The Royal Society of Victoria
Promoting science since 1854

SCIENCE VICTORIA

NEWS FROM THE ROYAL SOCIETY OF VICTORIA RSV.ORG.AU DECEMBER 2022

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Protecting Your Health From Severe Hot Weather 41

THE OFFICIAL NEWSLETTER OF RSV

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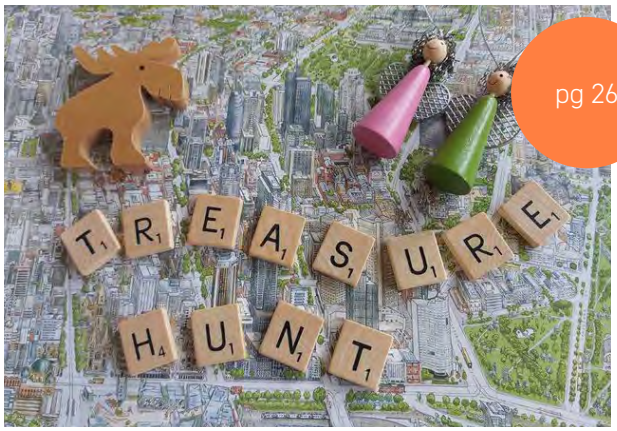

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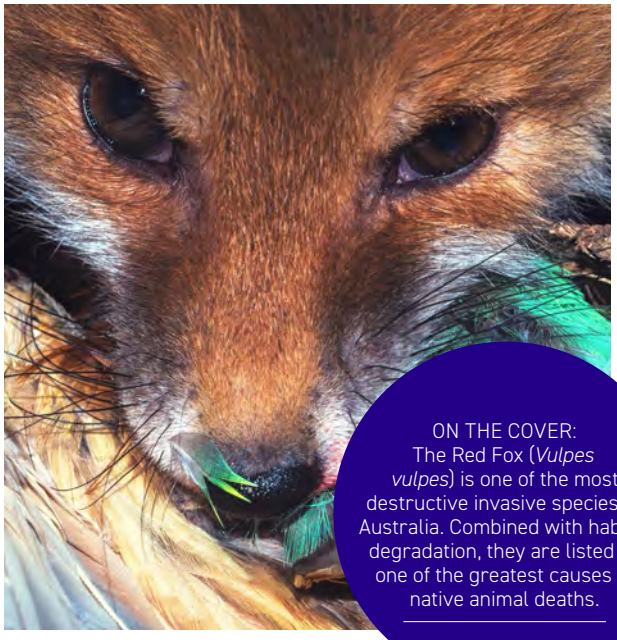
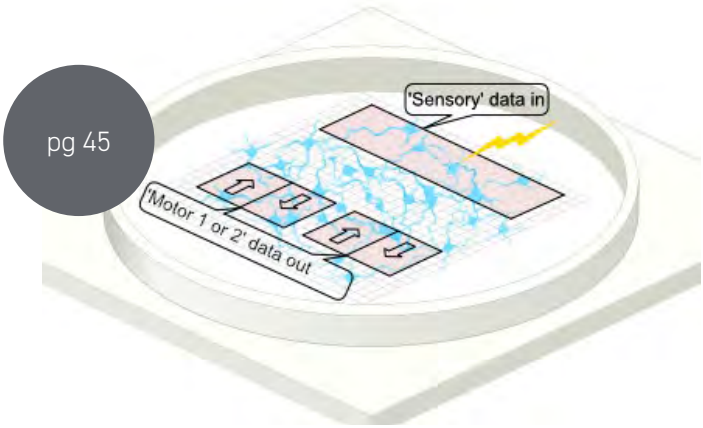


ON THE COVER:
The Red Fox (*Vulpes vulpes*) is one of the most destructive invasive species in Australia. Combined with habitat degradation, they are listed as one of the greatest causes of native animal deaths.



INTERESTED IN SCIENCE? ENJOY WRITING? WE WELCOME LETTERS, ARTICLES AND IDEAS.

Please note that the submission deadline for content to be included in the February 2023 edition of *Science Victoria* is **27th of January 2023**
Email **editor@sciencevictoria.org.au**.

FROM THE CEO

So Much Left to Do!

It's been quite a year – the impacts of the pandemic on the Royal Society of Victoria's capacities have truly made themselves known, but we have persevered, and December is here in the blink of an eye. My thanks to everyone who has offered their support for and involvement with our programs in 2022, whether as a longstanding member, a new member, or one of the thousands of people who align themselves with our mission to promote science and scientific thinking for all who seek a better future together. As a community sector organisation, we rely on your patronage to sustain our efforts; so if you haven't already joined us, please consider becoming a member of the Royal Society of Victoria. The online form is at **https://rsv.org.au/membership/how-to-join/**.

Our final event for the year is coming up on Thursday 8th December, celebrating the work of our 2022 Research Medallist, Professor Rachelle Buchbinder AM. Open to all - **join us**!

With the Victorian Election all done and dusted, it's time to get to work with the next iteration of State political leadership to win progress for our agenda. We are delighted to celebrate renewed support from the Victorian Government for the Inspiring Victoria program and will be consolidating our partnerships for delivery to communities across the State from 2023 to 2026. We're also releasing our new position paper on the *Conservation and Recovery of Victoria's Biodiversity* this month, just in time for this week's 15th Meeting of the Conference of the Parties (COP 15) to negotiate a new post-2020 Global Biodiversity Framework in Montreal, Canada.

In this month's edition you'll find articles on new technologies for tackling invasive species, using the guiding principles of biological intelligence to inform machine intelligence, the remarkable work of our doctoral researchers across the disciplines, Christmas Treasure Hunts in the Melbourne CBD, and more. My particular thanks to Scott Reddiex and Dr Catriona Nguyen-Robertson for their excellent work, much valued support and expansive thinking about the role of our humble publication in 2022.

The Royal Society of Victoria will be closed from Tuesday, 20th December and reopening on Monday, 16th January – our staff will be on leave, but any queries during this time can be directed to **rsv@rsv.org.au** and we'll aim to respond in a timely manner.

My best wishes to all for a happy, healthy and relaxing conclusion to 2022, and an excellent new year ahead.

Mike Flattley
CEO, The Royal Society of Victoria

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The Monthly Publication of the Royal Society of Victoria – established 1854 for the promotion and advancement of science.

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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.

FROM THE PRESIDENT

2022 Wrap-Up

OPEN ACCESS TO SCIENCE RESEARCH

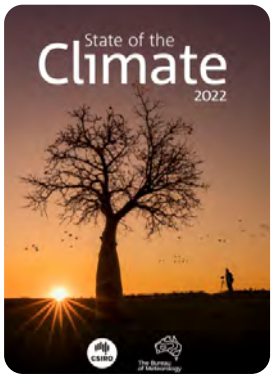
In an effort to promote innovation and transform Australia into a knowledge-based nation, Chief Scientist Dr Cathy Foley has recommended to the Albanese government that scientific literature be made 'open access', to facilitate industry collaboration and to address important economic and social issues.

Australia's Chief Scientist, Dr Cathy Foley AO PSM

Interviewed by **InnovationAus.com**, Dr Foley's proposal is to make research literature available to the public service, businesses, and the general public – not just other researchers. This would be facilitated through new arrangements with publishers, who have historically kept research literature behind expensive paywalls.

Dr Foley's proposition is that taxpayer-funded research, peer-reviewed by experts who donate their time, is then provided to publishers. Publishers would continue to play their important part in the open access model, through maintaining the functional role of managing the peer review process. They would continue to be duly paid for that function, but would then make research literature permanently and freely available online for any Australian to read.

Objectives of the scheme are a better educated public and innovation in small business through access to published research, as opposed to the need for direct research and development.



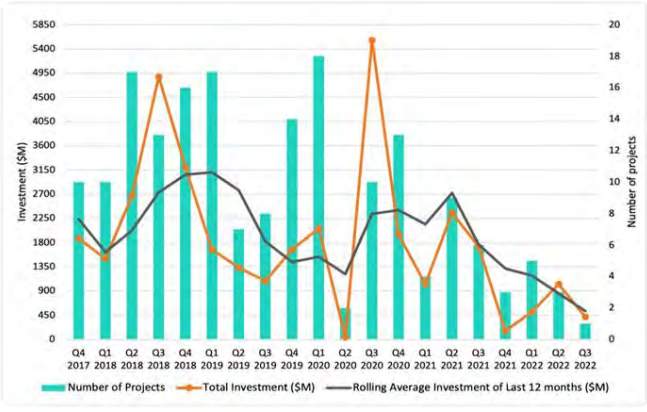
State of the Climate 2022

CLIMATE AND ENERGY

Two documents of interest released in late November this year are the CSIRO-Bureau of Meteorology ***State of the Climate 2022*** and the **Clean Energy Council**'s *Renewable Projects Quarterly Report Q3 2022*.

Australia's climate has now warmed by an average of 1.47 °C (± 0.24°C) since national records began in 1910. Sea surface temperatures continue to increase, observed seasonal rainfall decreases in southwest and southeast Australia are 10%-19% since 1970. This has led to streamflow decreases across most stream gauges since 1975. Extreme fire weather has increased, tropical cyclones have decreased in number, snow cover and depth is decreasing, oceans are acidifying, and sea levels are rising. It's a familiar story.

On what might otherwise be the positive side of the ledger, the Clean Energy Council has reported that financial commitments for new renewable energy projects hit a record low in the September quarter. Investment in financially committed new projects reached $418 million in Q3 2022. This was 59.3% less than what was seen in the previous quarter, and 75.8% less than the same quarter in 2021. The curve should be going in the *other* direction.



Financially Committed Renewable Energy Projects and Investment (Source: Clean Energy Council)

#CREDNOTCREDITS

Offsetting schemes for both greenhouse gases emissions and for 'no net loss' of biodiversity continue to be problematic. Their value as market mechanisms in reducing emissions and protecting biodiversity are under question at many levels as either trading

threatened species for cash[1] or as a driving force in the expansion of fossil fuel production[2].

The Australian Government continues to fund and provide subsidies to the fossil fuel sector ($11.6 billion in 2021-22)[3] and facilitate payments for questionable offset schemes. Presumably if the fossil fuel sector was truly committed to investing to protect the nation's biodiversity, it could voluntarily act to make investments in reforestation and land restoration without the need for repayment.

In the "credibility not credits" space, some Australian companies are providing genuine support for positive programmes. Bank Australia is supporting **Seed** a programme designed to build up the next generation of Aboriginal and Torres Strait Islander young people to lead climate justice campaigns and to protect country, culture, and communities from the causes and impacts of climate change.

Donations to Seed are tax deductible.

WHAT'S ON FOR 2023?

The Royal Society of Victoria is now expanding its horizon to take science to society. The RSV must endeavour to become a facilitator of science dialogue at all levels of society. We are delighted that the Victorian Government has provided new, substantial funding for '**Inspiring Victoria**' for the next four years. The RSV intends to use this programme as the cornerstone for the development of new initiatives.

We are exploring opportunities to redevelop our prominent site and buildings to build a new science focal point in the City of Melbourne and a new identity for the RSV. The City of Melbourne now has a '**Zero Carbon Buildings for Melbourne**' programme. Could we use the RSV's 163-year-old building as a 'net zero' test case? Can we take our heritage-listed building to a 7-star energy efficiency rating? How can we use our site to demonstrate a range of sustainable technologies and make science information available to the public, to build awareness of the value of science to the community? For example, the Environment Protection Authority's air quality monitoring station shares our site – how can we best display the EPA's air quality data to the public?

I would welcome your thoughts and ideas on how you or your organisation might support this proposition.

In 2023, we wish to build strong relationships with both the science technology sector and like-minded science-focussed organisations.

RSV AFFILIATION

We have begun a programme offering affiliation with other organisations to forge closer links between professions, institutions, companies, and communities through a mutual exploration of the latest scientific intelligence and its implications for education, industries, the economy, society, and the environment. We consider our role is to convene the scientific community and provide a platform for broad communication and discussion around an evidence base on matters of importance to Victoria and Victorians.

Please **contact us** to discuss this opportunity for collaboration to facilitate 'science speaking with one voice'.

ORGANISATIONAL MEMBERS

In parallel we are actively engaging with the corporate sector for the same purpose. We now have new Organisational Members from the property, food production, technology, and renewable energy sectors, and we are actively engaging companies to join the RSV as Organisational Members.

We hope this initiative will provide opportunities to engage in new conversations with the science technology sector that will promote science, provide opportunities for wider collaboration, enable engagement with our members (particularly our young members), and to share our building for meetings and functions.

Affiliation and Organisational Membership is **available on our website** or simply **email me** to discuss what's involved.

May I take this opportunity thank members of the RSV's council for their dedication, diligence, enthusiasm, and support through this year – all of which is steered and managed by our tireless CEO Mike Flattley and our small office team who deserve our sincere thanks for ensuring the organisation delivers its substantial work programme.

I wish you all a safe and enjoyable festive season and new year, and look forward to growing the Royal Society of Victoria's capacity in 2023.

Rob Gell AM MRSV
President, The Royal Society of Victoria

1 **https://www.theguardian.com/australia-news/2022/nov/24/nsw-environmental-offsets-scheme-risks-trading-away-threatened-species-for-cash-inquiry-finds**
2 **https://www.theguardian.com/environment/2022/nov/13/australia-risks-being-a-state-sponsoring-greenwashing-if-it-relies-on-carbon-offsets-expert-warns**
3 **https://australiainstitute.org.au/post/australian-fossil-fuel-subsidies-surge-to-11-6-billion-in-2021-22/**

LETTERS

The Merri Paddle

DREAMING THE (IM)POSSIBLE DREAM?

Few if any degraded urban waterways in Australia have been remediated to a condition that would encourage the return of a resident population of the platypus.

So for a group of community activists in Melbourne's north, returning the platypus to the Merri Creek, a 70 kilometre tributary of the lower Yarra, might seem like mission impossible.

But for the Merri Paddle, a collaboration of a number of community groups, including Friends of Merri Creek (FoMC) and a local chapter of the Australian Conservation Foundation, North x North West, the task is no greater than that faced by previous generations of committed environmentalists.

Slated to be 're-engineered' as a barrel drain under a freeway, the Merri was saved from the fate of other Melbourne waterways by a dedicated band of community members that first coalesced in 1976.

Years of hard work and lobbying later, the Merri has been saved, and repaired – to a point. The creek is now supported by a distinctive not-for-profit, governance body – the Merri Creek Management Committee (MCMC) – with representatives from the community and the six local councils bordering the creek. MCMC conducts ongoing revegetation work, supported by a hardy band of volunteers, and advocacy on planning matters. After decades of work, the riparian zone along the creek has been transformed from an industrial wasteland to a vibrant green corridor that gives the local community access to highly valuable natural experience. **FoMC bird surveys** show increasing diversity, especially in the lower sections of the creek, and an increasingly sophisticated 'citizen science' effort is tracking this progress[1].

However, the hydrological condition of the creek is another story. For much of European settlement, the Merri has served as a stormwater drain for Melbourne's north. The result is urban stream syndrome - the unnaturally high flows caused by the torrents of water running off impervious surfaces (roads and roofs). **A report by Josh Griffiths** of enviroDNA for the Merri Paddle confirmed these flows as the chief culprit in explaining the absence of the platypus[2]. The torrents of stormwater discharged into the creek wipe out the macroinvertebrate species on which the platypus relies for its food supply. The equation is simple: no food = no platypus.

1 **https://www.mcmc.org.au/images/Flora_and_fauna_report_2019-20.pdf**
2 **https://www.friendsofmerricreek.org.au/content.cfm?page_id=1693885&current_category_code=20985**

The problem is compounded in the middle reaches of the creek by industrial contaminants. Pettigrove and Hoffman (2005) showed that many macroinvertebrates, on which the platypus relies for food, were not able to survive in the contaminated sediments found in parts of Merri Creek[3]. And there is also the problem of gross plastic pollution, which has proven a platypus killer in other places.

> ***But like many environmental challenges, we have the solutions if we have the will.***

An experimental contaminant trap funded by Melbourne Water and evaluated by a team including Professor Pettigrove was successful, and water sensitive urban design (WSUD) could begin to reverse the tide of urban stream syndrome[4]. Victoria's ban on single use plastics, coming into force in 2023, offers some hope that the mountains of plastic in the creek can be reduced.

On all of these issues, the Merri Paddle is advocating for the platypus, and linking up with similar groups, like the Bacchus Marsh Platypus Alliance.

> ***The platypus is now listed as vulnerable in Victoria, so the animal is going to need all the help it can get, and the Merri Paddlers aim to give it.***

Our program for 2023 includes a roundtable of stakeholders to workshop habitat improvement works, platypus eDNA monitoring, water quality testing and platypus spotting walk – and lobbying governments and urban developers to do their bit.

The Merri Paddle can be found at **https://www.friendsofmerricreek.org.au/merri-paddle**

You can contact the Merri Paddle team by emailing **Dr Peter Ewer**, **Julia Cirillo**, or **Trevor Moyle**.

Dr Peter Ewer is a committee member of the Friends of Merri Creek, FoMC representative to the Merri Creek Management Committee and co-founder of **The Merri Paddle**.

Julia Cirillo is the Waterwatch & Rapid Response to Litter after Rainfall Coordinator at the MCMC, and has a long history with citizen science programs including the National WaterbugBlitz, Waterwatch, Melbourne Water frog census, the Great Australian Platypus Search, LitterWatch Victoria and iNaturalist.

3 Pettigrove, V. and Hoffman, A. (2005) A field-based microcosm method to assess the effects of polluted urban stream sediments on aquatic macroinvertebrates. Environmental Toxicology and Chemistry 24(1), 170-180.

4 For the contaminant trap, see Marshall, S., Pettigrove, V. & Kearns, J (2006) A toxicant treatment facility for the field evaluation of filtration media for urban stormwater treatment, 7th International Conference on Urban Drainage Modelling and the 4th International Conference on Water Sensitive Urban Design, Melbourne, Australia, 2-7 April 2006

Letter to the RSV President

The Royal Society of Victoria building, designed by Joseph Reed and constructed in 1859. Image Credit: RSV

Dear Mr President,

On a Friday night a few weeks ago, while I was stopped by the lights on the corner of Rathdowne St and Victoria Pde, I looked ahead to see the Royal Society of Victoria building in darkness, and even looking a bit abandoned. This is in contrast to other buildings like the State Library, Old Parliament House, or even our neighbour the Royal Exhibition Building

I trouble you with this preamble because I think the RSV has trouble with visibility! And it is not only physical visibility, but also as far as the general public is concerned, a lack of visibility of its ongoing and important activities.

This is not to diminish the enormous effort put in by the Council and Executive to running workshops, seminars, awarding of medals and prizes, and in producing the magnificent and unique '*Science Victoria*' magazine 11 times a year.

> ***But if you ask the general public where the RSV actually is, and what does it do, the common answer is - "****I don't know. Should I? Where is it? Anyway, what does it do?****"***

We need some solutions to address this lack of visibility, and so I would like to suggest the following:

1. Outside, we need signage and lights.

I don't mean a large neon sign that says," Royal Society of Victoria", but rather an active video screen, similar to that installed by Cricket Victoria outside the Junction Oval on Lakeside Drive. The RSV could utilise such a display to tell the passing public in real time relevant and engaging information: perhaps atmospheric CO_2 levels, air pollution, intensity of UV, upcoming RSV events, what's happening at COP27 (or similar), Victoria's biodiversity and feral animal problems, etc. Such displays could be installed on the corner of Exhibition St and Victoria Pde, and Exhibition and Latrobe St, to alert the general public to what is happening in the Victorian environment and what the RSV is trying to do about it.

These displays could be coupled with lighting of the building that strikes a balance between visibility at night, low energy usage, and minimal contribution to light pollution.

This, of course, will cost money, however I suggest that this could be addressed through sponsorship from a commercial partner with a shared interest in promoting data and messages relating to action on climate change, biodiversity, etc.

2. Inside and outside, it would be good to get the public engaged with this magnificent iconic building in its own beautiful garden setting.

