fungi, killing off competition when competing with other microbes for food and water and other limited resources. Penicillin, for example, was discovered when Dr Alexander Fleming realised that the mould on his rotting food produced a chemical that killed bacteria. Today, scientists study the incredible diversity of microbes, including bacteria and fungi, hidden within soil to search for the next antibiotic. The search is made easier with the help of citizen scientists around the country as part of the Soils for Science program, who send soil samples from their backyards, gardens, and farms to microbiologists at the University of Queensland, and with school students - like those who visit Whittlesea Tech School - learning to design innovative solutions.

As part of a pilot program in 2020, students at four partner schools rose to the challenge of producing their own antibiotics at Whittlesea Tech School. Students were invited to walk in the shoes of a scientist to create their own bacteria-fighting serums from food- or plant-based extracts. They cultured two different bacteria in the Melbourne Polytechnic laboratories with which they could test their solutions: *Lactobacillus acidophilus*, usually found in the intestine, and *Escherichia coli*, which is also common in the gut but there some harmful strains cause diarrhoea. The students' goal was to design a product that would kill E.coli while leaving *L. acidophilus* (representative of healthy gut microbes) unharmed. Once students had successfully developed a serum, the next phase of the "design sprint" was to propose a product incorporating their antimicrobial solution (e.g. Band-Aids infused with an antibiotic extract or drinks). More recently, students have participated in the renamed *Medical Biotech Scientific Inquiry* program remotely, developing a method to test the antimicrobial properties of a chosen plant-based extract (such as olive oil, peppermint, or manuka honey), and producing a scientific poster to outline their findings.

The Biotechnology in Focus Program is not only centred around scientific investigation, but also on building career awareness of the biotechnology industry. "We have Australia's largest biotech industry on our doorstep," says Sandra McKechnie, Director of Whittlesea Tech School. Sandra wants to make the most of the Tech School's location, and to provide a strong link between industry and education.

For the first time, CSL Broadmeadows opened its doors to 100 secondary students as part of the pilot program, for students to tour the laboratories and hear from the heads of the HR, Research, and Manufacturing divisions. "Biotechnology is not an industry that is very well-known within Australia," says Kathy Sacca, Director of Talent Development at CSL Behring. It has been a great opportunity for students to have their minds opened to real biotechnology applications and jobs here in Melbourne that they were not previously aware of – many students even commented that they are now considering a career in the biotechnology industry.

"I never knew much about biotechnology...and I think it's amazing. I think it's the way of the future," said a student from Viewbank College. Students loved the program and took ownership of their research – continuing to work on their projects over lunch time and at home.

Biotechnologists are going to be required to solve the challenges that society will be facing in the future. "Tech schools are designed to prepare students for jobs of the future," says Sandra. Whittlesea Tech School is therefore committed to provide opportunities for students to innovate and prototype solutions to real world problems and challenges.

You can learn more about the Biotechnology in Focus program at: **whittleseatechschool.vic.edu.au/program/medical-biotech-scientific-inquiry**

Watch an overview of the *Biotechnology In Focus* Pilot Program at Whittlesea Tech School at: **youtu.be/6NVeMp9diGw**