The possibility of a café has been discussed, and is often dismissed by the argument that there is not enough passing foot-traffic to make it worthwhile. But I am reminded of the expression "if you build it, they will come", and what could be better than to have people sitting inside and outside, with important material to hand to alert the general public to the task at hand - *preserving the environment and our health using evidence-based information*. With discussions afoot at the present time for the so-called Hoddle Grid in the CBD to be made into pedestrian friendly 'Superblocks' as in Barcelona (**see: The Conversation, Nov 16**), the RSV building and triangle could become a traffic-free, people-friendly hub. A place to grab a coffee before a walk through the Carlton Gardens. Just such a café/ watering hole could be called Ellery's (after former RSV President and huge figure of early Melbourne science, **R. L. J. Ellery**), or Sweet's (after both the amazing **Dr. Georgina Sweet**, the first female D.Sc graduate from the University of Melbourne, and her father, former RSV President **George Sweet**) (but, please, not The Burke & Wills!). Any other suggestions?

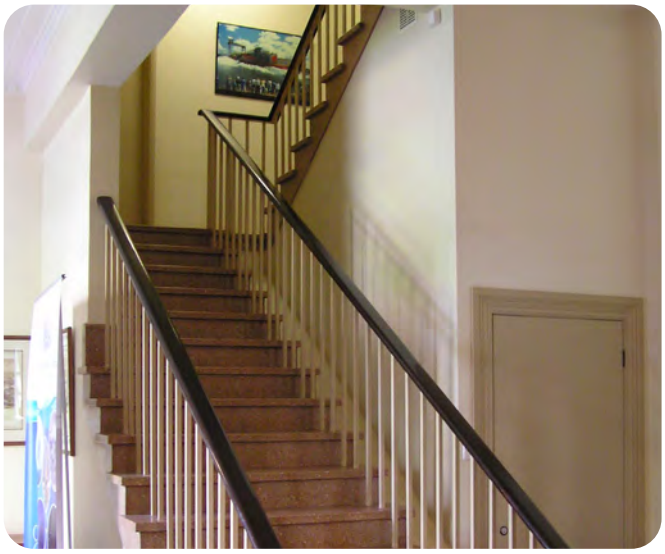
The RSV precinct sits atop the Hoddle Grid. Image Credit: Google Maps/ Airbus, CNES

3. Membership-driven activities.

As a way of getting more people to use the magnificent RSV headquarters, I would like to suggest that RSV members form *Special Interest Groups (SIGs)* around issues important to them and their expertise, and to then organise small, cost-neutral workshops at the RSV building and an open invitation to the general public to participate. This should also cure a problem that I have heard with increasing frequency from some RSV members – that, since COVID-19, they feel the RSV doesn't provide enough activity for them. Perhaps RSV members - including Fellows - might step up and organise activities to engage with the public? After all, the RSV building is also *their* building.

4. Accessibility.

All of the above assumes that the general public at large have equal access to the RSV building, and so we must make sure that the building is perfectly suitable for everyone, including any person who has a disability. It is extraordinary in 2022 that we cannot accommodate people with a disability, particularly wheelchair users. I'm sure many among us think twice before going up the stairs to the 'high altitude' toilets on the 2nd and 3rd floor. Can we ask RSV members to get behind a fund-raising drive to modify the building to bring the toilets down to the ground floor, and to also provide wheelchair access to the key facilities in this historic building? I hereby pledge a donation!



Accessibility needs to be addressed so that all visitors to the RSV can feel welcome. Image Credit: RSV

The aim of this 'Letter to the President' is to encourage the RSV membership to become more active, and find ways to work with the Council and Executive to bring life back to our fabulous headquarters, and also to make the public sit up and take notice of all the important work that the RSV is doing now, and will be doing for the next 160 years! And with plans afoot to make the RSV building an example of how a 19th century building can be renovated to be a luminary, 7-star energy efficient building, what better time to engage with the whole membership and public about this important initiative!

David W Walker

Professor David Walker is a physiologist at RMIT's School of Health and Biomedical Sciences, and an **RSV Councillor.**

RSV NEWS AND NOTICES

New RSV Members

INDIVIDUAL MEMBERS

Mr Richard Dent,
CEO Leading Progress

Mr Harry Gielewski,
Retired

Ms Winnie Wen,
Secondary Student,
Our Lady of Sion College

Miss Reah Shetty,
Undergraduate Student,
The University of Melbourne

Mr Milindu Liyanapathirana,
PhD Student, RMIT University

Mr Markus Terjung,
Town & Regional Planner, DELWP

NEW ORGANISATIONAL MEMBER

Inteum Companny LLC
Representative: **Mr Robert Sloman**, Chief Executive Officer

Inteum Company, LLC, founded in 1992 and headquartered in Kirkland, Washington USA, is the developer and publisher of Inteum Software. Our flagship Software, Inteum Minuet is used by many research organizations in Australia to manage their Intellectual Property.

Towards Conservation and Recovery of Victoria's Biodiversity

THE ROYAL SOCIETY OF VICTORIA'S POSITION IN BRIEF

December 2022

The following is a summary of the Royal Society of Victoria's position paper titled *Towards Conservation and Recovery of Victoria's Biodiversity: Report for Changemakers.*

Developed with 2022 RSV Fellows and authorised by the Society's governing Council, the paper draws on proceedings from a forum involving Victorian research expertise, First Nations knowledge holders, government policy leaders, catchment management authorities, finance sector leadership and community sector champions, held at the Society on 4 June 2022.

2022 RSV Fellows, from left: Ms ***Fern Hames*** FRSV, Director, Arthur Rylah Institute for Environmental Research (Department of Environment, Land, Water and Planning), Mr ***Damein Bell*** FRSV, Atlantic Fellow for Social Equity and previously CEO, Gunditj Mirring Traditional Owners Aboriginal Corporation, Ms ***Judith Downes*** FRSV, Chair, Bank Australia, immediate past Chair of the Global Alliance for Banking on Values Governing Board Forum, Professor ***Brendan Wintle*** FRSV, Conservation Ecologist and Director of the Biodiversity Council at the University of Melbourne.

Through this position paper the Royal Society of Victoria (RSV) seeks to:

- elevate recognition of the biodiversity crisis in Victoria and Australia as a political, social, and economic priority, parallel to addressing climate change and environmental pollution.
- inspire cross-sector leadership of a series of regulatory, research, funding and communication activities that will drive the effective conservation and recovery of native plants, animals and ecosystems in Victoria and Australia.

THE PROBLEM

Up to one million of Earth's estimated eight million plant, insect and animal species are at risk of extinction within the next few decades.[1]

Australia ranks 8th in the world for threatened mammals, 7th for threatened fish, 2nd for threatened molluscs, 1st for other threatened invertebrates (a considerable proportion of all terrestrial and marine life on our continent) and 11th for plants.[2] More than 1,800 native Australian species and ecosystems are threatened with extinction; from land clearing, from predation and displacement by invasive species, from chemical pollutants and, increasingly, the regional impacts of a changing global climate system.[3]

We are losing more biodiversity than any other developed country, with the extinction of over 100 native species since European colonisation now formally recognised under legislation.[4]

THE VALUE OF VICTORIA'S BIODIVERSITY

The loss of biodiversity has profound ramifications for the ability of our ecosystems to maintain clean air and water, productive agriculture, pollination, and human well-being. Here in Victoria, our agricultural industry reported a gross value of $17.5 billion over 2020-21.[4] Meanwhile, our national parks and conservation reserves contribute over $1 billion to the State economy through tourism, save up to $200 million on health costs, and provide over $80 million of water purification, while preventing almost $100 million in damages associated with flooding and coastal erosion.[6]

Yet, a third of all of Victoria's terrestrial plants, birds, reptiles, amphibians, mammals, invertebrates and ecological communities are threatened with extinction.

THE COST OF RECOVERY

The cost of recovering Victoria's biodiversity is a challenge to estimate; to our knowledge, this complex analysis has not yet been undertaken. It presents a task similar to estimating the value of vast holdings in a major museum or library: we could analyse the cost of discrete restorative projects as representative samples and use these to extrapolate a cost for addressing restoration of the whole. We acknowledge this would remain an estimate.

Meanwhile, as a blunt measure based on the total expenditure legislated to address the decline of all threatened species in the United States of America, the cost of halting species loss and recovering nationally listed threatened species in Australia would be about $1.7 billion per year.[7]

The Australian government has pledged welcome funding of $224.5M for threatened species recovery in the October 2022 Federal Budget, but this is still less than 10 per cent of the USA comparison, representing an investment of about 8 dollars per person, per year. By comparison, Australians spend 18 times that amount, about $30.7 billion, each year on our pet cats and dogs.[8]

Further, the unique nature of our ecosystems and species compared to those on other continents require unique responses. Ultimately, we need to understand what has worked (and not worked) through past efforts, and fill our knowledge gaps with diverse, scientifically rigorous projects that test hypotheses and demonstrate where best we can derive a clear return on investment from very limited resources.

This work must begin immediately.

BUILDING POLITICAL WILL IN VICTORIA

The Victorian Government outlined its vision for conserving the State's natural heritage in *Protecting Victoria's Environment – Biodiversity 2037*.[9]

However, a review by the State's Auditor General in October 2021 found the level of investment by the Victorian Government is insufficient to meet the plan's objective. It also found the benefits returned from existing, funded schemes were unclear.

There is international research that illustrates the most effective way to address the biodiversity crisis is to implement legislation and increase regulation to manage, and reduce the clearing of, land with high biodiversity values.[10]

Given the extent of land clearing already conducted in Victoria – sadly, a national leader – it appears we may have already reached the end of the envelope available for production purposes, meaning more gains are to be found through restoration than conservation.

Environmental laws should be robust and less discretionary; for example, a 'law to restore Victoria' could meaningfully address the biodiversity crisis in this State, while incentives must be considered to encourage landowners to restore and revegetate habitat on private land in Victoria.

This is unlikely to proceed successfully without widespread electoral support. *Biodiversity 2037* makes this clear in its two stated goals: that "Victorians value nature," and that "Victoria's natural environment is healthy." These aims are interdependent.

Government strategy must include setting the priorities for biodiversity conservation, compiling advice, bringing people together for collective impact, collaborating to define a shared vision, identifying standard measures, and ensuring good communication on the path to achieving the strategic goals within established timelines and budgets.

THE ROLE OF OTHER SECTORS

The human species is a component of biodiversity and maintaining the health of our ecosystems is the responsibility of our whole society. The role of our governments – State and Commonwealth – is to convene, learn, and light the path to collective endeavour through policy and regulation. Governments can provide leadership, strategy and catalyse funding to stimulate investment, but private sector capital is vital to closing a significant financing gap, community effort is essential to sustaining regional ecological health, and research is central to understanding how our time and money is best expended for optimal results.

Public engagement on biodiversity can provide political leverage and may also stimulate private sector investment. Given the limits of public funding, it is imperative to invest strategically to ensure the greatest impact. This could be through direct intervention via government programs or leveraging further investment with intersectoral partnerships that demonstrate mutual benefit and a clear return on investment.

Where there are knowledge gaps in the efficacy of these types of programs, collaborative work between all sectors must begin. We must establish projects that measure the success or failure of different modes of research and direct intervention.

Business

Demand for investment in biodiversity is growing. Driven by shareholder and customer sentiment, the business, industry and finance sectors increasingly seek to invest in a sustainable future and make a more substantial impact on biodiversity conservation. However, consistent measures and robust projects that demonstrate a return from natural capital investment are required, particularly where historically flawed instruments such as offsets might fail to win the reputational outcome desired.

We must create instruments and incentives for the finance sector - and the institutional borrowers with whom they do business, such as major property developers and agribusiness – to support biodiversity-positive development, regulated as a part of the various compliance schemes already in place to ensure ethical conduct in business.

Government subsidies of loans schemes that support conservation covenanting by private landowners could help scale up the footprint of impactful schemes like the Trust for Nature, and further enable investment in ecological restoration as a marketable form of capital improvement.

First Nations

Indigenous knowledge of landscape management extends from tens of thousands of years of caring for land, sea and freshwater Country in support of human wellbeing. This is a reciprocal relationship that the broader community must come to value, understand and support.

Whole of Country Plans, recently developed by Traditional Owner groups, set clear goals and priorities, principles of engagement and measures of success in caring for Country. These plans support biodiversity through relationships between people and Country and are an essential way to improve broader community understanding. Twelve plans currently exist in Victoria.

In addition, there are 65 partnership agreements between Aboriginal Traditional Owner groups and key water catchment agencies. These promote Aboriginal values and traditional ecological knowledge in water planning and management. In tandem, 'Joint Management Plans' embed Aboriginal knowledge in the everyday management of parks and reserves.

The ***Victorian Traditional Owner Cultural Landscapes Strategy*** sets out a way to enable and empower Traditional Owners to lead planning and use cultural knowledge and practices to care for, restore and redress harms to Country in Victoria. It also guides the Victorian Government on future forest and parks management and decision-making, including policy and legislative reform.

Co-creation of projects through partnerships with environmental scientists, governments and the private sector are essential to building the capacity of First Nations to heal Country.

Agricultural Communities

The Landcare movement is strong, and future-focused agricultural communities are working to adapt or phase out professional practices that have been shown to damage the health of soils, waterways and ecosystems over time. Landcare enjoys significant goodwill from rural and metropolitan communities, businesses and government, an outcome of almost four decades of work. Collaboration and capacity building with Landcare will be key to developing further community participation programs informed by robust scientific methodology and research in restoration ecology.

Collaboration for Local Action

No particular sector or group holds sole responsibility for Victoria's ecological health. We must sustain healthy partnerships and be clear – this is a collective responsibility. Nobody can continue to ignore, much less actively contribute to the deterioration of our State's biodiversity.

Resourcing people from all walks of life to contribute to informed decision-making and project delivery is vital to building a sense of ownership and responsibility for the health of our natural systems across Victoria.

Leadership and participation by a range of local groups and industries is essential to build the long-term, cultural commitment to the ecological health of each region necessary to drive and sustain local action, so people with a personal stake in regional outcomes are best placed to advise on priorities for action by a local community.

This will need to be informed by measures to conserve and restore ecological health in each particular location, advised by Traditional Owners, scientists and natural resource managers holding expertise. As ecological systems are complex, we need to bring these multiple sources of "best advice" together to inform cost-effective actions on the ground with a high likelihood of success.

TOWARD SOLUTIONS

Natural systems are interdependent and complex, and very difficult to recover once lost without expert guidance, sustained effort and considerable expense. As a general principle, the cheapest and easiest approach is prevention; beyond the front line of conservation, restoration becomes more difficult, and more expensive.

However, in the Victorian context where over half the State has been cleared since colonisation, prevention of further loss through human activities will not be enough to recover species and ecosystems because of lag effects running through the system. Restoration must be a part of the solution, and climate change adaptation for our most vulnerable ecosystems – such as those in our alpine environments – will require considerable innovation and investment.

There is clear engagement by Victorians with the imperative to conserve our State's ecosystems.[11] A key barrier for people acting is a lack of expertise, direction and assistance with addressing the biodiversity crisis at a local or regional scale. Information is needed about *how* to be involved through consumer choices, behaviour changes, and participation in citizen science programs focused on ecological renewal.

Ultimately, every positive action collectively adds up to protect Victoria's natural systems. The key to sustaining action is to demonstrate the direct and cumulative effects of even the smallest project to participants, which builds ownership, pride in accomplishment, and a commitment to further beneficial work.

Funding Biodiversity Conservation and Recovery

Biodiversity conservation is a public good. Work on recovery needs to scale up dramatically and immediately. This means understanding the real scale of investment required for ongoing engagement and coordination, then identifying sources of leadership, financing and labour.

Diversifying sources of investment in biodiversity recovery is vital to riding out the political ebb and flow of public sentiment over the long term. New and existing projects could benefit from industry engagement to support, enhance and stimulate commitments to adequate public funding. The case needs to be made, and financing secured, if we are to address the crisis in a time-sensitive fashion.

Co-design and co-delivery are also important. Biodiversity conservation projects need to be defined in similar ways to how businesses define projects – with clear, demonstrable benefits that reward investors. Whether public or privately funded, project outcomes should inform and drive further financing decisions for increasingly beneficial interventions in future.

> ***"Native vegetation is well adapted to the harsh Australian environment and provides essential ecosystem services such as integrated pest management, healthy soils and landscapes."***
>
> ***"Striving towards ecologically healthy and diverse farming systems provides more resilience to climate change and can improve both profitability and biodiversity values."***
>
> *– Agriculture Victoria, "Managing for Biodiversity"*

Starting from Here

Pilot projects should be small and have a high chance of success to be effective, noting that we can learn from ones that fail. These projects should build on previous work and be part of a broader strategy.

- Farmers are working to integrate ecosystem values into productive land but need considerable support in overcoming pests and soil degradation without recourse to excessive fertiliser and pesticide use. These can be mutually-reinforcing goals, but we acknowledge many pest threats do not recognise fence lines – meaning collaborations between all categories of "land manager" to restore ecological systems at the landscape scale. Over 21,000 commercial farmers manage half of Victoria's land area – 11.3 million hectares – and we cannot achieve our goals without the agricultural sector taking a leading role.
- Human population increases and consequent changes to settlement patterns add pressure on Victoria's ecosystems. We must question the impact on regional biodiversity from changes to population sizes, resource needs and behaviours, and mitigate this through our planning frameworks before proceeding with various projects and schemes, including stronger regulation to avoid or mitigate development in locations inappropriate for housing or industrial activities due to impacts on regional ecology.
- Researchers within universities, government and industry contribute evidence, tools and networks. However, more effort is required to transfer this knowledge and skill base to accessible planning tools and coordinated actions by businesses, governments and the community. Scientists can help inform governments, community groups or businesses on prioritising ecosystem interventions, where investment will bring the most benefit, and the most efficient and effective actions to stem biodiversity loss and ecosystem decline. The more these interventions are conducted as a component of professional research, the more we can fill our knowledge gaps to inform the success of future projects.

- Decision-making tools need to be developed, taking the complexity of the natural world and delivering this in a way that connects to human-based decision systems – informing policy, planning and on ground decision-making, and enabling users to demonstrate the benefits of different actions in a standardised way. Providing highly accessible field guides for local people seeking to make a difference in their own region will be essential to reducing reliance on governments or scholars on local management of restorative projects.
- Robust monitoring is required to determine whether or not biodiversity conservation projects are succeeding. This will inform adaptive approaches to project delivery and evolve practices in the field for further work. A credible, publicly accessible, user-friendly measurement system must provide transparency, accountability and evidence to support claimed benefits or recommendations for new methodologies. Governments can host data sets while provide tools and training to project participants, including the common measurements required, how to measure, and det data types.
- Measurements need to be standardised and based on rigorous research. Businesses, in particular, require the assurance of robust, science-based evaluation and tracking. Presently, Victoria's biodiversity science and data capability are diminished by a lack of coordination. A research strategy is required for investing in an ecosystems approach to decision-making and policy development.

NEXT STEPS

We recognise and commend much positive work underway across all sectors. However, the scale of the current collective effort remains inadequate to the task at hand.

Transformation is urgently required, in how we think and talk about biodiversity, how we fund its conservation, how we change our behaviours to support it, and how we connect our collective efforts. This will require substantial investment.

The RSV seeks:

- a response from the new Commonwealth Government to the October 2020 recommendations of the ***Independent Review of the Environment Protection and Biodiversity Conservation Act 1999*** (Samuel Review), particularly with regard to establishing effective and enforceable National Environmental Standards, and diligent monitoring and control of cumulative impacts on biodiversity.
- a response from the Victorian Government to the Legislative Council's Environment and Planning Committee's December 2021 report for the ***Inquiry into Ecosystem Decline in Victoria.***
- a detailed study of the methodologies and results of government-funded conservation projects in Victoria over the past 30 years to make clear what has worked, and what has not.
- planning, then investment in a diversified, scientifically rigorous program of conservation projects that posits hypotheses for effective interventions in different landscapes by different groups, sets controls, and tracks rates of success and failure to inform and drive further investment.
- invigorated public sector and corporate leadership collaboration to design and support effective market mechanisms, activating cross-sector partnerships to co-invest in this diversified conservation and recovery program.
- a regulatory response to the relationship between the finance sector, property development and agribusiness to ensure compliance with biodiversity positive outcomes in investment, lending, planning and delivery.
- establishment of a Community of Practice for Traditional Owner Corporations and Elders to collaborate with environmental scientists, exchanging expertise and building a contemporary cultural knowledge base to heal a much-changed Country.
- sustained cross-sector collaboration to identify and deliver the structural and behavioural alignments required to achieve success.

COLLECTIVE ACTIONS

While there are many possible actions to address Victoria's biodiversity extinction crisis, the RSV has chosen to highlight the following actions as the most critical and likely to lead to elevation of the biodiversity crisis as a unifying social cause with targeted funding for a successful intervention.

These actions aim to:

- elevate recognition of the biodiversity crisis in Victoria and Australia as a political, social, and economic priority, parallel to addressing climate change and environmental pollution.
- inspire cross-sector leadership of a series of regulatory, research, funding and communication activities that will drive the effective conservation and recovery of native plants, animals and ecosystems in Victoria and Australia.

Action 1: Recognition of First Nations' Leadership in Ecological Management

Significant cultural change in Victoria is needed for the benefit of our natural systems, acknowledging this will take a sustained effort over a long period of time. Acknowledging the Treaty process underway, and in keeping with the principles of social and environmental justice:

- The RSV calls on politicians, public servants, businesses, academics, non-government organisations, community groups, and the people of Victoria to recognise and respect the claim of First Peoples to cultural custodianship of our State's many landscapes and ecosystems.
- The RSV calls on First Nations' knowledge holders to engage in regional action to help balance the many demands on Country to recover and sustain healthy ecological communities.
- The RSV calls on the Victorian Government to resource Indigenous leadership capacity in species conservation and environmental health on Country for all Victorians.

Action 2: Resourcing Local Ownership & Leadership of Restoration Ecology Projects

Building on DELWP's Victorians Value Nature report, communication and education activities must guide a necessary shift in how Victorians regard nature, transitioning from a resource perspective to a reciprocal relationship, reinforcing personal responsibility and an appreciation of the value of flora and fauna indigenous to Victorian regions over destructive invasive species and human activities.

While initiatives such as the **BushBank program** provide a welcome financial stimulus for conservation on private land, it is clear there are few materials available that summarise decades of ecological research into tractable, accessible guides for land managers seeking to restore ecological values in their specific region.

Given the scarcity of government funding available for staff-based interventions and the private ownership of the majority of affected land, we seek an investment in creating region-specific field guides for local people to initiate ecological restoration projects as citizen scientists and conservation volunteers, matched up with recognised expertise in restoration ecology who can offer professional consultation and guidance on projects.

> ***"The economy is a wholly owned subsidiary of the environment. All economic activity is dependent upon that environment and its underlying resource base of forests, water, air, soil and minerals. When the environment is finally forced to file for bankruptcy because its resource base has been polluted, degraded, decapitated and irretrievably compromised, the economy goes into bankruptcy with it. The economy is, after all, just a subset with the ecological system."***
>
> *– Gaylord Nelson, "Beyond Earth Day: Fulfilling the Promise"*

Action 3: Appointment of an Independent Regulator to Govern Biodiversity Values in Victoria

The health of our natural world supports all other activities in our state. Much has been extracted from our natural systems for far too long without due constraint or sufficient reinvestment. We seek a reallocation of Victoria's biodiversity and ecological system health as first order priorities for economic and social sustainability.

We consider there are too many powerful, competing interests at play in our political system for biodiversity conservation to be maintained as a first order priority within Ministerial and Departmental structures.

We seek an independent regulator – such as an ombudsman - to be appointed or restructured from existing roles and agencies within the Victorian Government, suitably realigned, resourced and empowered.

Defined, supported and supplied under State legislation, this regulator would possess due powers of review and veto of applications submitted for development within the State's planning system referred to the office for unacceptably impacting biologically sensitive land or

failing to add sufficient ongoing support for biodiversity values in design, construction and ongoing land use. The following measures would be required:

3.1: A Conservation Significance Classification Layer to the State's Planning System

Work with a Board of subject matter experts and stakeholders with appropriate cultural authority to assess, certify and govern a land management system, assigning a robust, scientifically-assessed conservation status to whole landscapes and waterways classified in accordance with IUCN Red List categories irrespective of title status. This must include aspirations to recover degraded regional ecosystems in addition to conserving remnant and intact biological diversity.

3.2: Regulation of the Finance Sector to Restrict Biodiversity Negative Investment

Restrict lending by institutions operating within Victoria's jurisdiction to companies and individuals seeking to develop or otherwise utilise land in a manner that damages or destroys its biodiversity values on properties holding high conservation status under the State's Planning System.

3.3: No Net Loss: Reform and Constrain Offset Programs to Operate Within Sites of Impact

Reform and constrain "offset" programs to avoid the destruction of biodiversity values through property development and industrial activities as a "cost to the project." At a minimum, all "offsets" must guarantee no net loss of ecological system function on directly-affected properties and waterways, rather than augmenting or protecting biodiversity values elsewhere as a compensatory measure.

An early opportunity may be a reframing and broadening of the powers, capacities and objectives of the Conservation Regulator, in accord with the compliance role of the Victorian Government Land Monitor, the data gathering and reporting role of the Commissioner for Environmental Sustainability, and the enforcement role of the Environment Protection Authority Victoria.

Penalties for non-compliance must act as a genuine deterrent, as smaller fines without criminal charges and the loss of license to operate have been historically treated as "the cost of doing business" by the unscrupulous. We recommend making new provisions for biodiversity sensitive land under the *Planning and Environment Act 1987* (Vic), similar to the reforms made to protect heritage buildings from unlawful demolition and neglect. (State of Victoria, 2021)

> ***"Offsetting land proposed to be cleared fails to consider natural ecosystem processes, species interactions, microhabitat requirements of all species in a community, and population genetics. Most importantly, it encourages the approval of land-clearing because it can be offset. The overall consequence is more protected (environmentally managed) habitat through the creation of biodiversity offset areas, but significantly increased clearing, fragmentation, and degradation of habitat outside offset areas and other protected conservation areas. This leads to disruption and potential collapse of ecosystems and overall, less habitat for native biodiversity."***
>
> – *Stephen Ambrose, A Broken System of Biodiversity Protection.*

Action 4: Establishing Funding Diversity for an Intersectoral Nature Fund

We seek the appointment of influential leaders within the research, business, community, First Nations, and philanthropic sectors as Trustees to govern a science-backed Nature Fund for Victoria, financing pilot projects that seek to restore and recover the State's biodiversity. To ensure confidence is maintained in the program's integrity for all stakeholders, this must be an intersectoral initiative that attracts finance from both public and private investment, building and expanding on the example provided by the Nature Fund established within the Victorian Government (DELWP) in 2022, and operating with full transparency to sustain trust in the Fund's actions.

There is considerable interest from all sectors in biodiversity and the restoration, conservation and preservation of species and vegetation. There are many options for activating funds from the business sector; direct collaboration is recommended. As examples, ideas proposed at our June 2022 Forum are provided below.

4.1: Voluntary EFT Transactions

Our Forum proposed working with major banks to provide the option of donating an amount to the Nature Fund every time a customer undertakes an electronic transaction (say, $0.05), noting that periodic microtransactions of this nature can be easier for household budgets to accommodate than larger, one-off donations.

Current technology gives banks the ability to manage many transactions with little cost. The Reserve Bank of Australia's Payments System Board reports that, on average, Australians made approximately 625 electronic transactions per person in 2021, up from 275 per person in 2011. (Reserve Bank of Australia, 2021)

The trend to electronic transactions, rather than paper or cash, continues to grow through market forces and increased government regulation of the cash economy. A 5-cent donation per transaction would equate to around $30 per customer, per year.

There is considerable groundwork to be done to investigate the feasibility of this idea, including:

- review data on types of electronic transactions (debit cards, credit cards, automatic bill payments) and determine where the option will be offered
- assess the market reaction to the scheme
- decide which amount to suggest for an optional donation (e.g., 5 cents, 10 cents, 20 cents)
- ensure availability of year-end statements of the total amount donated per customer
- obtain tax deduction status for the Fund (which could be stewarded in partnership with an existing not-for-profit with Deductible Gift Recipient status)
- review the existing Fund, prescribe how the Fund can be used, and appoint an independent Board to manage the Fund
- consider regulation, such as legally binding restoration targets (a model may be the EU's proposal for a Nature Restoration Law)

4.2: A State Levy on Pet Care Products

With invasive species and genes identified as a leading cause of biodiversity decline in Australia, we seek to balance the explosive growth in pet ownership in our State through imposing a related levy, raising funds to explicitly address the impacts of invasive plants, fungi and animals on regional ecosystems, with flow-on biosecurity benefits for the agricultural sector.

A strong precedent is provided by a hypothecated trust instrument established by the *Environment Projection Act 2017*, which gathers proceeds from landfill levies to resource a Sustainability Fund managed by DELWP, which in turn supports "projects, programs, services or technologies that will benefit Victoria environmentally, socially and economically."[12]

The Sustainability Fund could also be the recipient of proceeds from the proposed pet care products levy, with these funds earmarked to address invasive species management in the State of Victoria. Currently the Sustainability Fund does not address ecological restoration or conservation, which is overwhelmingly concerned with the related priorities of sustainable waste management and mitigating climate change. Either this Fund's scope must expand to recognise there are three concurrent crises affecting our environment, or the Victorian Government can otherwise direct pet care product levies for management by the independent governors of the Intersectoral Nature Fund.

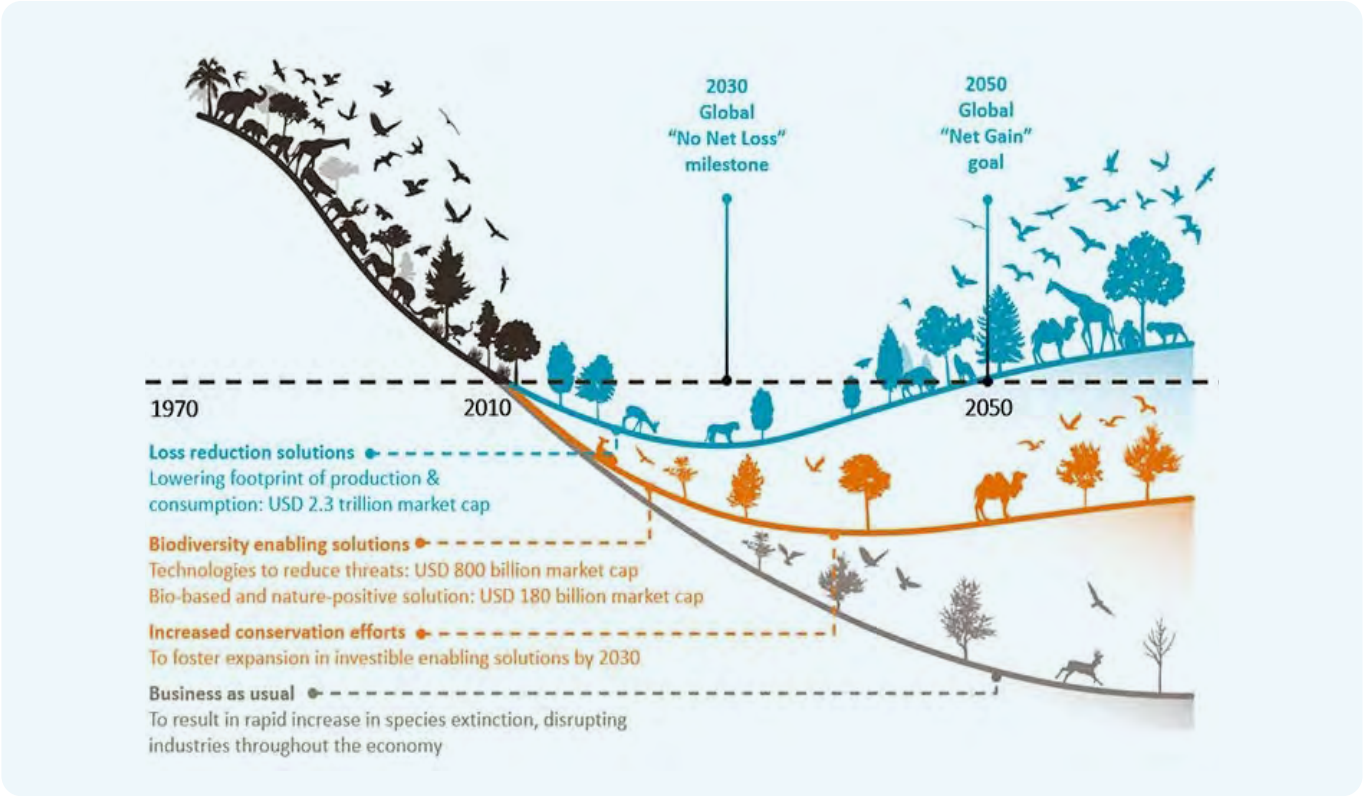
We seek further discussion with the government, business, community, and philanthropic sectors to co-govern and review diverse funding options for the Nature Fund and/or seek reform of the Sustainability Fund governed by an independent Committee appointed by the Secretary of DELWP.

Action 5: BUILD Effective Investment Instruments for the Business Sector

We recommend the creation of incentives for the finance sector to produce highly competitive, biodiversity-positive investment products to expand the conservation covenanting effort; this could be accompanied by a redirection of state or federal subsidies from major industry polluters to an ethical finance scheme for the property sector.

Instruments that help businesses and governments to track their performance as an element of cost accounting, demonstrating the value of investment in biodiversity conservation and recovery, must be developed. This will lay the foundation for companies to assess what measures they can take to invest in nature in ways that counter the anticipated impact of – and on – their business.

It can also help identify what governments need to do to stimulate further investment (e.g., regulation, legislation, information systems, scientific monitoring design, resources for threat management), and provide confidence to communities of concern that investment is made transparently in projects that demonstrate a genuine contribution to Victoria's ecological health.



Reversing the biodiversity threat by 'bending the curve' of biodiversity loss brings huge investment opportunities. Source: Robeco, Bloomberg. Illustration adapted from Leclère et al, Nature, 2020

5.1: Reform of the Treasury Corporation of Victoria's Sustainability Bond Framework

The Treasury Corporation of Victoria's (TCV) Sustainability Instruments are employed for the financing, and re-financing, of Green and/or Social projects and assets ('Eligible Projects') across Victoria, which are funded through TCV 'Participating Authorities,' Victorian Government Departments and State related entities. (Treasury Corporation of Victoria, 2022)

Strengthening the governance, management and transparency of the TCV's Sustainability Bonds Instruments, managed by the Victorian Funds Management Corporation (VFMC), offers an opportunity for impactful reform. A review of the various international guidelines referenced to govern management are overwhelmingly focused on social benefits and emissions reduction to mitigate disastrous climate change; there is no discussion of ecological restoration nor biodiversity conservation as investment priorities.

The VFMC had $74.5 billion in Funds Under Management as of 30 June 2021, but as yet provides no indication on where, how and if these funds are being invested to promote the ecological health of Victorian landscapes and the many species they sustain through the TCV Sustainability Bonds Instruments.

We note there are private sector equivalents to the VFMC who have developed explicit investment strategies to target companies that can benefit from the transition to a nature-positive world. For example, international asset manager Robeco launched their **Biodiversity Equities** strategy on 31 October 2022. (Thomas, Robeco to Launch Biodiversity Equities Strategy, 2022)

Accordingly, we recommend the following specific actions for the Treasury Corporation of Victoria and the Victorian Funds Management Corporation:

- Adoption of Sustainability Bonds guidelines that recognise projects and programs addressing the biodiversity crisis as a leading priority for investment
- Appointment of VFMC Board Members with recognised expertise in biodiversity recovery and conservation to inform ESG decision making and guide investment opportunities to impactful interventions
- Creation of a Chief Sustainability Officer role to provide expert advice
- Separate, visible and equal status for "Sustainability Bonds" in listed asset classes, promoted beyond a subset of "Non Traditional Strategies" (State of Victoria, 2022)
- Separate and equal status for "biodiversity" as an ESG theme – currently, neither the urgency nor complexity of biodiversity management is clearly recognised, reduced to a subset of climate risk management in the most recent *Responsible Investment Update* (State of Victoria, 2022)
- Inclusion of a detailed ESG investment section in the VFMC annual report, disclosing the projects supported and their impact against the Key ESG Themes of Climate Change, Modern Slavery and Occupational Health and Safety, and including Biodiversity as a fourth ESG theme (State of Victoria, 2021)

> ***"The TCV Sustainability Bond Framework sets out the process by which TCV intends to issue and manage sustainability instruments on an ongoing basis to finance, and re-finance projects and assets across Victoria, which are consistent with delivering a low carbon and climate resilient economy and/or delivering positive social outcomes for Victorian communities."***
>
> ***"The TCV Sustainability Bond Framework may be subsequently updated at TCV's discretion as relevant market standards and best practice continue to evolve over time."***
>
> *– Treasury Corporation of Victoria, 2022*

5.2: Create a Template Case for Sustainable Practices in Business

Develop a template business case that collates existing data and builds on emerging market frameworks to demonstrate the value to businesses of investment in biodiversity conservation and recovery. This will lay the foundation for business leaders to assess what measures they can take to invest in nature-positive schemes in ways that directly counter the anticipated impact of – and on – their business.

The business case could consider value creation via:

Tangible Biodiversity Outcomes

- biodiversity recovery and protection
- resilience of species and natural assets from climate change and other human activity impacts
- increased conservation covenanting

Tangible Economic Outcomes

- the role of future carbon and biodiversity markets
- reduction in negative impacts from a lack of biodiversity (food security from improved protection of pollinators, importance of soil health for carbon sequestration) and from natural hazard mitigation (i.e., floods and bushfires)
- long-term budget and resource commitment

Intangible Corporate Leadership Outcomes

- customer, employee attraction and satisfaction
- inclusion of First Peoples and culturally diverse communities in conservation partnerships
- collaboration with other sectors to build buy-in and strengthen outcomes
- brand leadership, partnerships and influence on the market

The Template Business Case would demonstrate a case for corporates valuing and investing in nature. It can also identify what government needs to do to assist (e.g., legislation, information systems, scientific monitoring design, resources for threat management).

5.3: Develop and Deliver Business Awareness and Engagement Campaigns

Victoria's business sector is yet to pervasively engage with natural capital and other biodiversity or climate-related financing tools.

Leading companies can convene a community of practice, creating a multi-stakeholder platform for like-minded partners and corporates to drive engagement with awareness-raising campaigns in the private sector, including calls to action, industry guides, and fundraising for the Intersectoral Nature Fund.

A campaign can involve or be directed towards employees of participating businesses, customers or their supply partners. The collective push by corporates can result in greater momentum towards a specific delivery organisation or partner.

Calls to action can be embedded in the campaign, including industry guides and fundraising requests for a specific cause. A guide could be developed with small to medium-sized enterprises to enhance their positive impact while minimising destructive practices.

Action 6: CREATE an Independent, Intersectoral Taskforce for Biodiversity Recovery and Conservation in Victoria

Recognising a whole-of-society crisis requires a whole-of-society response, the RSV seeks resourcing to establish an independent and intersectoral taskforce on biodiversity conservation and recovery to oversee implementation of these and further actions. Operating as an open and authentic partnership between all sectors, the taskforce will:

- build a system-wide understanding and ownership of effectual biodiversity programs and outcomes
- help all concerned to track and communicate progress to the broader population
- build fruitful partnerships between policy-making, natural capital investment schemes and projects in the field with demonstrated impact driven by researchers, citizen scientists and conservation volunteers
- stimulate engagement and participation
- build on the recommendations of the Samuels Review and the Victorian Inquiry into Ecosystem Decline
- identify the biodiversity impacts of activities and development planned by government, and recommend biodiversity-positive alternatives
- develop electoral support for public investment and market support for private investment in projects that demonstrably repair and conserve ecological systems to safeguard biodiversity in Victoria.