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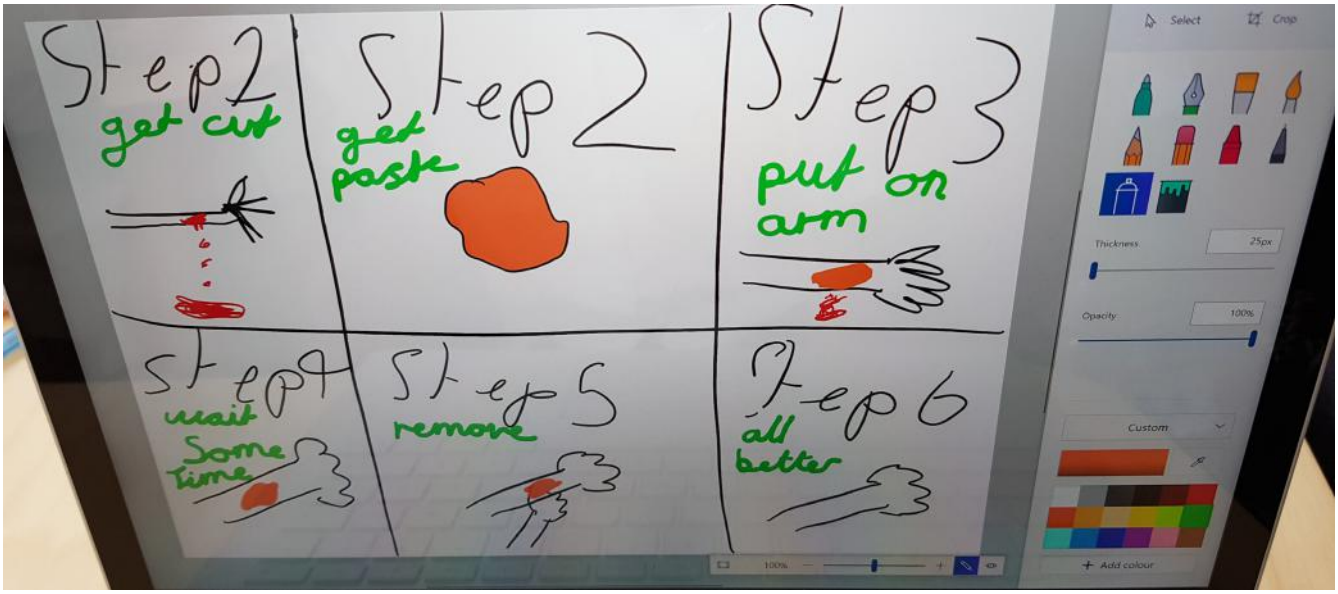
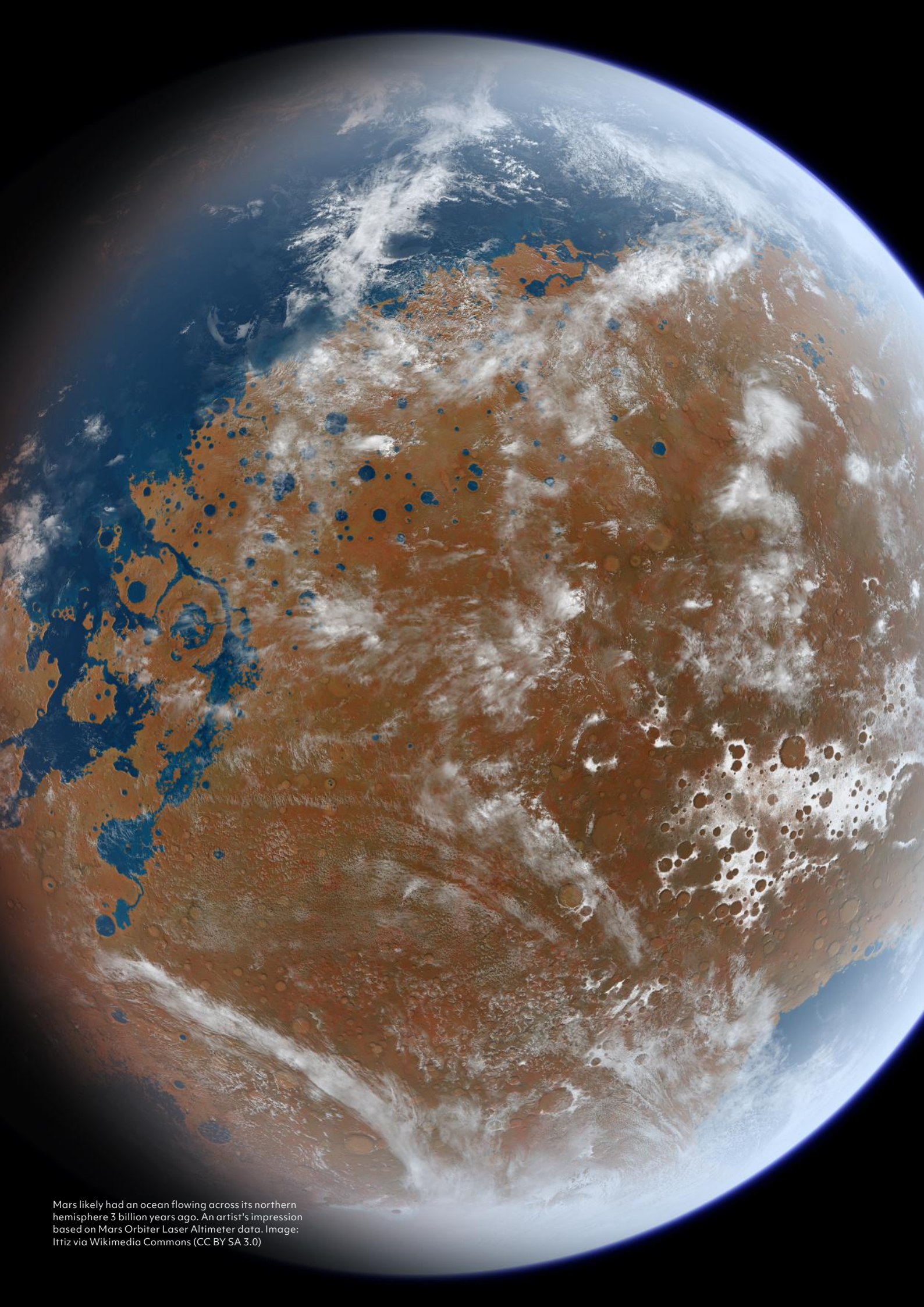


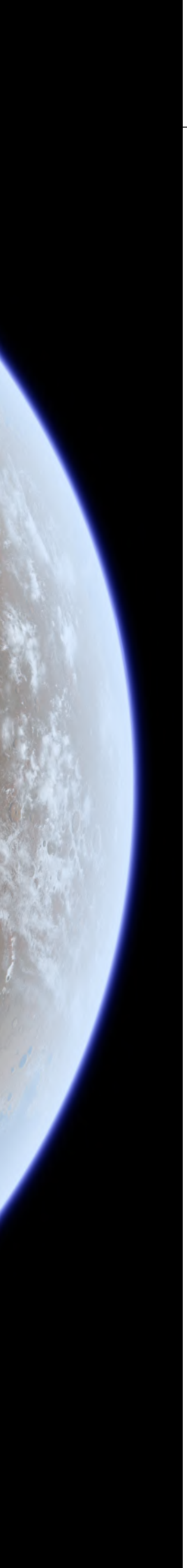
Once students have developed an antimicrobial, they have to think about its application and how it might go to market. Photograph: Sandra McKechnie, Whittlesea Tech School



Mars likely had an ocean flowing across its northern hemisphere 3 billion years ago. An artist's impression based on Mars Orbiter Laser Altimeter data. Image: Ittiz via Wikimedia Commons (CC BY SA 3.0)

WHERE'S THE WATER IN OUR SOLAR SYSTEM?