REFERENCES

All statements are supported by the RSV's full position paper, which includes references throughout in support of key observations and arguments. This and other positions held by the Royal Society of Victoria are available from our website at **https://rsv.org.au/publications/position-papers/**.

Key references in support of this brief paper are provided as Endnotes, below.

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EVENTS

Optimising Healthcare for People with Musculoskeletal Conditions

Inspiring Australia Victoria

Thursday, 8th December 2022 (6:00pm–7:30pm) — Ellery Theatre, The Royal Society of Victoria

While medical care brings benefits for many, there is accumulating evidence that unnecessary care is a growing problem.

Not only does it fail to provide benefit and sometimes causes harm to the recipients of that care, it also diverts scarce resources away from those that need it most.

Join Professor Rachelle Buchbinder, whose research has focused on ways of optimising care for people with arthritis and other common musculoskeletal conditions such as low back pain; landmark trials examining treatments accepted into practice before their proper evaluation; and ways of more rapidly translating new evidence into practice as soon as it emerges.

ABOUT THE SPEAKER

Professor Rachelle Buchbinder AO, FAHMS is an Australian NHMRC Investigator Fellow. She has been the Director of the Monash-Cabrini Department of Musculoskeletal Health and Clinical Epidemiology since its inception in 2001 and a Professor in the Monash University Department of Epidemiology and Preventive Medicine since 2007. She is a rheumatologist and clinical epidemiologist who combines clinical practice with research in a wide range of multidisciplinary projects relating to arthritis and musculoskeletal conditions.

Professor Buchbinder recently chaired the steering group for The Lancet Low Back Pain Series, a series of three papers published in March 2018 that drew attention to the urgent need for action to reduce the current and projected disease burden from low back pain. In particular it outlined the epidemic of low value care for low back pain across the world and identified promising solutions.

Her current broad program of work, funded through various NHMRC schemes including a program grant, partnership centre, CRE and project grants include:

- reducing inappropriate overdiagnosis and over-testing across musculoskeletal conditions
- reducing waste in the health care system and identifying more efficient alternative service delivery models
- strengthening the recently established ANZMUSC clinical trial network
- living reviews and living guidelines
- implementation of the Australian Clinical Care Standard for osteoarthritis of the knee
- Development of a decision aid for knee arthroscopy
- Investigating ways of improving imaging reports to reduce overtesting, overdiagnosis and overtreatment
- Development of a core set of outcome measures for trials of shoulder disorders
- Development of the Back Pain Burden Questionnaire and the Back Pain Misconceptions Questionnaire
- Identifying ways of supporting people with suboptimal health literacy
- Long term outcome of inflammatory arthritis in Australia

Professor Rachelle Buchbinder AO is the **2022 recipient** of the Royal Society of Victoria's Medal for Excellence in Scientific Research. She will be awarded the Medal following her lecture by **Laureate Professor Peter Doherty AC**, a Fellow of the Royal Society of Victoria.

This is a hybrid event. Please register at **https://rsv.org.au/events/optimising-healthcare/** to attend in person at the Royal Society of Victoria in Melbourne or via Zoom webinar from anywhere. All are welcome. RSV members are prompted to enter their "promo code" to access a members' ticket.

This live presentation will be streamed online via **YouTube** with the support of the *Inspiring Victoria* program.

Melbourne Christmas Treasure Hunts

Sunday, 11th December 2022 (9:30am–3:30pm) — The Royal Society of Victoria

The Christmas Treasure Hunts are a fun learning experience for families. groups and individuals as a part of the the City of Melbourne's Christmas Festival in December 2022. Catering for people of all ages, activities will take participants all around the City of Melbourne, exploring key Christmas installations as well as increasing awareness of Melbourne's iconic and lesser-known landmarks and locations.

Treasure Hunt adventures with maps and clues (designed by Spatial Vision cartographers) will be provided across three categories:

Christmas-Themed Treasure Hunt for families with young children in the Carlton Gardens

- Sign up here – bookings essential. Select your start time and register tickets for a supervising adult with up to 4 kids (other adults welcome to join)
- Pick up your map and clues from the Royal Society of Victoria at your allotted time
- Head over to the park, follow the map, answer the questions and
- Return your answer sheet any time before 3pm – all children will collect a prize

Suitable for Pre-school and Primary School aged children. Adult supervision required. Approx time to complete – an hour or two (depending on how long you spend in the playground!).

Advanced Cryptic Treasure Hunt Challenge for individuals/families/teams

- Race against the clock and discover the many amazing treasures in Melbourne's CBD
- Sign up here – bookings essential. Select your start time and participate as an individual or with a team of up to 4 people in total (you can sign up your team on the day)
- Pick up your map and the 80 question/answer sheet at your allotted start time at the Royal Society of Victoria
- Head off in any direction you choose, travelling by any means you wish
- Find the many treasures and answer as many of the questions you can/want
- Return your answer sheet within the 4 hr limit for a chance to win a prize.

Mapped Tour of Melbourne's Treasures

A Non-Competitive Activity for Individuals/Families/Teams

The Melbourne Christmas Treasure Hunts are a part of the 2022 **Melbourne Christmas Festival**, supported with an activation grant from the City of Melbourne.

These FREE events will take place throughout the day on Sunday, December 11 with participants encouraged to wear Christmas-themed clothing. Activities will be accessible by walking, cycling or public transport (free City Circle trams operate within the Melbourne CBD).

Prizes in each category will be awarded, with a prize awarded to all participating children.

Each event will start and finish at the Royal Society of Victoria (8 La Trobe Street, Melbourne) providing participants with an opportunity to learn about the role of the Society in promoting science in Victoria and also discovering this historic building – an iconic yet lesser-known heritage-listed treasure of Melbourne.

Our grateful thanks to the hard-working Ms **Libby Hillman** MRSV and our colleagues from **Geography Victoria** for leading this excellent seasonal event!

Register online now to participate in any of these three activities at **https://rsv.org.au/events/melbourne-christmas-treasure-hunts/**.

AWARDS, PRIZES AND FELLOWSHIPS

Young Scientist Research Prizes 2022

This article recaps the Young Scientist Research Prizes competition, which was held at The Royal Society of Victoria on 10th November, 2022 and livestreamed via YouTube.

The 2022 Finalists, from left: Linda Riquelme, Aung Zaw Zaw Phyo, Pui Kwan Cheung, Michelle Xu, Mahshid Sadeghpour, Daniel Urrutia Cabrera, Hoseong Lim, Yongqiang Wang.

Every year, final year PhD candidates present their doctoral studies to the Royal Society of Victoria, competing for four Prizes that recognise excellence in Victoria's early career scientists. Eight finalists present under the four categories: Biological Sciences, Biomedical & Health Sciences, Earth Sciences, and Physical Sciences.

First Prize winners 2022, from left: Pui Kwan Cheung, Michelle Xu, Mahshid Sadeghpour, Daniel Urrutia Cabrera

We congratulate all our finalists, with particular acknowledgement of Pui Kwan Cheung, Michelle Xu, Mahshid Sadeghpour and Daniel Urrutia Cabrera, the first prize winners of their respective categories. The rationale for each presentation is provided below, along with links to the video presentations from all finalists; short articles on the work of our first prize winners will be released in the coming weeks. You can also view the whole competition via the Society's YouTube channel at **https://youtu.be/g6HrXcxLFZQ**.

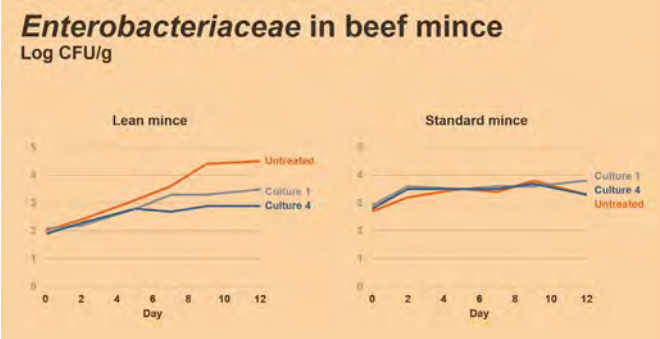
BIOLOGICAL SCIENCES

First Prize: Michelle Xu, STEM College, RMIT University

Protective cultures as natural antimicrobials for fresh meat shelf-life extension: their application and consumer acceptance

Michelle Xu presenting to the Society. You can view Michelle's presentation on YouTube at **https://youtu.be/UeJsl-On7dI**.

Protective cultures are microorganisms that have the ability to inhibit certain other microorganisms by competing for space and nutrients, producing antimicrobial compounds, or a combination of these. Protective cultures have been investigated in a number of studies for microbial control in fresh meat and meat products and achieved great success.



To date, most studies have focused on evaluating the effects of protective cultures against pathogenic bacteria, such as Salmonella spp. and Listeria monocytogenes, since these bacteria are associated with health risks. Spoilage bacteria generally do not cause illness and have received much less attention; however, they are responsible for meat spoilage and limit product shelf-life, leading to food waste, economic losses, and environmental impacts. Michelle's work was conducted to evaluate the potential of protective cultures for extending fresh meat shelf-life from both the practical application and consumer acceptance perspectives.

When used with vacuum packaging, the culture containing L. sakei and the one containing S. carnosus and L. sakei showed strong inhibitory effects against spoilage bacteria in both lamb and beef and intact cuts and comminuted products. However, fat may be a factor limiting the application of protective cultures to lean or low-fat fresh meat products. In addition to laboratory studies showing the potential of protective cultures in the technical application aspect, the online consumer survey revealed that consumer acceptance would unlikely be an issue for adding protective cultures to fresh meat products for shelf-life extension.

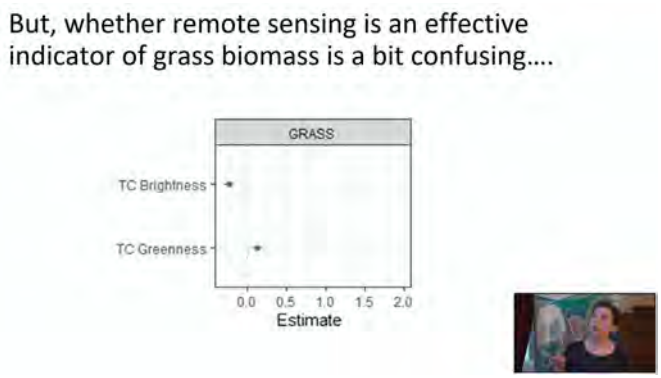
Second Prize: Linda Riquelme, School of Ecosystem and Forest Sciences, The University of Melbourne

Measuring grass from space: estimating understorey biomass using remote sensing in semi-arid woodlands of south-eastern Australia

Linda Riquelme presenting to the Society. You can view Linda's presentation on YouTube at **https://youtu.be/2LdMiP4v4-w**.

Ongoing grazing is inhibiting regeneration in several semi-arid woodland communities in south-eastern Australia, including the nationally endangered Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions. Western grey kangaroos are thought to switch from grass to lower-quality browse, including tree seedlings, when grass biomass falls below a purported threshold.

Land managers are interested in using forage availability to inform cull targets for kangaroos, to minimise the risk that browsing poses to regeneration in these woodland communities when forage is low. They want to monitor grass biomass without the need for field data collection, which is costly and time-consuming. Remote sensing allows for frequent observations over broad spatial scales. Linda's work examined the ability of satellite-derived vegetation indices (VIs) to estimate understorey biomass in semi-arid woodlands in north-western Victoria.

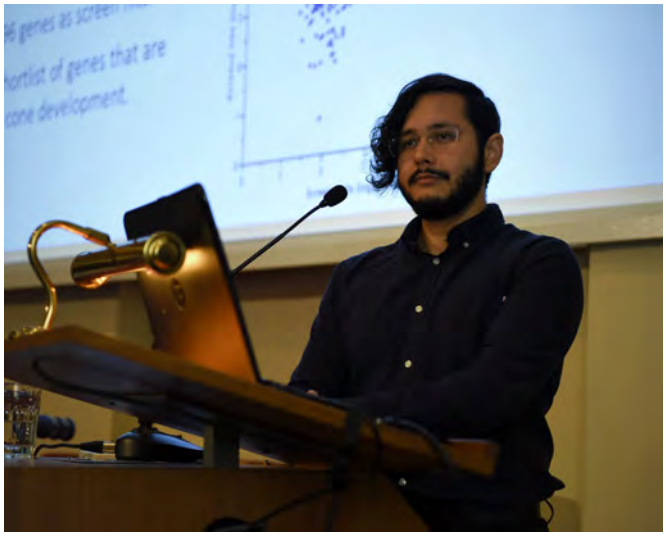


Linda found that satellite-derived VIs are promising as an easily-available source of vegetation information; however, this study shows that VIs alone are not able to predict grass biomass to new areas. Additional landscape-scale data (such as satellite-derived soil moisture and tree cover) can greatly improve model performance, providing managers with a more cost-efficient method of estimating grass biomass for herbivore management for woodland restoration in this semi-arid landscape.

BIOMEDICAL AND HEALTH SCIENCES

First Prize: Daniel Urrutia Cabrera, Faculty of Medicine, Dentistry and Health Sciences, The University of Melbourne

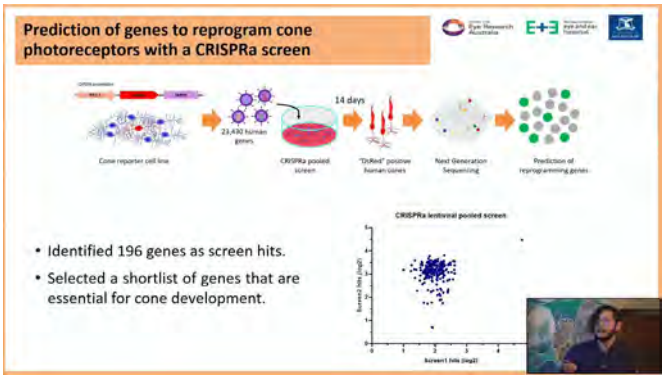
Using Cellular Reprogramming and CRISPR Technologies to Regenerate the Retina and Treat Vision Loss



Daniel Urrutia Cabrera presenting to the Society. You can view Daniel's presentation on YouTube at **https://youtu.be/zPIQHEHjOfc**.

Modern societies are predominantly built around visual cues, meaning patients living with visual impairment and blindness face major challenges that can severely impact their quality of life. Vision relies on a complex network of different neuronal subtypes that extend from the retina to the visual cortex. The photoreceptors begin the visual pathway in the retina by detecting and transforming the light from the environment into electrical signals that are later relayed to the brain.

Human vision largely depends on cone photoreceptors, as they mediate our vision during daylight and the detection of colour. Photoreceptor loss is one of the main causes of blindness and visual impairment. Notably, the damages caused by the death of photoreceptors are irreversible and there are currently no effective treatments to restore vision once they are lost.



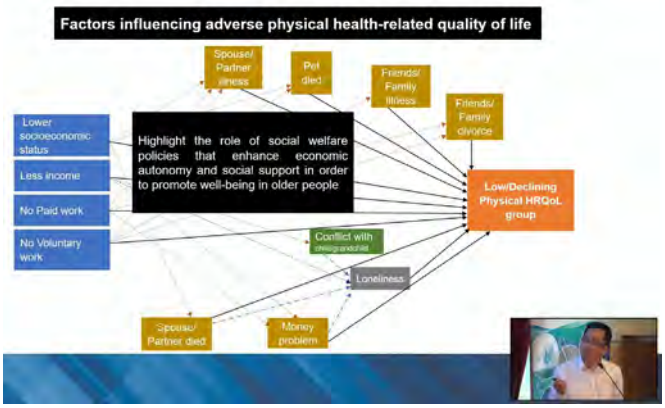
Daniel's project aims to stimulate the reprogramming of a supporting cell type of the retina, called Müller glia, into becoming novel cone photoreceptors to regenerate the damaged retina and reverse visual impairment. He uses in vitro models to optimise a protocol to reprogram Müller glia into cones. Subsequently, he employs a rat model with photoreceptor degeneration to assess the feasibility of translating his research team's reprogramming protocol into a regenerative therapy to treat vision loss. This is the first study to pursue cone regeneration using cellular reprogramming technologies.

Second Prize: Aung Zaw Zaw Phyo, School of Public Health and Preventive Medicine, Monash University

Health-Related Quality of Life in Later Life: Predictors, Trajectories, and Health Outcomes

Aung Zaw Zaw Phyo presenting to the Society. You can view Aung's presentation on YouTube at **https://youtu.be/GWDac6Ncaao**.

Given that older individuals are at a higher risk of adverse health outcomes, the rapid growth in the global ageing population is accompanied by an increase in years of life lived with disability or in poor health. Identifying older individuals most at risk of developing agerelated diseases such as cardiovascular disease (CVD) and dementia, would support the implementation of preventive interventions to reduce the associated socioeconomic burden on society and increase years lived without disability. In contemporary healthcare, integrating patients' views into clinical practice has been increasingly considered as an essential aspiration. Health-Related Quality of Life (HRQoL) is the self-reported measure that assesses an individual's perception of their health status. Lower HRQoL has been shown to predict rehospitalisation and subsequent mortality in patient populations; and has the potential to predict future health outcomes in the general community.



Aung and colleagues investigated whether the physical (PCS) or mental component score (MCS) of HRQoL predict incident CVD, cognitive decline, dementia, and all-cause mortality among community-dwelling older individuals from Australians and the United States, enrolled in the ASPirin in Reducing Events in the Elderly (ASPREE) study. Based on the findings, the research group then identified trajectories of PCS over 5-years and examined whether these PCS trajectories predict subsequent risk of fatal and non-fatal CVD, and all-cause mortality in this cohort. Finally, they explored whether economic factors, social health or stressful life events impact PCS trajectories among older Australians. The research team's results demonstrate the predictive power of HRQoL for the risk of health outcome; a new, much needed and overlooked perspective in the multidimensional approach to chronic disease prevention in older individuals, suggesting that HRQoL could complement traditional objective measures (e.g., blood pressure, body mass index, and lipid levels) during standard outpatient health risk assessment in primary care as a means of reducing future disease risk. This suggestion is also consistent with recommendations of the Australian Commission on Safety and Quality in Health Care to incorporate HRQoL into the health system as a policy goal.

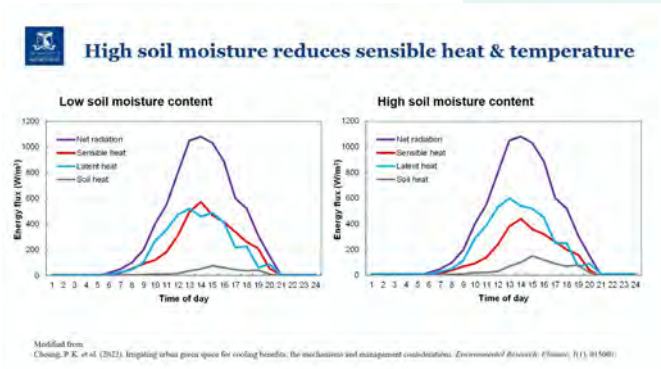
EARTH SCIENCES

First Prize: Pui Kwan Cheung, School of Ecosystem and Forest Sciences, The University of Melbourne

Measuring the micro-climactic impacts of turf irrigation in a temperate summer season

Pui Kwan (Paul) Cheung presenting to the Society. You can view his presentation on YouTube at **https://youtu.be/4o_HZ1xQY18**.

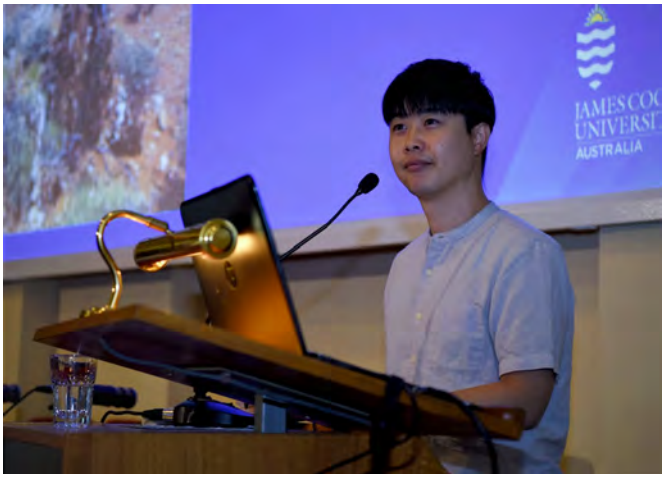
Backyards are an important space for individual households because they provide a private and safe green space for social interactions, exposure to greenery, relaxation, gardening and children's activities. People's willingness to use backyards are dependent upon the thermal stress (measured in Universal Thermal Climate Index, UTCI) of the space. Turf is a common surface type in backyards but unirrigated turf can be as warm as pavement, bringing thermal discomfort and discouraging people from using them. Under certain conditions turf irrigation provides an opportunity to reduce thermal stress by increasing evapotranspiration. Most studies in the literature modelled the impacts of irrigation on microclimate and a strong cooling effect was often predicted. However, such impacts are rarely measured in the real-world environment. Experimental studies are needed to verify the thermal benefits of turf irrigation.



Pui Kwan's research provided empirical evidence to verify the potential of applying irrigation to cool the urban environment. The future climate is likely to become warmer in many parts of the world due to climate change. Mitigation strategies are needed to reduce heat stress in cities because strong heat stress can lead to higher heat-related morbidity and mortality. Heat stress also reduces people's willingness to visit urban green space to engage in physical and social activities, which can reduce people's quality of life and their perceived mental and physical health. Irrigation is a novel idea to reduce urban heat stress in additional to other existing heat mitigation strategies such as tree planting and the use of reflective materials. The findings from this research provided a proof-of-concept for application and laid a solid foundation for further research on the cooling potential of irrigation at a larger scale.

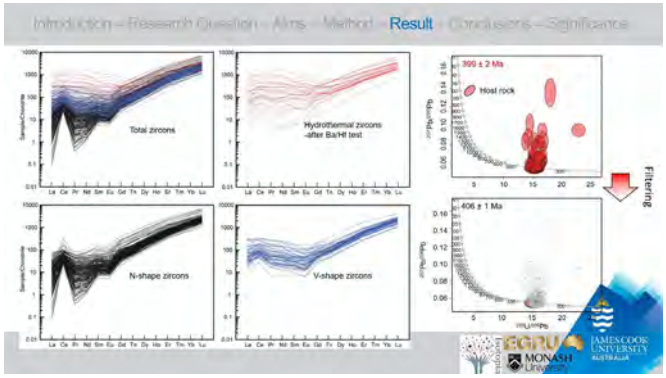
Second Prize: Hoseong Lim, School of Earth, Atmosphere & Environment, Monash University

Timescales of granite infancy: Advances in granite geochronology



Hoseong Lim presenting to the Society. You can view Hoseong's presentation on YouTube at **https://youtu.be/BDghuuMAtp0**.

Granite is a rock type that makes up ~70% of Earth's continents, and is therefore an important study for understanding the history of the Earth's crust. We can obtain the absolute age of granite by using radiometric dating techniques on a specific mineral contained in a granite rock sample, then assume that the age of the mineral is equivalent to the age of the rock. While the dating of granite is commonly derived from measuring the mineral zircon, grains of this mineral yield are found to return large age spans over tens of millions of years. Accordingly, Hoseong and colleagues have challenged the suitability of zircon for granite dating, while attempting to improve on this widely used technique. They found apatite and titanite to have great potential, as their general compositions are suitable as both age dating and environment indicators.



Most of the granite ages from Victoria reported in the literature are biotite or hornblende ages. However, zircon ages and corresponding apatite and titanite ages in this study are consistently around 20 Myrs older than the previous biotite/hornblende ages. These age differences may also occur in other granite bodies. Hoseong's study shows fluid-mobile elements collection in addition to radiometric dating is significantly important to improve age reliability.

Zircon dating is the dominant technique in geosciences, and this fluid-mobile element quality control process may enhance reliability of the huge amount of zircon age data currently generated in geological research. The final implication of the study is the potential of apatite and titanite ages for use as alternative granite age indicators. Although more studies are required, these dating techniques can support zircon age dating and might even substitute the current zircon dating technique.

PHYSICAL SCIENCES

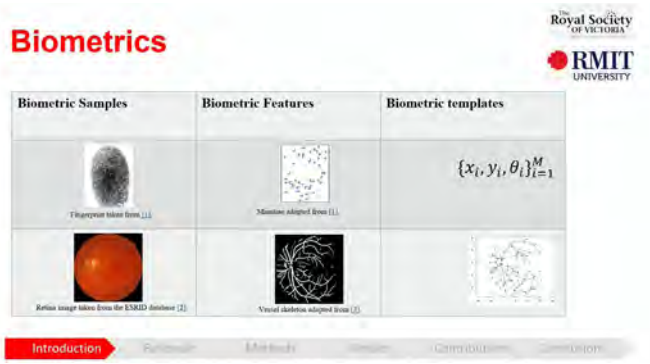
First Prize: Mahshid Sadeghpour, School of Mathematical Sciences, College of STEM, RMIT University

Developing a Privacy-preserving Retinal Biometric Recognition System

Mahshid Sadeghpour presenting to the Society. You can view Mahshid's presentation on YouTube at **https://youtu.be/V4M1iqsrl4A**.

Biometrics are physiological traits of individuals that are unique to them, e.g., fingerprints or the eye's retina. Biometrics, although convenient for the purpose of human recognition, contain sensitive personal information about individuals, such as their ethnicity and health conditions. It is imperative to protect the private information in biometrics.

Because biometric data is "fuzzy," it cannot be protected using conventional encryption methods. Biometric systems extract features from the biometric traits of the users and store them inside their databases as "biometric templates." Even though the retina is the most accurate biometric characteristic known and is currently used for high-security identity verification, there exists no retinal recognition system that protects retinal templates. Mahshid and her colleagues are working to fill this gap, designing a retinal recognition system that protects the private information of its users. To achieve this aim, the biometric templates stored in the system's



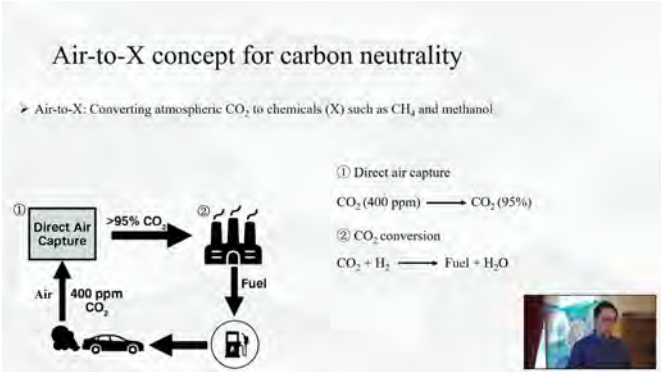
database should be irreversible and unlinkable.The research team developed a software system that can recognise individuals with high accuracy using their retinal images while protecting biometric information from privacy-invasion threats. Machine learning methods were applied to evaluate the system's accuracy and the level of privacy protection; these evaluations demonstrated the proposed system achieves high recognition accuracy, resulting in a user-friendly system secure against hacking and identity theft.

Second Prize: Yongqiang Wang, School of Chemical and Biomedical Engineering, The University of Melbourne

Solar-driven CO_2 capture and production from the air

Yongqiang Wang presenting to the Society. You can view Yongqiang's presentation on YouTube at **https://youtu.be/3E00Uz9CW_I**.

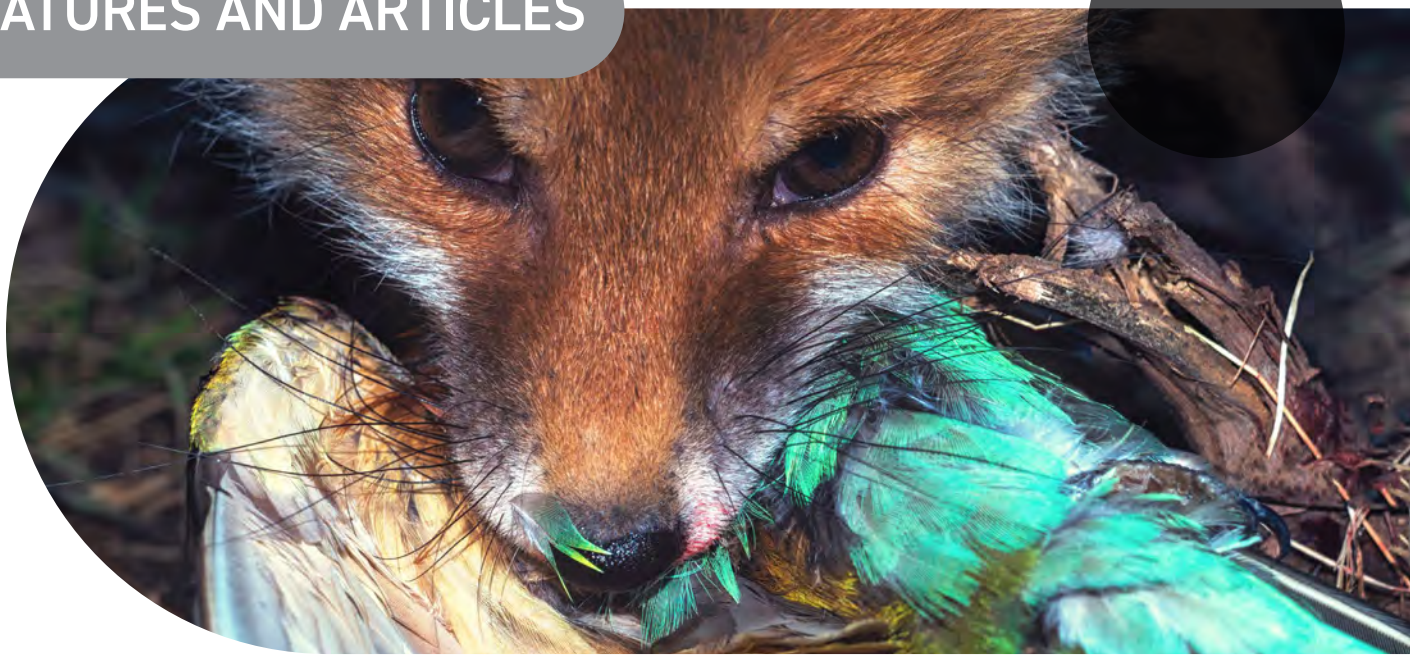
Direct Air Capture (DAC), a negative emission technology for direct extraction of CO_2 from ambient air, has garnered interest for its potential in helping nations achieve their long-term climate targets set under the 2015 **Paris Agreement**. However, the regeneration of the adsorbent materials used for DAC is energy-intensive and usually powered by electrical energy or thermal energy provided by natural gas, which in turn greatly increases the CO_2 emissions of the DAC process. Therefore, the application of renewable energy to the adsorbent regeneration process is crucial for DAC. Photothermal conversion, which converts solar to thermal energy, is an efficient method with high energy conversion efficiencies (>60%). If only thermal energy is required for the desorption process of DAC, then the integration of DAC and photothermal system to current measures would be a promising approach to realising negative carbon emissions.



Yongqiang and his colleagues designed a proof-of-concept DAC system for producing high-purity CO_2 from the air based on a synergistic desorption technology without the use of electricity for regeneration. The system was successfully realised by applying water adsorbents to the DAC system for harvesting atmospheric water and regenerating CO_2 adsorbents through purging effects of the desorbed water vapor. Photothermal conversion was also integrated with the DAC system, and the received thermal energy was sufficient for releasing H_2O and CO_2 from the adsorbents, even when the solar intensity was moderate.

TRANSACTIONS

FEATURES AND ARTICLES



Tackling Invasive Species

By Dr Catriona Nguyen-Robertson

*This article follows a **one-day symposium on next-generation biocontrol of invasive vertebrate pests**.*

Australia is home to many plants and animals that have been introduced since Europeans arrived. Some have become invasive, multiplying and spreading through the environment rapidly to the point that they are destructive. They threaten the persistence of threatened native species and are a burden on our health, economy, and society.

Many introduced species have become so established in Australia that it is now considered almost impossible to eradicate them. In fact, we are sometimes oblivious to the pets we love to care for or the garden plants we tenderly water can be catastrophically dangerous to Australia's unique biodiversity if allowed to propagate in the wild. (Editor's note – disturbingly, many people don't seem to know what is – and is not – a native animal, much less the damage that pest exotic species are causing to Australia's landscapes and ecosystems. Consider the pervasive imagery of deer and reindeer in our homes and workplaces, particularly as we approach the Christmas season.)

When walking through parks and other grassy areas in Melbourne with friends, I have heard them exclaim "what a cute bunny" when one hops across our path. However, I am never as excited; the European rabbit is the **top pest** impacting Australia's threatened plants and animals. Reading about why rabbits were brought over, it is not such a surprising story: 13 rabbits were brought to Australia for hunting on one estate – from which they quickly proliferated across the landscape. It became the fastest known invasion by a mammal anywhere in the world. I also see many cats out and about in my neighbourhood, knowing that each roaming pet cat kills **110 native animals** per year on average.

As someone who has always lived in the city, I have always known that invasive species were a massive problem, however, I was unaware of the immense scale of the problem.

How big is the problem of invasive species? In the words of Deakin University Professor of Wildlife Ecology and Conservation, Euan Ritchie, 'the short answer is: it's massive'. Invasive species are one of the biggest environmental problems facing Australia and are the number one cause of native animal extinctions.

Invasive species are not merely an environmental problem. They also cause immense economic and cultural damage. Since the 1960s, Australia has variously spent and incurred losses amounting to $390 billion due to invasive species. The problem only continues to grow, compounded by the impacts of land development, climate change and other human-driven impacts on native plants and animals, and we now face the challenge of containing the damage. Thankfully, there are many researchers and organisations who are working towards solutions.

WHAT ARE INVASIVE SPECIES?

When we hear the term 'invasive species', we may think of rabbits and cane toads. Perhaps feral cats and foxes also come to mind. While cats and foxes alone kill over **2.6 billion native animals** each year, the problem is much greater than these well-known offenders - although, for the purposes of this article, only invasive vertebrates are discussed.

Feral animals steal the burrows of native animals, prey on native animals and degrade land and water through overgrazing in competition with livestock and native herbivores. They are a detriment to landscapes and agriculture. Farmer and industry representative Gerald Leach outlined how feral animals impact his land and livestock. Farmers deal with a long list of invasive species, investing money, time and effort to prevent feral animals from destroying soils, crops and livestock. Accompanying this economic impact is the great mental health cost for farmers like Gerald who see their stock repeatedly attacked, their landscapes damaged, and livelihoods destroyed.

Another issue is the ever-increasing damage of invasive species to Indigenous people's connection to Country. The Yugul Mangi Rangers in Southeast Arnhem Land are struggling to control feral animals, the worst offenders being pigs and cane toads. Pigs disturb freshwater wetlands and dig up edible plants, and cane toads kill small native animals like goanna and quolls that were also once food. These bush foods have now become rare, along with the traditional practice of harvesting them.

Mr Gerald Leach, Chair of the Environment, Planning & Climate Change Committee for the Victorian Farmers Federation, presenting to the Royal Society of Victoria on the "On Farm Costs of Invasives."

Arrernte woman Chelsea Cooke of Warreen Beek Trainee Rangers Program and Trust for Nature.

Elsewhere in the Northern Territory – in fact, covering 40% of it – feral camels eat native plants and destroy important Aboriginal cultural sites. The Ghan Railway was built with the help of camels, who travelled 200-300 km per day and lasted days without water. But then the camels were set loose once construction was complete. Trust for Nature Conservation Officer and Arrernte woman Chelsea Cooke, spoke about how heartbreaking it was to see cultural sites and waterholes decimated by the growing population of feral camels – particularly as her cultural heritage is also drawn from the Afghani cameleers who have traditionally nurtured this introduced species.

Most of the environmental impacts on threatened species in Australia are caused by 267 invasive species, of which 230 are non-native to Australia. Native species can also become pests when they are introduced to regions and habitats where they are not endemic, or lack natural predators to control numbers. Invasive vertebrate species alone have widespread impacts on ecosystems, agriculture, and cultural activities throughout Australia.

WHAT CAN WE DO ABOUT INVASIVE SPECIES?

While it would be desirable to completely rid the Australian continent of the worst offenders, it is simply not feasible in most cases. Complex interactions between native and invasive species can complicate decisions and actions around control. For example, in many areas, feral rabbits are a major food source for foxes and feral cats; reducing the number of rabbits may therefore mean that foxes and cats turn to native animals instead, while reducing the predators means less pressure on the rabbits. It is also difficult to ensure that an invasive species cannot easily re-invade.

Mr Andreas Glanznig presenting an overview of national collaborative vertebrate pest biocontrol measures.

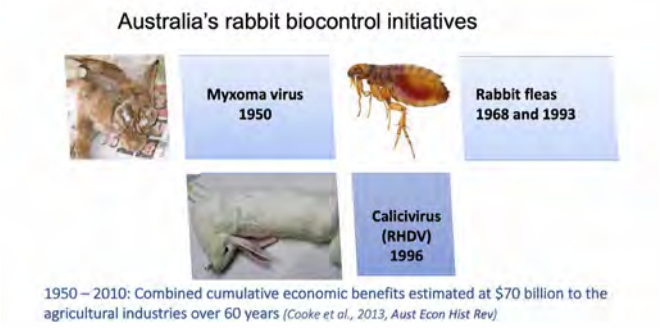
Mr Andreas Glanznig, CEO for the Centre for Invasive Species Solutions, advocates for innovation pipelines: putting in place the capacity to deal with invasive species through biocontrol strategies over 20 years or longer. Short-term solutions simply will not work as an invasive population will often bounce back quickly, wasting time, effort and resources.

Gerald Leach (Victorian Farmers Federation), **Chelsea Cooke** (Warreen Beek Trainee Rangers Program), **Professor Euan Ritchie** (Deakin University), **Shalan Scholfield** (Department of Agriculture, Fisheries & Forestry), **Andrew Cox** (Invasive Species Council), and **A/ Professor Anthony Boxshall** (Science Into Action).

Invasive species management therefore focuses on minimising their impacts as cost effectively as possible. Given community concerns for animal welfare, pest control programs must also be humane and have minimal impact on non-target species. To this end, there is great promise in the development of new and emerging biological control strategies.

Biocontrol measures are never a silver bullet, as they are not guaranteed to be effective for every single animal. It is therefore imperative to have multiple bullets.

RABBITS



For decades, CSIRO has been leading an ongoing battle to ease the enormous detrimental economic, environmental, and social impacts of rabbits. In 1950, CSIRO released the world's first vertebrate pest biocontrol, myxoma virus, killing 99.8% of infected rabbits. But as we often see with evolution, rabbits became resistant. In 1996, rabbit haemorrhagic disease virus was released in Australia, reducing rabbit numbers to very low levels. Nearly 20 years later, an additional strain was identified that further curtailed wild rabbit populations.

Dr Tanja Strive (CSIRO), Dr Ellen Cottingham (University of Melbourne), Dr Andreas Galnznig (Centre for Invasive Species Solutions), and Dr Agus Sunarto (CSIRO).

Dr Tanja Strive: 'If you have a dollar to spend [on pest control], spend it on rabbits.'

Dr Tanja Strive is the Principal Research Scientist for CSIRO Health & Biosecurity, working hard to boost viruses that already exist and identify new pathogens that could be used to keep rabbit numbers down. She also looks to novel genetic approaches to maximise the outcome of rabbit biocontrol operations.

CATS

Many of us love our cats, and therefore do not necessarily want to consider biocontrol measures to manage them. However, feral cats kill 75 million native animals every night, and we urgently need an intervention.

Dr Ellen Cottingham, Postdoctoral Research Fellow with the University of Melbourne.

Dr Ellen Cottingham at the University of Melbourne has developed an innovative approach: immunocontraception, using a cat's own immune system to induce a contraceptive effect. This does not lead to the death of animals; rather, it prevents an excessive number from being born in the first place. Immunocontraception has previously been used to curb African elephant overpopulation without any behavioural side effects. Now Ellen wants to develop this technology for feral cats.