Dr Tanya Hill, Senior Curator of Astronomy at Museums Victoria



NASA has a saying – "follow the water" – because wherever there is water here on Earth, we find life. Water provides an ideal environment for life to flourish. But even more importantly, all life on Earth can't exist without water.

From tiny bacteria to giant blue whales, the chemical reactions going on inside all living things – including us – that keep them alive cannot happen without water. By taking NASA's lead and following the water, scientists can pinpoint the most compelling locations where life – either past or present – might possibly exist beyond our home planet.

There's no place like home

Water, in all its various forms - liquid oceans and seas, ice sheets and glaciers, and water vapour in the atmosphere - helps to make Earth a great place to live. If it weren't for the oceans absorbing the heat of the Sun and spreading that heat around the globe, our planet would be unbearably hot. Conversely, water vapour in the atmosphere ensures that our planet never gets too cold. By trapping heat in the atmosphere, it acts like a blanket keeping us warm throughout the night.

Driven by water in the seas and skies, Earth's climate is just right - not too hot and not too cold. But we are in danger of critically upsetting this delicate balance.

Dry, rocky terrestrials

On the surface it appears that the Earth has an abundance of water. Oceans cover 70% of our planet. But in reality, our world is very dry. If we stripped the Earth of all its water – from the oceans, lakes and rivers, groundwater, ice sheets, water vapour in the atmosphere, and even the water found in all living beings – and scooped it up to form a ball, that ball would be just 1,400km across or about nine times smaller than the barren, rocky Earth. Amazingly, very little water is needed for life to thrive.

Earth, along with the other terrestrial planets – Mercury, Venus and Mars – are all rocky worlds without much water. Of these Venus is the hottest and recent studies have shown that no water persists there. Its thick carbon dioxide atmosphere traps so much heat that the surface temperature remains constant at 460°C, regardless of whether it's day or night.[1] Even in the upper atmosphere where temperatures are cooler, there is extremely little water vapour found.

Mercury, being the closest planet to the Sun, also experiences extremely high temperatures. Without oceans to absorb the Sun's heat the daytime temperatures reach a scorching 430°C, and without a protective atmosphere to keep warmth in, temperatures plummet to almost -200°C overnight. Mercury therefore is incredibly dry for the most part, but surprisingly, water is hidden in deep, dark craters near Mercury's north and south poles.[2] There, the Sun barely rises above the horizon and sunlight can't penetrate the crater floors. In 2012, the Messenger spacecraft, which is the only spacecraft to have orbited Mercury, confirmed the presence of water ice in those permanently shadowed craters.

Our Moon, which is similar to Mercury in its extreme temperature swings, has also been found to have frozen lakes of water inside its permanently dark craters. Current lunar exploration is focused on the Moon's south pole precisely in the hopes of discovering water hidden there. Water on the Moon could be processed for drinking or, by breaking water (H_2O) into its hydrogen (H_2) and oxygen (O_2) components, astronauts could obtain both oxygen for breathing and rocket fuel.

Future astronauts arriving on dusty, red Mars may also have success in finding water. In 2018, the European Space Agency's Mars Express spacecraft found signs of liquid water in the form of a very salty pond, buried 1,500m near Mars' south pole.[3] This was off the back of NASA's Phoenix that found the first proof of water on Mars in 2008. But after scraping water ice up from under the planet's surface, the ice turned into gas that dissipated in a matter of days.[4]