The technology starts off similarly to vaccination: select a target gene involved in reproduction, then deliver the gene within a viral vector to "vaccinate" the cats. Their cells will then produce the reproductive protein, but now in the context of a viral infection – it will appear as an invader to the immune system. Cats will then raise an immune cell army to target the reproductive protein to wipe it out, reducing their own fertility. This approach will be specific for feral cats, as pets should already be vaccinated against the virus used as a vector (feline herpesvirus); and as Ellen points out, we should be sterilising our pet cats anyway. By using cats' own immune systems to reduce their fertility, this could ensure that the feral population does not continue to grow uncontrollably.

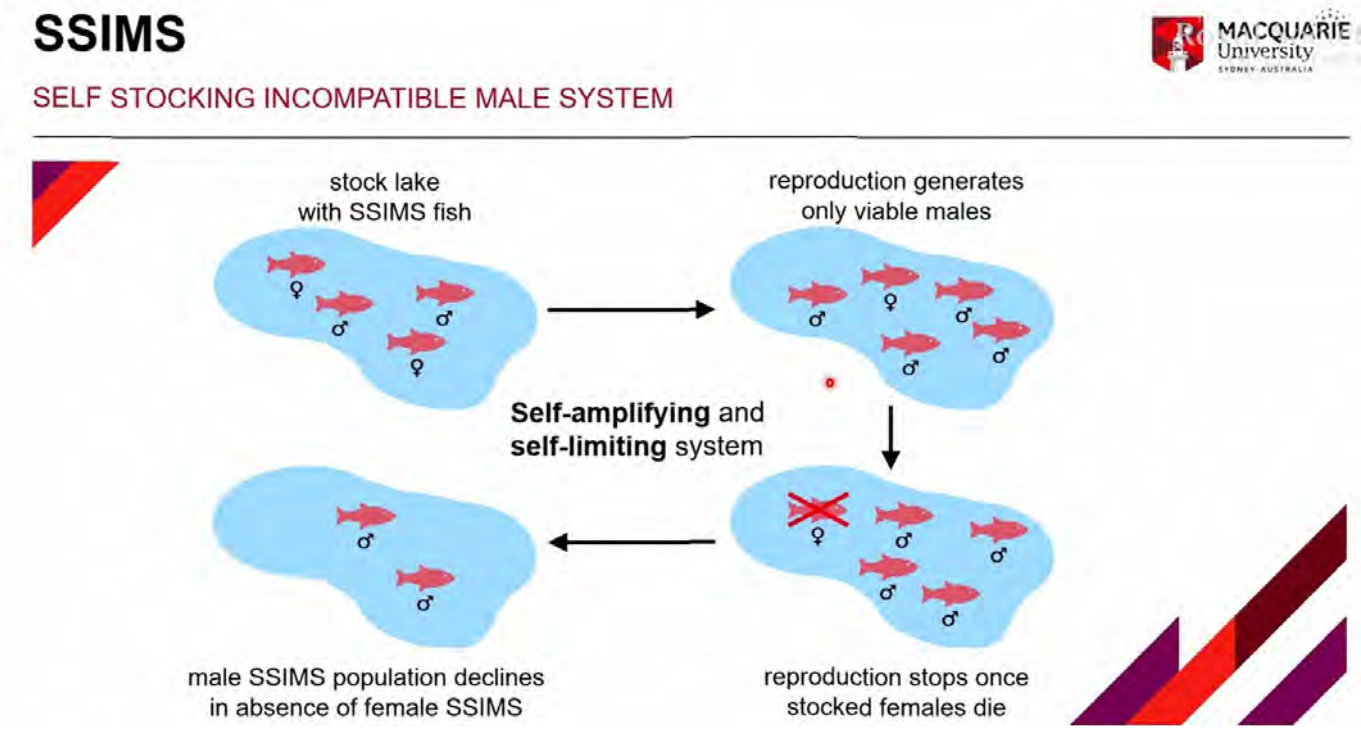
FISH

Dr Agus Sunarto, Molecular Virologist with CSIRO Health & Biosecurity.

Swimming in our waterways, pest fish such as the European carp and tilapia outcompete native fish for habitat and food. Their feeding and nesting habits can also directly degrade water quality. While the use of a virus to curb pest rabbits is familiar to many, perhaps less familiar is the application of biocontrol to fish. Dr Agus Sunarto is investigating the possibility of using the tilapia lake virus, which kills tilapia quickly without impact any native fish. He is ensuring that researchers have approaches in place to test the safety and efficacy of the tilapia lake virus – and any other biocontrol agent.

Dr Chandran Pfiztner (Macquarie University), Professor Paul Thomas (University of Adelaide), Dr Stephen Frankenberg (University of Melbourne), and A/Professor Anthony Boxshall (Science Into Action).

Top: **Professor Ben Phillips** (University of Melbourne) and **Professor Dan Tompkins** (Predator Free 2050). Bottom: **James Trezise** (Invasive Species Council) **Dr Aysegul Birand** (University of Adelaide), **Rita Hawkes** (RSPCA), and **A/Professor Anthony Boxshall** (Science Into Action).



Taking a different approach, Postdoctoral Fellow Dr Chandran Pfiztner from Macquarie University is genetically engineering fish. Genetically modified male and female "stock fish" are engineered to only generate male offspring. Furthermore, when they mate with pest fish in the wild, their offspring will be completely unviable. By ensuring that reproduction of carp in a stock results only in viable males and no females, the population will eventually crash as they can no longer reproduce without both sexes.

Molecular biologist Professor Paul Thomas is the Director of the South Australian Genome Editing Facility at the University of Adelaide. As a biomedical researcher, he has been working with mouse models to address human disease for the past quarter century, and has found the technology can be transferred to address rodent pest control through biotechnology interventions.

GENE DRIVES

Gene drive applications are being increasingly considered in biocontrol. They can provide significant positive benefits, especially where alternative methods are ineffective, damaging to the environment and/or costly. With normal genetic inheritance, the chance that a version of a gene will be passed on from parent to offspring is 50-50. Gene drives, which are self-propagating genetic elements, boost these odds and are preferentially passed on. If the genetic element happens to be a mutated version of a reproductive gene to decrease fertility, it will be spread rapidly through a population.

Researchers are investigating the use of gene drives to tackle rodents, cane toads, carp, foxes, and rabbits. However, given that the field is still somewhat in its infancy, other researchers, such as Dr Stephen Frankenberg, need to ensure that we will have total control. For example, using a genetic modification in two separate genes, rather than one, could help prevent the spread of the gene drive to non-target animals – similar to two-factor authentication on our phones when we sign into accounts on our computers.

As gene drives are in an early stage of development, the discussion around their possible consequences and risks are still largely speculative. When considering implementing gene drives, it is important to model the process to reduce uncertainties. Professor Paul Thomas has modelled a gene drive that makes alterations to a female fertility gene in mice to render them infertile. His team used modelling to determine that a release of 256 mice with the gene drive into a population of 200,000 on an island would eradicate the population in about 25 years. This is welcome news to farmers like Gerald, who hope for a curbing of invasive mice numbers.

WHAT ARE BARRIERS TO SEEING THESE IMPLEMENTED?

As with any area of research, funding is a large barrier. Scientists can only research and develop solutions to tackle these problems so long as they have the funds to do so. But once we get there, for any research breakthroughs, concepts, and applications, we must consider underpinning knowledge & socio-political contexts. As Professor Dan Tompkins points out, even if we develop a great way to tackle invasive pests, it will not get off the ground if there is public resistance.

James Trezise presenting on "Building social licence for pest animal control."

Mr James Trezise works with the messy and highly contested space of public opinion concerning invasive species every day as the Conservation Director of the Invasive Species Council. The cane toad continues to loom large in our minds almost ninety years following its disastrous introduction to the Australian continent, meaning a strong legacy of further, successful biological controls of pests have not succeeded in shifting public perceptions on the trustworthiness of science-backed interventions.

James emphasises that the concept of "social license" does not mean political power, nor the ability to affect change. Essentially our main barrier to popular support for intervention with invasive species is a lack of understanding about the scale and urgency of the threat to our environment, and assessing who is simply waiting for clarity before offering support or opposition.

James tells us the most trusted messengers in Australian society are members of the scientific community. Communication is therefore so important. People have power. One of the best ways to reduce invasive species in Australia is through education and awareness. As mentioned previously, many people are unaware that certain species are in fact pests. Invasive species is a poorly understood issue, yet Australians do care about wildlife extinction. Without effective communication, we won't see change.

You can view all three sessions of the Next-Generation Biocontrol of Invasive Vertebrate Pests symposium on the Society's YouTube channel: each tackles 'The Problem,' 'The Technologies' and 'The Caveats' in succession. The playlist is available from **https://bit.ly/next-gen-biocontrol**.

Protecting Your Health From Severe Hot Weather

by Dr Jane Canestra, MBBS, MPH, FACEM, MRSV

Jane is a retired emergency physician with expertise in public health and emergency management. This article is based on a series of talks she gave to local government, emergency services, and hospital and health professionals over a number of years as part of the Department of Health Summer Preparedness series.

Heat is a major killer. Over 70,000 excess deaths occurred in Europe in the 2003 heatwave[1]. This year, more than 2,800 excess deaths of people aged 65 and over occurred in England during the long summer heatwave[2]. In 2009, 374 excess deaths were recorded in Victoria from a briefer heatwave[3]. More heatwaves, more intense, and of longer duration, are expected as the planet warms.

Here is an explanation of how our bodies respond to extreme heat, why we become ill, and how we can protect ourselves.

ACHIEVING BALANCE

Like a high-performance vehicle, the human body is very finely calibrated for peak efficiency. The brain regulates body temperature, keeping it within a very narrow range for optimum functioning.

A balance must be struck between heat generating activities (such as exercise, metabolism, and hot food and drink ingested), heat loss (through sharing heat through closeness or touch, breathing, sweating, and other excretions) and the environment.

When the air around us is a comfortable 21°C, 70% of body heat is lost through radiation (think of your body as a radiator), 27% through evaporation of sweat (even though we are not aware of perspiring), and a little through breathing, urine and faeces. As the air temperature increases, we are less able to shed heat to the environment through radiation, and sweating increases as a proportion of heat loss from the body.

In a hot environment, the skin is flushed as the brain redirects blood flow to maximise heat loss via radiation. Sweating increases to maximise the effectiveness of evaporation, although dripping sweat is not very effective at cooling the body as it has little chance to evaporate. We also breathe faster. Dogs don't sweat - it's why they pant in hot weather.

On the other side of the balance, appetite is reduced, minimising the desire for hot foods. Apathy and inertia are the brain's signals to avoid heat generation from undue exertion in hot weather.

The change in blood flow to the skin can increase its share of the output of the heart from almost 0% to around 30%, which is better tolerated in fit, healthy bodies. Heat is conducted from the skin to the air trapped against the skin by clothing, then to the inner and finally outer aspects of the clothes to the exterior. As the rate of air exchange is affected by the thickness and texture of fabrics worn, wearing loose light clothing is an important adaptation to hot weather.

Unfortunately, fat is an excellent insulator, reducing heat loss via the skin by up to two thirds compared to other types of tissue.

When the air temperature is greater than the temperature of the skin surface, (which typically ranges from 29 to 35°C, depending on the body part) the only means by which the body can lose heat is through evaporation of sweat. At rest in lower air temperatures, around 50 mL of sweat evaporates from skin every hour. We are not aware of this *insensible* sweating. If we are fully adapted to hot conditions or acclimatised, it is possible to sweat as much as 1.6 L per hour - up to a maximum of 15 L per day! High humidity reduces the rate of evaporation of sweat, and therefore its effectiveness in cooling the body.

The rate of heat loss by convection, typically through movement of air away from the body, is increased by the presence of breezes or fans. A breeze shifts warmer air away from the skin, replacing it with cooler air. This is less effective when the air temperature is greater than the temperature of the skin, and may even be uncomfortable. Fortunately, water is even more effective than air in conveying heat away from the body. Hence, the relief we feel when we take a cool shower, or bathe in a pool or the sea.

Exercise can increase the body's heat production up to 10-fold. This creates competing demands on the circulation, and particularly the heart. Blood flow to exercising muscles is several times greater than blood flow to the skin. Additionally, there is considerable loss of fluids and electrolytes through increased sweating.

Heat that is not shed continues to raise the body's core temperature until heat losses match the heat generated from exercise and the environment. If balance cannot be restored, illness will result.

ACCLIMATISATION

Acclimatisation increases our tolerance for hot weather by adapting our ability to maintain the balance of our body's heat exchange. It occurs following around 2 hours of exercise per day in hot weather for 1 to 6 weeks. The body adapts by doubling the maximal rate of sweat loss, reducing the salt content in the sweat by up to 10-fold, and the kidneys work to retain sodium which helps retain fluids and minimise dehydration.

Acclimatisation occurs more rapidly if you are fit. However, the benefits of acclimatisation are undone by:

- sleep deprivation
- excess alcohol
- dehydration
- salt depletion, and
- infection

DEHYDRATION

Exercise in a warm to hot environment often leads to dehydration of 2% to 6 %, and fluid intake is frequently inadequate to replace these losses. Thirst is not sensed by the body until we are more than 2% dehydrated. Even drinking as much as you feel like mostly does not match fluid losses. More than 2% dehydration leads to impaired thinking, increased risk of injury, and increased susceptibility to heat-related illness. More than 3% dehydration causes greater stress on bodily systems.

The consequences of dehydration are complex:

- reduced blood volume reduces the amount of fluid available for sweating,
- lowered blood pressure reduces the blood flow to vital organs,
- increased heart rate, which may not be tolerated by those who are older, or with pre-existing heart disease, or on certain medications,
- increased blood viscosity (thick and sticky) and likelihood of blood clots, increasing the probability of heart attacks and strokes,
- as the kidneys work to retain fluid, the urine becomes more concentrated, with increased risk of kidney stones.

HEAT-RELATED ILLNESS

Even with maximal sweating, the body's capacity to lose heat may be overcome, causing a rise in core temperature. Excessive heating of the brain reduces its ability to regulate body heat and causes sweating to decrease. A set of overlapping conditions are possible. In escalating severity, these are: heat cramps, heat exhaustion, and heat stroke.

Heat cramps are associated with strenuous exercise. Loss of sodium in sweat may lower the sodium level in blood, interfering with muscle relaxation. Lactic acid build-up from the exercise, can result in hyperventilation, aggravating the cramps. The cramps usually settle with rest and electrolyte replacement.

Heat exhaustion results from dehydration and electrolyte loss due to sweating, and inadequate replacement. As a result, there may be fatigue, light-headedness, nausea, vomiting, severe headache, low blood pressure and increased heart and breathing rate. Core body temperature is not raised or minimally raised, and sweating is usually profuse. Fluid replacement is an important part of treatment.

Heat stroke occurs when the core temperature is raised. This is associated with severe symptoms:

- loss of consciousness
- irritability, confusion, bizarre behaviour

- fitting, signs of stroke
- widespread organ damage

Heat stroke victims may no longer be actively sweating, and may appear paradoxically pale. Death occurs in up to 80% of affected people: this is a medical emergency. First aid measures include removing the victim from the heat, removing excess clothing, sponging and fanning, and, if available, applying ice packs to the armpits and groin.

Other heat-related illnesses include:

- impaired judgement and problem-solving, and confusion
- impaired heart function
- kidney stones
- aggravation of asthma and other respiratory disease by increased pollution from temperature inversions associated with protracted hot weather, and associated bushfire smoke
- falls
- gastroenteritis (generally due to food spoiling more quickly outside of refrigeration)

The rates of severe illness increase with each passing day of heatwaves, reflected in increased ambulance callouts, hospital attendances and deaths. Deaths are rarely due to heat stroke. In studies of large heatwave events, numerous deaths occur and mortality increases in the following disease categories:

- cardiovascular disease,
- asthma and respiratory disease,
- kidney disease,
- diabetes,
- neurological disease, and
- cancer.

PREDISPOSITION TO HEAT-RELATED ILLNESS

There are numerous conditions that predispose someone to a heat-related illness:

- being very young or very old
- disregarding public health messages about avoiding strenuous exercise in extreme heat
- lack of acclimatisation
- lack of aerobic fitness
- impaired ability to sweat due to
  - dehydration
  - skin disorders, especially sunburn and prickly heat, but any extensive dermatological condition
  - congenital conditions, including cystic fibrosis
  - neurological conditions
  - pre-existing heart disease
- certain medications
- infections
- obesity
- immobility
- heavy alcohol use.

AVOIDING HEAT-RELATED ILLNESS

Long-term strategies to minimise the risk of heat-related illness include improving home insulation, ventilation and shading. It is very important to keep direct sunlight off windows to reduce the impact of the sun's radiant energy entering your home, through plantings or exterior coverings, even low-tech solutions like shade cloth strung outside your window.

Aspirational strategies include losing weight, getting fit and acclimatising. Remember, acclimatisation takes weeks, so start slowly in moderately hot weather. It may help with the first two recommendations! Also talk to your doctor about severe heat and your health and medications for advice specific to you.

During extreme heat, try to ensure you are fully hydrated, but minimise your alcohol intake! Salt supplements are generally unnecessary, as the average Australian diet has excessive amounts of salt. Wear loose, light clothing and stay in cool, shaded, well-ventilated spaces. Avoid unnecessary outdoor exercise, sunburn and prickly heat. And get some relief with cool sponging or bathing. Look after yourself!

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What Can Brain Cells on a Microchip Tell Us About Intelligence?

Dr Brett J. Kagan, Cortical Labs

WHAT IS INTELLIGENCE?

How can we create an intelligent system?

The former question has remained contentious since it was first posed, with disagreements even as to the definition of the original Latin, *intelligentia*[1, 2], while the latter has inspired countless science fiction stories. Despite fragmented semantic use and fantastical fiction, exciting advancements in STEM offer pathways to empirically investigate – and perhaps one day answer – both questions.

While substantial research has been devoted to the development of artificial intelligence through silicon computing hardware[3, 4], other work has focused on new hardware approaches such as "**neuromorphic engineering**" – using electrical circuits to mimic the way our nerves function[5].

Whether "intelligence" can be created within hardware is a fascinating question, and is one that remains unanswered despite significant efforts. In contrast, biological intelligence from a neural source offers a "ground truth" of opportunity: from flies, to cats, to humans, all animals display a degree of generalised intelligence. As such, the question becomes not 'if' general intelligence can arise from something artificial, but 'how'.

Our recent work[6] offers one approach for how biological intelligence could be synthesised, which we have termed Synthetic Biological Intelligence (SBI).

A SHARED LANGUAGE OF SILICON AND BIOLOGY

Neuronal networks use an electrical signal to transfer information from one cell to another. This allows us to use electrical impulses as a 'shared language' to bridge the gap between traditional computing hardware and neurons cultured in a Petri dish.

Multielectrode arrays (MEA) have been used since the 1990s as a way to both measure electrical activity from neural cells, or to deliver an electrical signal to neural cells on a microchip[7].

Using this setup, neural networks can be observed both without stimulation, or in response to it, in what is known as an 'open loop' system. In this set up, the cells respond to the stimulation, but the activity does not impact future incoming information.

A system where we could 'close the loop' and have the activity from the cells *impact* an environment leads us to the question: can we 'teach' these networks to act in a certain way? Can we 'teach' them to anticipate a stimulus that hasn't arrived yet, or to produce a new, modified response? This would allow us to build a bridge between the electrical activity in neural systems and that used in computing systems.