Beyond the snow line

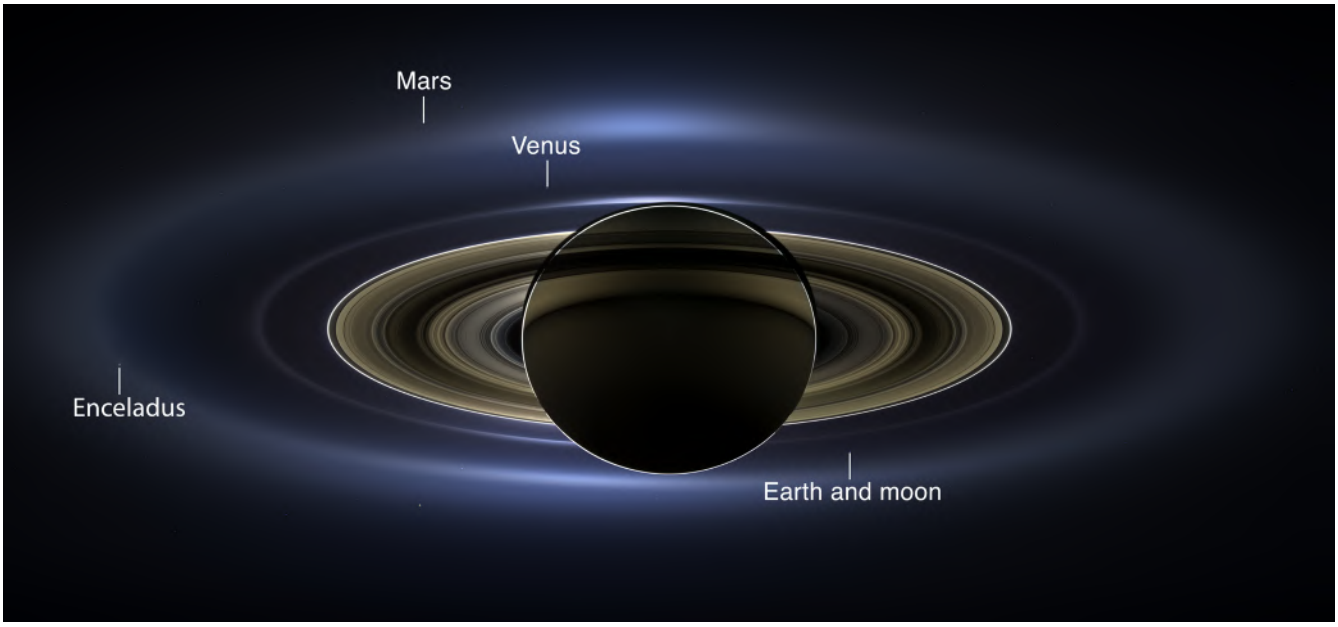
When the terrestrial planets were forming, around five billion years ago, the inner solar system was too hot for water to survive which is why they are dry and rocky. But within the asteroid belt lies the snow line. Inside this line the asteroid belt lacks water, but beyond it the outer asteroids are icy.

Beyond the snow line and far from the Sun, it was cold enough for water to become integrated into the planets and their moons. In fact, the dwarf planet Ceres is located very close to the snow line and may consist of as much as 25% water - which is more water than found here on Earth even though it is much smaller.[5]

The ice giants, Uranus and Neptune, are the two most distant planets in the solar system. They appear blue - not because of water - but due to traces of methane in their atmospheres. Hidden below each atmosphere, may be an ocean of boiling water or perhaps a super-hot fog heated by the planets' cores, which retain the 5000°C heat from when they first formed.[6] And since the ice giants are four times larger than Earth, their inner oceans hold more water than all Earth's oceans combined.

Closer to the Sun, water is found orbiting around the gas giants, Jupiter and Saturn, rather than within the planets themselves.

For Saturn that's quite literal. The planet's magnificent rings are composed of water - from tiny grains of ice to frozen boulders about the size of a house. Saturn's faint outermost ring is fed by water erupting from the tiny moon Enceladus. Only 500 km across, Enceladus was expected to be frozen solid and yet, in 2005 the Cassini spacecraft made one of



The ultimate selfie, taken by NASA's Cassini spacecraft. Through Saturn's watery rings, you can just make out Earth. Image: edited from NASA

the most remarkable discoveries of its 10-year mission. It saw plumes erupting from the tiny moon's surface. Since Cassini was coming to the end of its mission, the spacecraft was sent on a dare-devil dive through the plumes to sample or 'taste' the erupting material. It was water, and intriguingly, it was enriched with organic compounds, the building blocks of life.[7]

Jupiter's moon Europa has a vast ocean below its icy surface, containing more than double the water on Earth. Hubble Space Telescope images have revealed water being ejected up to 50 km or even 100 km above Europa's surface, likely because of hydrothermal activity. This means that both Enceladus and Europa have the three ingredients necessary for life: water, nutrients and energy.[8]

The origin of Earth's water

The only life that is known to exist is found here on Earth (which is a big responsibility for us!) and that life needs water. Except Earth didn't always have water, as it formed inside the snow line.

Earth's water must have been delivered once the Earth had cooled enough and an atmosphere had already formed so that oceans would not merely boil away. Some asteroids, small as they are, contain enough water to provide all of Earth's water. It's amazing, but we may only be here because asteroids seeded the early Earth with water that eventually supported life as we know it. But how many asteroids crashed here, and how much water did they each bring? Water from the frozen lakes in craters on the Moon could provide answers about water's arrival on Earth as the Moon likely received its water around the same time. All that history is now lost on Earth, but it remains frozen in time on the Moon.

Earth wasn't the only terrestrial planet to develop oceans. Around 3 billion years ago, Mars likely had an ocean covering nearly a third of its surface.[9] But at some point, Mars' atmosphere was stripped away, causing the oceans to dry up. The Sun continually emits a stream of charged particles known as the solar wind, and these particles speed through the solar system at hundreds of kilometres per second and can strip away a planets' atmosphere. As the atmosphere on Mars thinned, water evaporated into space or became locked below the surface.

This won't happen to Earth because our planet is protected by its magnetic field. Particles in the solar wind are deflected by this magnetic field shield, preserving our atmosphere and the oceans below. Unfortunately, Mars' magnetic field was short-lived and once it had deteriorated, Mars transformed into the dry and dusty planet it is today.

NASA's quest to "follow the water" was initiated by searching for ancient life on Mars, but it holds true as we explore worlds across the solar system. At Melbourne Planetarium, we have used this quest as the basis of our latest show "*Solar System Adventures: Where's the water?*".[10] This guided tour of the solar system uses the planetarium's remarkable technology to make it feel like you are travelling to these distant worlds beyond Earth.

There's lots to learn as we explore the solar system, but importantly contemplating our place in the universe also encourages a sense of wonder and awe. It makes us feel small, but in a good way, as we realise that we are connected to something much larger.

Space exploration encourages a renewed appreciation for our own planet, the only known world in the solar system where life is flourishing thanks to that precious resource – water.

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A Mountain Pygmy Possum and (below) a Bogong Moth. Photographs: Zoos Victoria.

MOTH TRACKER

A CITIZEN SCIENCE PROJECT WITH ZOOS VICTORIA

Help scientists at Zoos Victoria track the migration of Bogong Moths to help them and the Critically Endangered Mountain Pygmy-possum!

Beginning in spring each year, Bogong Moths make an epic migration towards alpine regions in Victoria and New South Wales, where Critically Endangered Mountain Pygmy-possums are waking from their hibernation. Bogong Moths are a crucial spring food source for Mountain Pygmy-possums and declines in Bogong Moth numbers are an urgent threat to the possums' survival. After Bogong Moth numbers crashed by an estimated 99.5% in 2017-18, these small but mighty moths were sadly listed as Endangered by the IUCN in 2021.

Moth Tracker is a citizen science initiative which aims to gather open-source real time data on the dates, locations and numbers of Bogong Moths travelling during the annual migration period.

For the current migration season, Moth Tracker has already received 416 submissions, including 220 verified Bogong Moth sightings.

If you see a Bogong Moth, or a moth you think could be a Bogong Moth, take a photo and upload it to Moth Tracker. It's quick and easy, and will help scientists better understand how to help the moths and if they will make it to the mountains this year.

The migration season isn't over yet, and we are hoping to collect more valuable citizen science data on the epic migration of this Endangered species in the coming months.

Learn more about the moths, the possums who eat them, and the Moth Tracker project at ***zoo.org.au/possums/***

CALL FOR SCIENTIFIC PAPERS

The Proceedings of the Royal Society of Victoria is our refereed journal, published twice annually by CSIRO Publishing. Current and recent editions are available online in open access format from **publish.csiro.au/rs**.

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.

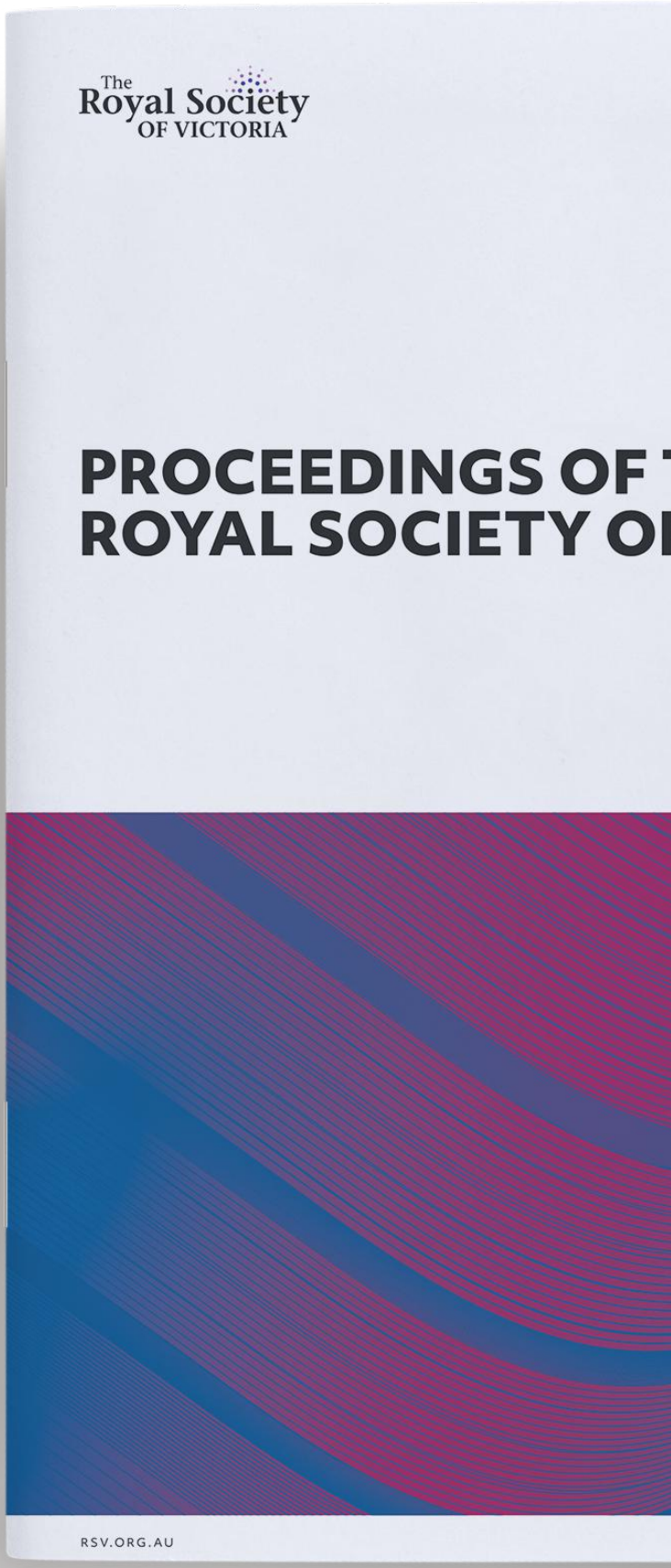
The journal began in 1855 as an irregular publication under the title *Transactions of the Philosophical Society of Victoria,* with the present name adopted in 1889. Since then, volumes of the journal have been published annually, often across one or more parts.