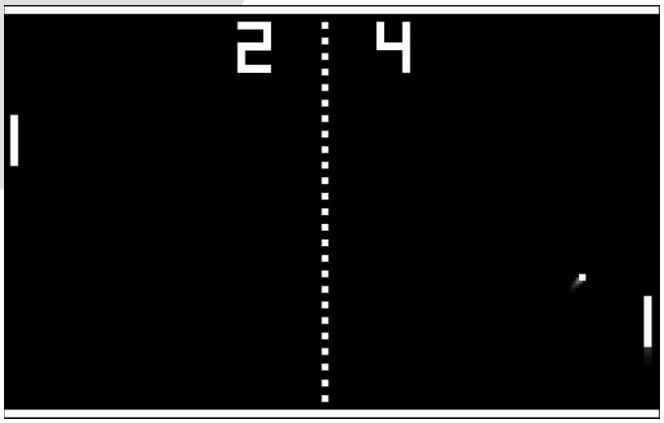

Figure 1: One of the first video games created, 'Pong' is a 2-dimensional table tennis simulator

In our recent work[6], we implemented a real-time closed-loop system to simulate a simplified version of the classic arcade game, 'Pong' (**Figure 1**).

To do this, we delivered electrical stimulation into cultures of neural cells. Our setup 'told' the neural cells the x and y positions of the ball relative to the paddle, using the 'location of the stimulation' and the 'rate of stimulation'. In response to this stimulation, the cells produced electrical activity, which was 'read' by the detector and used to move the paddle.

When the paddle missed the ball, the game would reset, with the ball reappearing at a random point. For the neural cells, this meant that missing the ball required greater energy usage to respond to this new, unpredictable location.

This setup allowed the outgoing activity to change incoming information dynamically, i.e., it was able to move the virtual paddle. In this instance, the neuronal cells on a synthetic chip appeared to have become goal-directed– a step closer to intelligence.

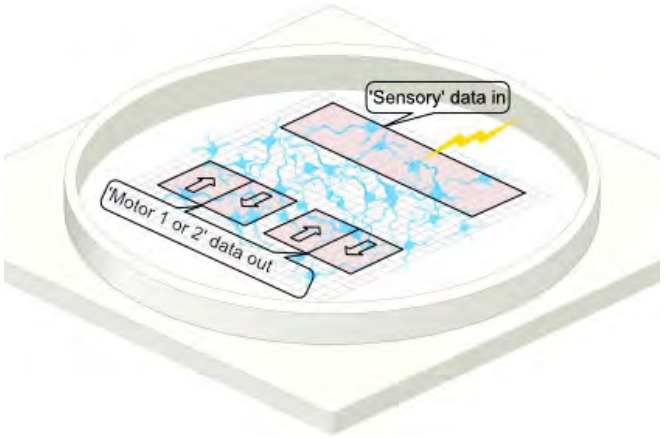

Figure 2: Schematic of a DishBrain input/output configuration on a high-density multielectrode array with neurons

GUIDING PRINCIPLES OF BIOLOGICAL INTELLIGENCE

Building a bridge between electrical signals and neuronal activity alone is not sufficient. We still need to figure out how to motivate neurons in a dish to act in any specific way, especially to achieve a goal or show an 'intelligent' response. While we, or other animals, often are predisposed to act in a particular way or do one activity over another, for cells in a dish, there is nothing obvious to act as a guide. Neural cultures in a dish are unlikely to have naturally occurring reward pathways present in animals or humans, like the hit of dopamine we get from pleasurable experiences. Even if they do, there is no special way to "reward" or "punish" these cells in real-time (as is done with machine learning algorithms) with any degree of reproducible control.

Instead, we first need to identify how intelligence arises at the most basic level, by looking at a theory called the '**Free Energy Principle**'. Simply put, this theory suggests that all living systems which interact with external environments, from cells to humans, are trying to do something called 'free energy minimisation' - trying to reduce uncertainty or minimise surprising information from the environment. When we receive visual (sensory) information, we can make an internal model of our environment in our brain, e.g., of a glass of water on a table. By reaching over to pick up this glass of water, we can test whether this 'internal model' matches the external world. If it does, we'll be able to pick up the glass. If the models do not match, we might unintentionally and unexpectedly knock the glass over (see **Figure 3**).

It makes sense that prediction is important; it would be impossible to survive in a changing world without it. Improving this prediction can be done in two ways, either by predicting the environment better, or by making the environment more predictable.

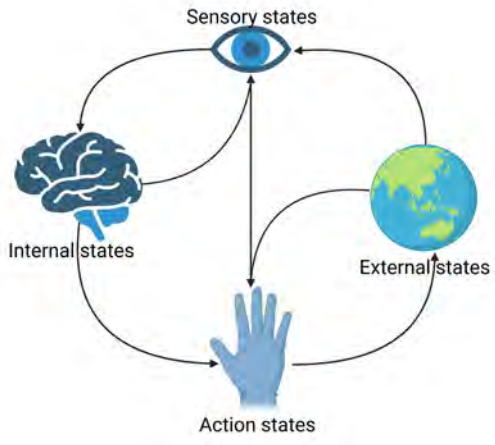

Figure 3: Schematic showing probabilistic dependencies between various states described in the Free Energy Principle

While the neurons in a dish used in our work are far too simple a system to do anything as complex as thinking about a glass of water, under the Free Energy Principle they should still try to minimise uncertainty or surprise from environmental information (via electrical stimulation).

For our game of Pong, we provided a random feedback stimulation (a 'negative' response) in response to any activity that resulted in the ball being missed, and a predictable stimulation (a 'positive' response) following the paddle hitting the ball. The result was that the neural cells appeared to self-organise their activity and got better at playing the game, supporting this as at least one driver behind intelligent behaviour.

APPLICATIONS AND OPPORTUNITIES: BASIC SCIENCE

Intelligence is a fascinating concept, especially in the context of that generated by a human brain. This is best summarised in the now famous quote by Pugh (circa 1983):

> **"If the human brain were so simple**
> **That we could understand it,**
> **We would be so simple**
> **That we couldn't."**

What we are hoping for is that SBI can offer the research community a simple model to help us understand intelligence. Of course, trying to understand how intelligence arises using animals or humans is very difficult as both have multiple layers of compensatory mechanisms; trying to disrupt or isolate one mechanism alone is almost impossible. Yet using SBI offers a simplified approach. For example, we recently identified interesting changes in the patterns of electrical activity in neural cells when they were presented with different types of information in response to an action[6]. While we previously explored the Free Energy Principle in our recent work[6], this is just one idea for why biological intelligence acts as it does. Other imperatives apart from free energy minimisation also likely exist and other ways that information can be organised in neural systems[8].

APPLICATIONS AND OPPORTUNITIES: TRANSLATIONAL RESEARCH

SBI may also prove useful in researching how we can understand or treat illnesses, through preclinical drug discovery and cell-based disease modelling.

Neural systems like the brain are very challenging to model, as we need to recreate the key functions of this complex organ. The brain's core function is to receive and then process information, before responding in an adaptive way, and current cell models used for drug discovery or disease modelling usually do not provide any structured stimulation to the cells in the form of an electrical interface.

By providing simple neural systems with the chance to process structured information and alter activity in meaningful and measurable ways (like the Pong example), it provides a chance to better understand how a drug or disease may impact more complicated systems such as our brains.

Finally, being able to generate cells from different genetic backgrounds with induced pluripotent stem cell technology also opens the opportunity to explore this in a personalised approach to see how different genetic backgrounds respond. In this way, SBI technology can be very useful in translational research for neurological focuses.

APPLICATIONS AND OPPORTUNITIES: INTO THE FUTURE

While there is a clear need to make sure this research is developed in an ethically responsible way[10], there are reasons to be excited by SBI's potential, particularly when compared to current machine learning (summarised in Figure 4).

Maximising the potential of SBI could provide access to a real-time learning system able to display generalised intelligence and function with relatively low power consumption.

Current machine learning algorithms require enormous data to converge on ideal solutions, yet in contrast biological intelligence is capable of rapid highly sample efficient learning[11]. Likewise, although humans and animals display considerable flexibility in their behaviours yet are able to pursue goal-directed activities despite massive changes in the environment or information quality, machine learning remains highly fragile and prone to failures when even minor changes are introduced[12].

Finally, running machine learning algorithms currently requires considerable power, using potentially millions of watts[13], while biological neural systems can operate in essentially glorified sugar water[14]. Indeed, the power consumption requirements from current machine learning methods are so great as to preclude consumer-wide access to this technology in a personal capacity (without massive changes to either power generation or consumption technologies)[15].

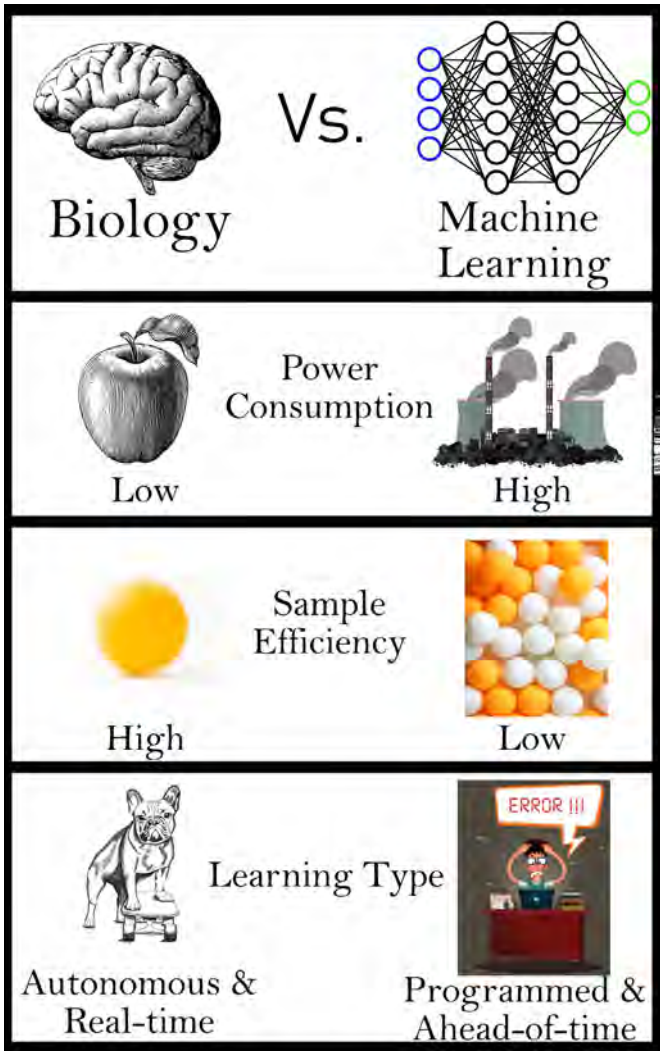

Figure 4: Biology has some key advantages over current machine learning approaches and requires us to just navigate how to leverage it.

If biologically-based intelligence could be leveraged, it may offer the possibility of a thermodynamically sustainable system, accessible at a personal level, that would act in a simple, efficient and adaptive manner. Such intelligence does not need to equal or surpass a human to be immensely valuable.

Harnessing even basic levels of biological intelligence could have numerous compelling applications. Perhaps it may even help answer the questions of: what is intelligence and how can we create a generally intelligent system?

ACKNOWLEDGEMENTS

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FROM THE ARCHIVES

Compiled by Scott Reddiex MRSV

1971

Australia, with a dotted line showing the extent of the continental shelf

Source: Proceedings of the Royal Society of Victoria, Volume 84 (New Series), 1971.

A ~~GOLDEN~~ COLDEN AGE OF AUSTRALIA

"Until recent times man has looked on the mountains and the levels of the seas as permanent, but neither are."

As part of his 1970 Presidential Address, RSV President Edmund D. Gill penned a piece for the *Proceedings on 'The Far-Reaching Effects of Quaternary Sealevel Changes on the Flat Continent of Australia'*. The lengthy article addresses topics such as the relationship between sea levels and glaciers, the underwater extent of the Australian continental shelf, and the impact of changing sea levels on ecology.

Painting a picture of the continent's cold past, Gill writes that, *"During the Last Glacial [period], Australia had a land mass one-third larger than it is at present. At that time it had an extra 2,600,000 km^2. To the north, the Sahul Shelf was dry. There was no Torres Strait or Gulf of Carpentaria; most of the Arafura Sea was dry. New Guinea was an extension of the mainland. Tasmania was a peninsula, and Kangaroo Island a promontory. The Great Barrier Reef area was a coastal plain."*

Gill draws on the stratigraphy and chronology of Melbourne's rivers and coasts to provide specific examples of the sea level related changes over time. In an interesting expansion on this, he discusses the changes to the Yarra River delta through its long history, and the profound impact of Europeans following their arrival in the area:

"The products of sealevel changes existing in the Yarra delta have profoundly affected certain aspects of the development of the city of Melbourne. To appreciate this, we need to look at the delta in its original condition. It was covered with vegetation, chiefly tea-tree (Bunce 1857). N. of the Yarra River and E. of the Maribyrnong River was a large shallow lake called 'Salt Lake' on Russell's original map of Melbourne, but later 'Batman's Swamp' (Selwyn 1868) and 'West Melbourne Swamp'. There were two 'lagoons', one in the area of the present Albert Park Lake, and the other at Port Melbourne where it obviously constituted the remnant of an old river channel. The first boats to sail up the Yarra had difficulty negotiating the sand bar at the mouth and the snags in the stream. They were forced to stop at the level of Market Street because there the Pleistocene basalt formed a bar across the river, making a waterfall about 1 m high. The pool below the bar was Melbourne's first port, but later landings were commonly made on Liardet's Beach (Port Melbourne), whence people walked two miles to the Yarra River which they crossed on a ferry. In time of flood, the Yarra waters flowed in a broad sheet across the flats to Port Melbourne in the vicinity of the lagoon. Further west there were sand ridges, and that is why Port Melbourne was at first called Sandridge. Similar sand ridges existed at Williamstown.

The first bad flood occurred in October 1844. A particularly bad flood in December 1863 poured across South Melbourne to Port Melbourne for several days without interruption (Adams 1865, Rawlinson 1865, Smith 1865, 1874). Flood control was decided upon, and in due time the river was straightened and deepened and the basalt bar across the Yarra removed."

From: Proceedings of the Royal Society of Victoria, Volume 84 (New Series), 1971. Article 20 - The Far-Reaching Effects of Quaternary Sealevel Changes on the Flat Continent of Australia.

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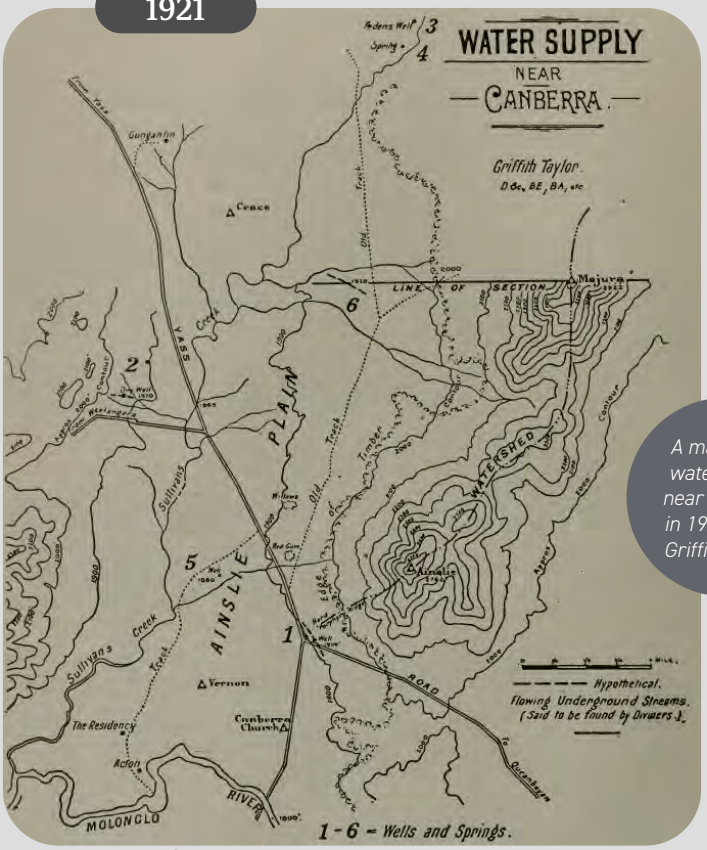
1921



A map of the water supply near Canberra in 1921, by Dr. Griffith Taylor.

Source: Proceedings of the Royal Society of Victoria, Volume 33 (New Series), 1921.

DEBUNKING DIVINATION

"In view of the widespread belief in Australia in the powers of the Water Diviner, the following personal experiences (followed by the authoritative opinions of others) should be of interest to members..."

In a fantastic example of using science to debunk the claims of charlatans, the Proceedings of the Royal Society of Victoria records that on the 8th of July 1920, Dr. Griffith Taylor presented his paper entitled '*A Geologist's Notes on Water-Divining*'.

With approximately 70% of the Australian continent classified as arid or semi-arid, the availability of fresh water has always been a major consideration for its inhabitants. It therefore comes as no surprise that particularly during times of water shortage, some would employ the services of 'water diviners', who claimed the ability to determine the location of underground water using nothing more than a forked branch.

In his paper, Dr. Taylor describes the geology of land near Canberra, the water table, and how the ideal location for the digging of a well can be determined. From here, he investigates six wells established on properties with the 'help' of water diviners, and explains that none of the locations were optimal, as they had been chosen based on nothing more than guesswork.

He concludes his piece by quoting a report made by the American Geological Survey (1917), which states: "*It is difficult to see how for practical purposes the entire matter could be more thoroughly discredited. To all enquiries the U.S. Geological Survey gives the advice not to expend any money for the services of any 'water witch,' or for the use or purchase of any machine or instrument for locating underground water.*"

From: Proceedings of the Royal Society of Victoria, Volume 33 (New Series), 1921. Article V. — A Geologist's Notes on Water-Divining. By Griffith Taylor, D.Sc, BE., BA.

1869

Yan Yean Reservoir, 1859.

Source: State Library of Victoria (Public Domain)

AIR AND WATER POISONING IN MELBOURNE, II: THERE'S SOMETHING IN THE WATER...

"...if active measures are not soon taken to remedy the evil, our water supply, now so pure and sweet, will one day become a poison. When the time comes – it may not be in our day (we shall poison our children, but may escape ourselves) – the evil will be past remedy."

In November and December of 1869, William Sydney Gibbons presented to the Royal Society of Victoria on the subject of Air and Water Poisoning in Melbourne. The series of presentations addressed two matters: 1. the current state and treatment of sewage in Melbourne, and 2. the possible pollution of the Yan Yean Reservoir.

In Part II, Gibbons addressed the state of the water quality of the Yan Yean Reservoir, north-east of Melbourne. Completed in 1857, the construction of the reservoir was a large undertaking and opened with much fanfare. Initially fed by the Plenty River, it provided Melbourne with a clean alternative to the 'Yarra Soup', which was at this point heavily polluted by sewage, drainage, and industrial discharges.

By 1869, there had been cause for inspections of the Yan Yean Reservoir's water quality by the City Health-Officer, who asked Sydney Gibbons and another doctor to accompany him. Gibbons assessed the quality of water samples taken from reservoir in 1858, 1868 and 1869, comparing its organic and inorganic content, and noting an expected decline in the total residue present as sediment had settled in the years since construction.

Importantly, he identifies the greatest risk to the water quality of the Yan Yean Reservoir (and consequently the health of Melburnians):

"I believe the real state of the case to be this: Whittlesea drainage is literally "going" to the Yan Year reservoir. But only literally, it has not gone into it yet, or, if at all, only lately to an unappreciable extent and under the least injurious conditions, as in flood. Happily swamps and flat country with much porous soil intervene. This land is gradually soaking up the filth discharged upon it. When it is saturated it will be a never failing source of water poison, and those who are then living may have to abandon the costly and splendid work whence we now derive that invaluable blessing, a copious supply of good wholesome water."

Warning against paying any heed to advertisements making incorrect and unscientific claims about how to clean the water of the reservoir, Gibbons leaves us with these timeless words:

"There is quite enough to find fault with, and quite enough to guard against, without resorting to sensational fictions."