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**.



CURRENT GOVERNMENT CONSULTATIONS OF INTEREST TO VICTORIA'S SCIENCE COMMUNITY

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

Waterways Protection Model By-Law Renewal

The current Model By-Law for Waterways Protection is being renewed. Have your say on the proposed Model By-Law for 2024.

Consultation closes 15 December 2023:
engage.vic.gov.au/waterwaysprotectionmodelbylaw

Soil Sampling for Waste Soils Guidance

The Environment Protection Authority Victoria (EPA) is seeking your feedback on updated guidance about soil sampling for waste soils.

Consultation closes 21 December 2023:
engage.vic.gov.au/soil-sampling-for-waste-soils-guidance

Classifying waste and waste soils containing PFAS

The Environment Protection Authority Victoria (EPA) is seeking your feedback on proposed changes to the way PFAS in wastes and waste soil are managed.

Consultation closes 21 December 2023:
engage.vic.gov.au/changes-to-how-epa-regulates-pfas-in-waste-soil

Goschen Mineral Sands Project Inquiry and Advisory Committee

An Inquiry and Advisory Committee is collecting submissions to consider the environmental effects of the proposed Goschen Mineral Sands and Rare Earths Project.

Consultation closes 17 January 2024:
engage.vic.gov.au/Goschen-IAC

Developing the first Victorian Transmission Plan

Provide your input to help plan Victoria's future reliable, affordable, and renewable energy grid.

Consultation closes 31 January 2024:
engage.vic.gov.au/victransmissionplan

PITCHING AND WRITING FOR SCIENCE VICTORIA

***Science Victoria* seeks the discussion and promotion of scientific topics of relevance to people living in the State of Victoria. We are particularly interested in new research, in-depth articles, or exploration of subjects where scientific work and thinking can directly address or deepen our understanding of environmental and socioeconomic challenges.**

We welcome your pitches and pieces for news, features, opinion, and analysis articles on current scientific research in Victoria, recent scientific discoveries, related social and policy issues, technical innovations, and overviews of impactful research. We cover a broad range of topics around Science, Technology, Engineering, Mathematics, Medicine/health (STEMM) under an overarching theme of "science and society."

Science Victoria's articles are written in plain, non-academic language, pitched at an intelligent and naturally curious audience that does not necessarily hold subject-matter expertise. This is not a platform for scientific journal articles nor media pieces. For more information on what we're looking for, please read our article submission guidelines below.

Have an idea for an article? Pitch your idea to us!

Send your idea to **editor@sciencevictoria.org.au,**

along with any questions you have regarding your pitch.

In your email, please outline:

- In one sentence, what is your key message? (No more than 50 words)
- Why should this key message be shared with the readers of *Science Victoria*? (No more than 100 words)
- Which style of article are you proposing to write? (See below for a guide to article types)

Article pitches can be submitted at any time, but please keep in mind the article submission deadlines for the next month's issue. Note that we may accept your pitch, but suggest it is more suitable for another style of article.

Article Submission

Once your pitch has been accepted, you can submit completed pieces that comply with the style guide below. Completed articles to be published in the next issue of *Science Victoria* must typically be submitted 2 weeks prior to the beginning of the next month.

All pieces will be reviewed prior to publishing and may be edited for length and clarity (although we will be sure not to alter the message or context of your work). We will also endeavour to fact-check and confirm any grey areas with you ahead of publishing in the interests of accuracy.

All published pieces will be accompanied by a by-line, and a short (<50 word) biography of the author (title, institution, qualifications, current projects, contact email) to be submitted with your piece.

Images and figures to accompany your piece are strongly encouraged, however please ensure that you only provide original images produced by yourself or those that already exist in the Public Domain. Images must include details of the source and any relevant descriptions. If you do not provide any images, we may include Public Domain or stock images that we deem suitable for visual communication of your content.

References

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, or contact **editor@ScienceVictoria.org.au**.

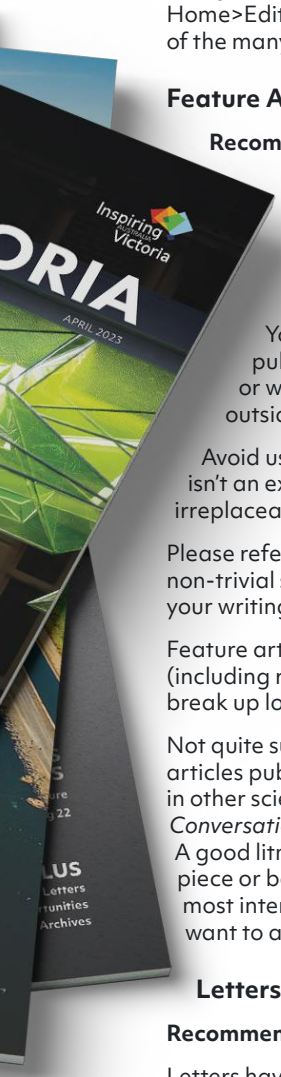
WRITING FOR SCIENCE VICTORIA: ARTICLE FORMATS

Style Guide

To successfully engage the largest audience, all pieces should have readability in mind.

Readability can be determined using a Flesch-Kincaid readability test, aiming for a score between 50-60. This score means that your piece should be easily understood by an educated 16-year-old (a year 10 student).

If drafting your piece in Microsoft Word, **you can easily view your document's readability statistics** at Home>Editor>Document Stats. Alternatively, you can use one of the many free online calculators.



Feature Articles

Recommended word count (600 - 1,800)

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.

Your audience is intelligent members of the general public, who share an enthusiasm for scientific topics, or who are members of the scientific community outside of your particular field.

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.

Please reference primary sources/journal articles for any non-trivial scientific claims, or for publications that prompted your writing of the article.

Feature articles typically run between 600 and 1,800 words (including references). 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 magazines for a general audience, like *The Conversation, Cosmos, New Scientist* or *Scientific American*. A good litmus test is knowing that most of us have read a piece or been to a presentation that managed to make the most interesting topics incredibly boring. This is what you want to avoid.

Letters

Recommended word count (400 - 1,000)

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 and/or the Royal Society of 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.

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

What I've been Reading

Recommended word count (400 - 1,000)

This is a column for you to tell us about a book broadly relating to science that you've read. These pieces are typically between 400 – 1,000 words and include a summary of the book and its ideas, as well as your interpretations or conclusions.

Possible questions to consider when writing this column:

- 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?

Opinion Articles

Recommended word count (600 - 1,000)

In contrast to an unbiased news or feature article, an opinion piece conveys your informed opinion on, or experiences with a particular topic. This is where your expertise on a subject can shine. 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,
- changes in your particular field of expertise
- 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,
- ethical problems related to scientific projects or careers in STEMM.

Please reference primary sources/journal articles for any non-trivial scientific claims, or for publications that prompted your writing of the article.

Opinion pieces should aim to be 600-1000 words. For anything shorter, consider submitting it as a Letter instead.

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.

News Articles

Recommended word count (400 - 1,000)

News Articles are for the discussion of current or recent news relating to science, with an emphasis on science in Victoria or news that impacts Victoria's scientific community.

These articles should be concise, avoid use of jargon and personal opinion, and be referenced as appropriate. News pieces should be between 400-1,000 words in length.

Reports 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.


THE ROYAL SOCIETY OF VICTORIA
Promotion and Advancement of Science

HOLD YOUR NEXT EVENT AT THE ROYAL SOCIETY OF VICTORIA

The RSV engages communities with scientific knowledge through aligned partnerships, special events, festivals, conferences, and education programs. Email **rsv@rsv.org.au** to discuss your needs and ideas!

Facilities for hire

The Royal Society of Victoria's facilities are available for hire to organisations, companies, or private groups. This heritage-listed building opposite the Carlton Gardens is suitable for a wide range of events, including conferences, seminars, meetings, and private functions.

Limited parking is available on-site and a commercial parking operator is adjacent on La Trobe Street.

The RSV has audio visual and seminar equipment available for use, including videoconferencing facilities. There is a commercial kitchen on the ground floor, suitable for your own use or by a caterer.

Services Available

We 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
- Campaign management
- Recruitment of scientific panels
- Convening community engagement and deliberation processes where scientific work contributes to social, environmental, and economic impacts and benefits.

The Burke and Wills Room

Multi-functional space with adjoining kitchen.

Capacity:

Workshops	≤30 people
Dinners	≤60 people
Seminars, functions, catering, etc	≤80 people

The Von Mueller Room

Seminar room great for smaller meetings and seminars.

Capacity:

Meetings, seminars, etc	≤15 people

The Ellery Lecture Theatre

Raked seating great for lectures, presentations, and conferences.

Capacity:

Raked seating	≤110 people.

The Cudmore Library

A picturesque room great for larger meetings and seminars.

Capacity:

Meetings, seminars, etc	≤24 people

We are registered as a Certified Social Trader working for the benefit of Victorian communities, which makes our services eligible under the Victorian Government's Social Procurement Framework, as well as the social procurement guidelines of the governments of New South Wales and Queensland. Our certification also assures industries of our authenticity in building social procurement into services and supply chains. For more information and bookings please contact our Business Manager at **james@rsv.org.au** or on +61 3 9663 5259

SUPPORT VICTORIA'S SCIENCE SOCIETY

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.

We manage the Inspiring Australia program in Victoria, 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. Your donations allow us to continue the work we have been doing for Victoria for more than 160 years.

To make a donation, please fill in the form below and return to the Royal Society of Victoria, 8 La Trobe St, Melbourne VIC 3000. Alternatively, you can donate online at **rsv.org.au/support-the-rsv**

RSV 2023 FUNDRAISING CAMPAIGNS

The area of greatest need, as identified by the Society's Council	$
Inspiring Victoria – Community Science Engagement Program	$
Science Awards & Prizes	$
Science History & Heritage	$
Science for All - Citizen Science Programs	$
BioQuisitive Community Lab	$
The Phoenix School Program	$
The BrainSTEM Innovation Challenge	$
Australian Indigenous Astronomy	$
Science Victoria - Magazine and Web Content Production	$
TOTAL	**$**

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By submitting this form I acknowledge that the amount entered against 'TOTAL' donations above will be charged to my credit card.

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I enclose my cheque or money order made out to The Royal Society of Victoria.

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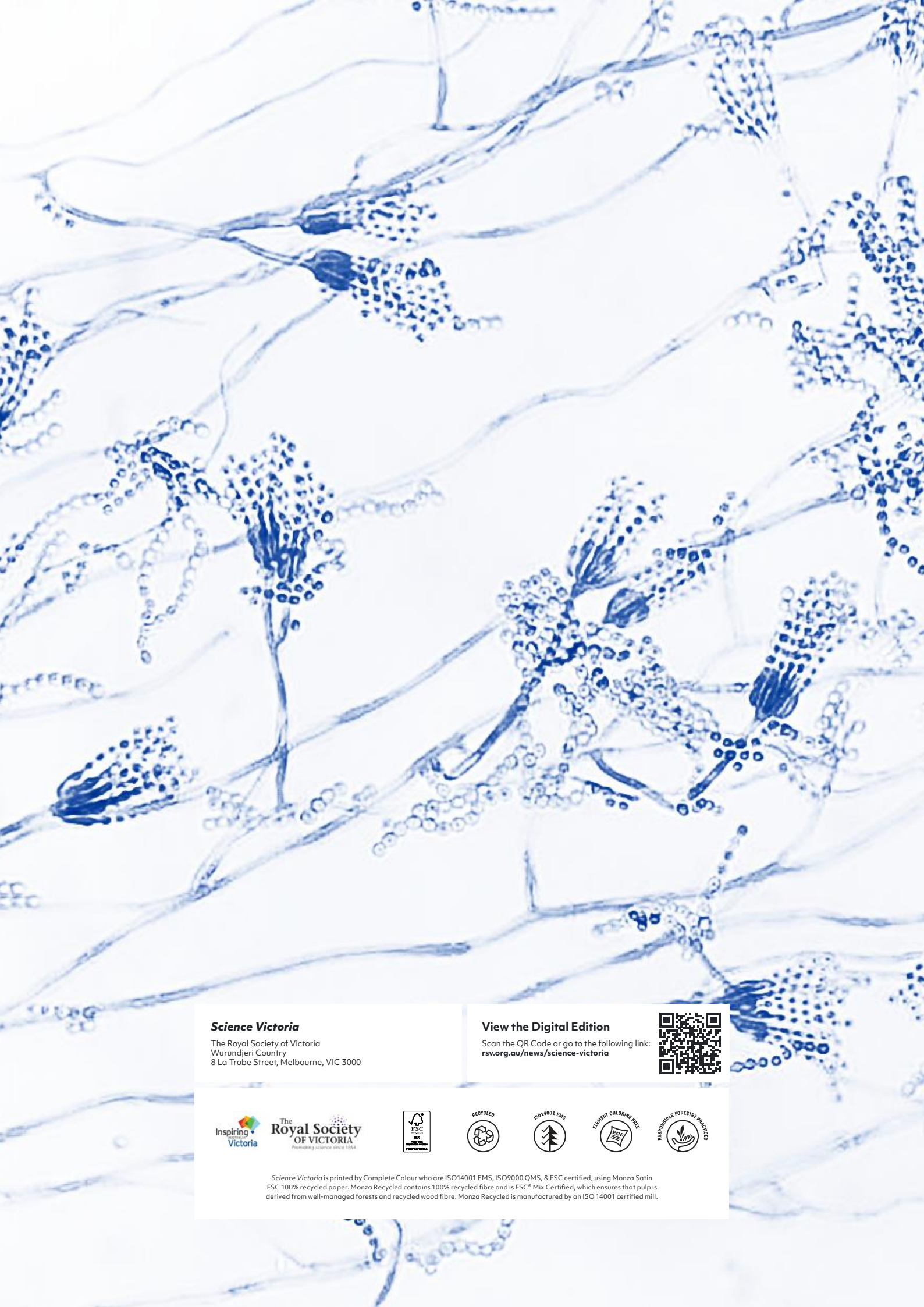
BSB: 083-019 **Account No:** 51-515-2492

Account Name: The Royal Society of Victoria **Reference:** Your Surname and "donation"



Science Victoria

The Royal Society of Victoria
Wurundjeri Country
8 La Trobe Street, Melbourne, VIC 3000

View the Digital Edition

Scan the QR Code or go to the following link:
rsv.org.au/news/science-victoria

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