William Sydney Gibbons was born in London in 1825, and migrated to Melbourne in 1845, where he worked as a tutor, an analytical chemist, and a lecturer at the Mechanics Institution. Gibbons was instrumental in the foundation of the RSV: in 1854, he founded *The Victorian Institute for the Advancement of Science*, which quickly merged with the *Philosophical Society of Victoria* to form the Philosophical Institute of Victoria. In 1859, it received a Royal Charter to finally become the *Royal Society of Victoria.*

From: Transactions and Proceedings of the Royal Society of Victoria, Volume X, 1869-1874, Article LV - Air and Water Poisoning in Melbourne, Part II.

INSPIRING VICTORIA

Inspiring AUSTRALIA Victoria

Science for the People – New Victorian Government Support for the Inspiring Victoria Program

The Victorian Department of Education and Training has confirmed funding of $200K per annum for the Royal Society of Victoria to manage the Inspiring Victoria program from 2023-26.

"The Royal Society of Victoria is a vital organisation that facilitates advancing STEMM literacy to Victorians. I will always advocate for promoting these goals. The Victorian Government is honoured to support such a pursuit from a historical organisation that has a longstanding commitment to making Victoria the best place it can be, both now and in the future."

– Dr Tien Kieu MP, Victoria's STEM Education Ambassador

"Our philosophy is that if we want a young person, particularly from disadvantaged circumstances, to achieve good educational and employment outcomes in the near future, or open broader employment options for young adults against the currents of their cultural and economic context, then we need to foster STEMM literacy in the lives of whole communities."

– Mike Flattley, CEO of the Royal Society of Victoria

The Royal Society of Victoria was delighted to receive confirmation in late September from the Hon **Natalie Hutchins** MP, the State of Victoria's Minister for Education and Minister for Women, of funding support from the Victorian Government for the **Inspiring Victoria** program. This represents our State's contribution to a unique partnership between Commonwealth and State Governments to address the nation's scientific literacy and capacity.

Dr Tien Kieu MP signs into the Royal Society of Victoria's historic membership register in the Cudmore Library. Before entering Parliament, Tien was a researcher in quantum physics, including fundamentals and quantum computing. He is still an adjunct professor at Swinburne University in the area of theoretical physics and a Fellow of the Australian Institute of Physics. Tien was prompted to run for Parliament to contribute to public life and shape policies by using his life experience as a refugee and his strong background in science and mathematics.

Inspiring Victoria is the State of Victoria's delivery of the nation-wide Inspiring Australia program, which draws program funding through the Commonwealth Department of Industry, Science and Resources to engage Australian communities in lifelong learning, citizen science initiatives and school extension programs concerned with attaining literacy in Science, Technology, Engineering, Mathematics and Medicine (STEMM). It includes delivery of one of Australia's longest-running annual community festivals, National Science Week.

The Royal Society of Victoria (RSV) has been delivering the Inspiring Victoria program to communities across rural, regional, and metropolitan Victoria since 2018 as the state-based host institution and has been instrumental in establishing and sustaining the partnership between the State and the Commonwealth.

"Inspiring Victoria does what it says on the tin," says Mike Flattley, the RSV's CEO and manager of the State-based program. "It inspires Victorians to engage with the utility of science to drive beneficial change."

"In the spirit of 'it takes a village,' we deliver the program as a whole of family educational initiative, involving people across the State in new developments in STEMM through a community development modality, focusing on the utility of scientific methods to help all of us confront the challenges facing us today and in the near future, at the local level."

Victoria's Commissioner for Environmental Sustainability, **Dr Gillian Sparkes AM** is the Victorian Government's Chair of the Inspiring Victoria Partnership Board, comprised of senior community engagement representatives from Museums Victoria, Royal Botanic Gardens Victoria, the Parliament of Victoria, the Arthur Rylah Institute for Environmental Research, and the community knowledge networks sustained by Public Libraries Victoria and Neighbourhood Houses Victoria.

RSV President Rob Gell AM emphasises the Royal Society of Victoria's unique value proposition in coordinating the program.

"The RSV is an NGO with a mission to promote and advance science in Victoria, which is perfectly aligned with the aims of the Inspiring Australia Program. We are commercially neutral, so we can freely involve all Victorian research and teaching institutions in our programs without competitive concerns over branding, rankings and student recruitment numbers, and engaging scientists from our public knowledge institutions without worrying about meeting annual goals for visitation rates and ticketing revenues."

"We are most grateful to Dr Tien Kieu for his tireless advocacy for the Inspiring Victoria program as Victoria's STEM Education Ambassador, and to Minister Hutchins for recognising the importance of a program that takes some of the pressure off our schools and teachers in a time of great challenge to our education system. We invite engagement and collaboration with all educators looking for ways to extend and enhance the experience of their students, and mentors who can help our young people navigate an increasingly challenging future with the reassurance of a supportive network of leaders in industry, academia and the community."

You can keep up to date with grant opportunities, upcoming events and science engagement news under the **Inspiring Victoria** program by subscribing to the mailing list hosted on the Royal Society of Victoria's **website**.

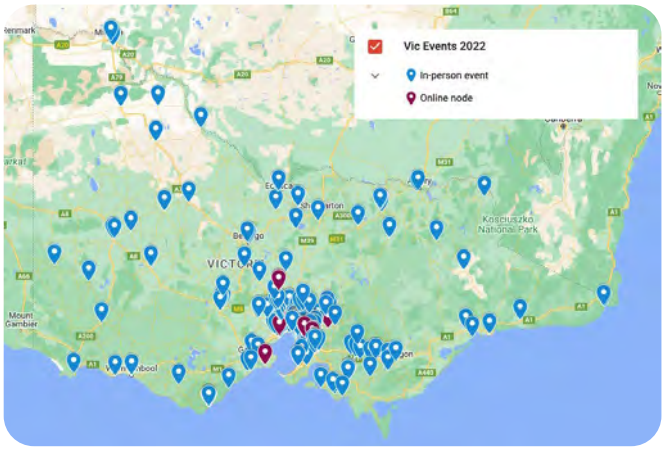
From 2023 to 2026, the Inspiring Victoria program represents a collaboration between the Royal Society of Victoria, the Commonwealth Department of Industry, Science and Resources, and the Victorian Department of Education and Training.

National Science Week 2022 – Report for Victoria

Science from the Shed – Ocean Grove & District's Men's Shed

Victoria's report for National Science Week in 2022 is now available from **https://rsv.org.au/publications/report-publications/**, *detailing this year's wide variety of grant activities, media impacts, demographic data and more.*

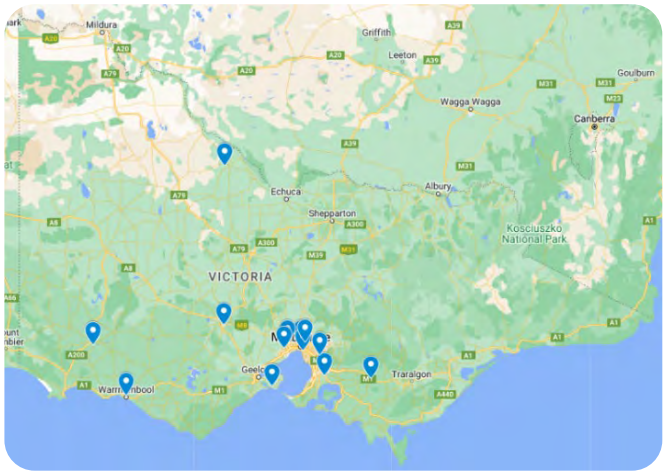
This year there was an excellent distribution of 380 individual events across the State, with our grant programs supporting a range of diverse activities across rural, regional and outer metropolitan areas. You will note a spread of target age groups and a pleasing focus on migrant communities for many projects offering culturally relevant science content.



In particular, the geographical coverage was pleasing, with National Science Week reaching some of the State's most remote communities in Corryong, Mallacoota, Mildura, Edenhope and Portland. With 75% of Victoria's population concentrated in metropolitan Melbourne, this represents excellent engagement from regional and rural communities. Self-reported topic categories were overwhelmingly concerned with "Environment and Nature" across the board.

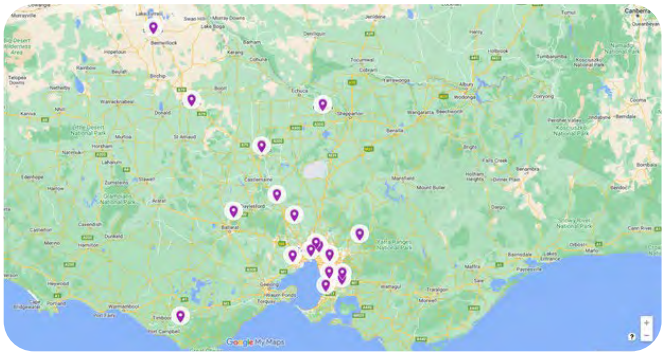
"Lovers of science were on hand to meet the national dark matter and quantum road trip participants like Kristen Harley (University of Queensland) for pub trivia in Bendigo." From the Bendigo Advertiser, covered by Lucy Williams on 18 August 2022. Photo: Noni Hyett

Other categories of science were more vigorously represented via the Major Grants program. The National Dark Matter and Quantum Road Trip was pure gold for delivering National Science Week events to regional and remote communities across five states and Victoria was no exception. En route from Brisbane to Perth via New South Wales, Victoria and South Australia, this ensemble of scientists and science communicators delivered engaging presentations, hands-on activities, pub quizzes and more! This was a wonderful collaboration by an amazing team of dedicated mathematicians and physicists drawn from research institutions located in the states travelled.



Inspiring Victoria's Community Seed Grants program distributed $10,000 in small grants across the State to eleven community organisations as a stimulus measure, largely focused on members of Public Libraries Victoria. All grants are listed below, and the map to the right demonstrates grantee locations.

This year we started mapping grant activities to the Sustainable Development Goals (SDGs) as a component of our relationship with the Commissioner for Environmental Sustainability in Victoria.



The Neighbourhood Houses program was a resounding success, activating a statewide network of Neighbourhood and Community Houses and Centres (NCHCs). 18 NCHCs were funded; 10 were located in Metropolitan Melbourne, 5 in Regional and Rural Victoria, and 3 in remote communities.

26 events totalling 66.25 hours of delivery by 60 volunteers across the State were delivered by NCHCs.

RARE Program

Featuring scientists from Victoria's major public scientific and cultural institutions with a strong broadcast focus for our regional audiences, we revealed the innate value of the unique and unusual in nature and sought your involvement in protecting the RARE.

RARE was a series of live audience and broadcast events presented in collaboration with Museums Victoria, Royal Botanical Gardens Victoria, Zoos Victoria, the Parliament of Victoria, and the Royal Society of Victoria for National Science Week. From scarce species to supernovae to special specimens you can't see anywhere else, Museums Victoria explored all things rare and precious on Earth... and beyond!

Program partners, grantees, stakeholders and families involved in the Inspiring Australia program gathered to celebrate the launch of National Science Week at the Melbourne Planetarium for a specially-curated 'Ticket to the Universe' show by astronomer Dr Tanya Hill.

To wrap up National Science Week on Sunday, 21 August, we gathered our State's leading botanists, zoologists and collection managers who are "caring for the rare" in the face of mounting challenges for a fascinating exploration of conservation science, broadcast from the Parliament of Victoria.

A panel discussion broadcast by the Parliament of Victoria during National Science Week 2022. Joining the Parliament's Bill Bainbridge (centre), from left: John Arnott, Manager of Horticulture at Royal Botanic Gardens Victoria; Dr Megan Hirst, Post-Doctoral Fellow at Royal Botanic Gardens Victoria; Dr Joanna Sumner, Manager of Genetic Resources at Museums Victoria; Dr Marissa Parrott, Reproductive Biologist at Zoos Victoria; and Darren Grover, General Manager of Threatened Species, Zoos Victoria.

For a deeper dive into engagement results and the many wonderful people who made National Science Week happen in Victoria this year, please check out our full report **online**.

Mike Flattley
Manager, Inspiring Victoria
CEO, The Royal Society of Victoria

PROCEEDINGS

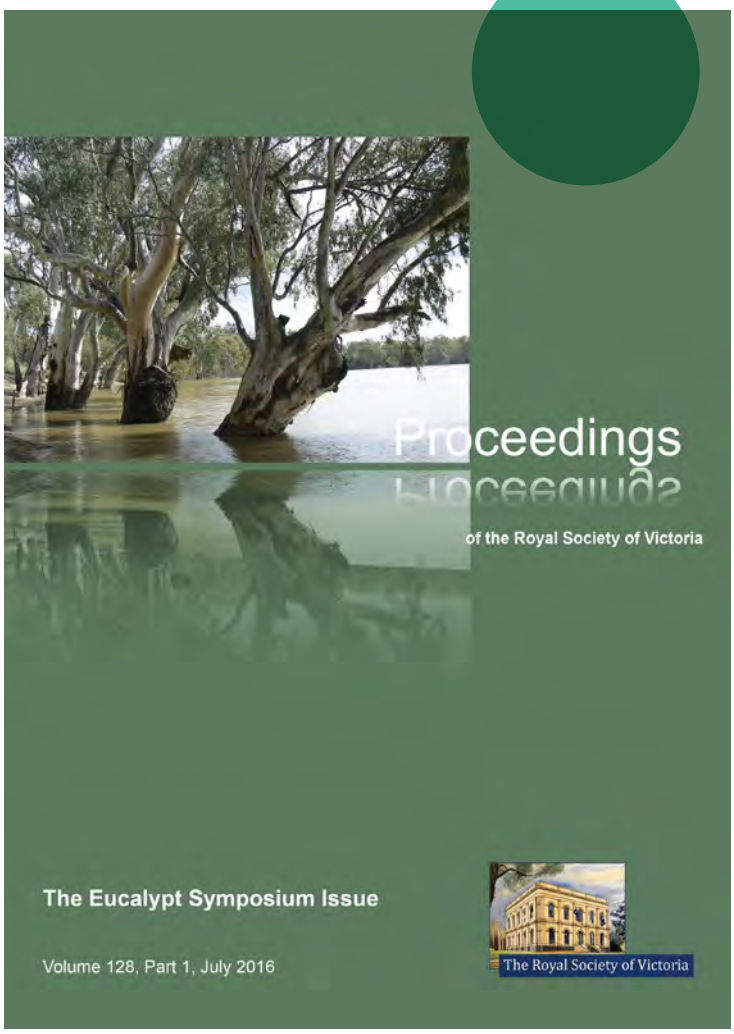
Call for Papers

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 http://www.publish.csiro.au/rs.

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. We are always interested in hearing from authors.

Papers, Reviews and Reports of experimental or descriptive research, submitted for publication by the Royal Society of Victoria, should not have been published hitherto, nor should they be under consideration for publication elsewhere. Published papers are typically concerned with natural history, encompassing the biological and earth sciences, in the Oceania region.

Those interested in submitting papers should review the **Instructions for Authors**. All enquiries and manuscript submissions should be forwarded via email to **editor@rsv.org.au**.



Science Victoria – Guidelines for Authors

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.

If you have any questions regarding suitability of your article for a particular style, or regarding putting your piece together, please contact **editor@ScienceVictoria.org.au**.

STYLE GUIDE

Letters and Columns

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, reviews and summaries of seminars or other scientific events, science-related issues and policies, concerns you'd like to raise with other readers, 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

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?

News Articles

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 the use of jargon or opinions unsupported by a robust evidence base, 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.

Feature Articles

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.

Our target audience comprises members of the general public with an interest in sustaining or extending their engagement with scientific ideas and knowledge, who share a commitment to the application of robust science to solve problems, or who are members of the scientific community outside of your particular field.

Please avoid using jargon, as it will quickly alienate anyone who isn't an expert in your field. Introducing one or two otherwise irreplaceable terms with a short explanation 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). The 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*.

Most of us have read articles or attended presentations that managed to somehow make the most interesting of topics incredibly tedious. This is the litmus test of what you need to avoid!

Opinion Articles

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. Please 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 could be submitted 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, bearing in mind we do not welcome self-promotional "fluff" pieces.

References

References for all articles should follow the Vancouver referencing style, however News Articles and Columns can either use a reference list either at the bottom of each page or grouped at the end of the article – whichever you prefer.

RSV Membership

Become a Member of The Royal Society of Victoria

OUR PURPOSE

The Royal Society of Victoria is the State's oldest scientific society, a part of Australia's intellectual life since 1854.

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

OUR WORK

- Fostering, recognising, and rewarding excellent Victorian scientists across their career trajectory through awards and prizes
- Promoting understanding of science in the community
- Promoting science literacy and education so that people of all ages discover and understand the value of science
- Assisting and lobbying governments on issues relating to science and evidence-based decision making

MEMBERSHIP BENEFITS

- Learn about developments in a wide range of science disciplines through our lecture program and symposia, and how this knowledge can be applied to issues confronting Victoria
- Connect and share knowledge with like-minded people, bringing together expertise and learnings from all backgrounds and fields.
- Collaborate with colleagues to deliver the Society's various programs and projects, using (and developing) your professional skills and experience
- Support the translation of science into action through development of policy and science education initiatives
- Access discounts to RSV events and forums, and car parking in the Melbourne CBD

MEMBERSHIP OPTIONS

Full Membership

Open to all adults (18+) with an interest in science! **$120/year**

Student Membership

For students enrolled full-time at a recognised Victorian education and/or research institution (proof of current, full-time enrolment required for Student Membership commencement/renewal) **$40/year**

Organisational Membership

For organisations to claim membership of the Royal Society of Victoria. Provides a method for general sponsorship of the RSV's programs, along with discounted rates for access to RSV facilities throughout the year. **$1000/year**

Contact us with any questions about membership
Email: **james.mcarthur@rsv.org.au**
Phone: **+61 3 9663 5259**
Or visit us at **8 La Trobe St, Melbourne VIC**

The Royal Society OF VICTORIA
Promoting science since 1854

RSV Services and Facilities

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!

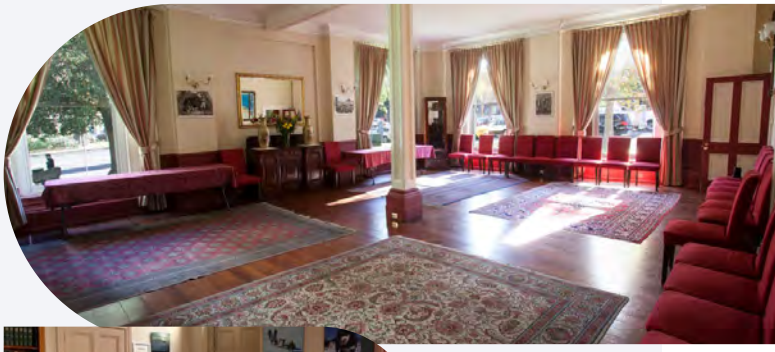
We provide services in **event management**, meeting **venues**, grants and awards **administration**, broadcasting and video **production**, social media c**ampaign management**, **recruitment** of scientific panels, and **convening** community engagement and deliberation processes where scientific work contributes to social, environmental, and economic impacts and benefits.

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

SERVICES AVAILABLE

The Burke and Wills Room
Multi-functional space with adjoining kitchen, suitable for: Workshops ‹*30 people; Dinners ‹60 people; Seminars, functions, catering, etc., ‹80 people.*



The Von Mueller Room
Seminar room for ‹*15 people.*

The Ellery Lecture Theatre
Raked seating for ‹*110 people.*

The Cudmore Library
Capacity for ‹*24 people*

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.

Support Victoria's Science Society

To support our programs with your donation, please fill out this form and return it to the Royal Society of Victoria, 8 La Trobe Street, Melbourne VIC 3000. You can also support our efforts through online donations and bequests at **https://rsv.org.au/support-the-rsv/**

RSV 2020 FUNDRAISING CAMPAIGN AMOUNT	*AMOUNT*
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	$
TOTAL	**$**

Personal Details

Family name: _____

Given names (in full):_____

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Method of payment (select one below):

☐ **Credit Card** WE DO NOT ACCEPT DINERS OR AMERICAN EXPRESS

VISA ☐ **MasterCard** ☐ **PLEASE CHARGE THE AMOUNT ENTERED AGAINST 'TOTAL' DONATIONS ABOVE TO MY CREDIT CARD.**

Card No.: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ **Expiry Date:** ☐☐ / ☐☐☐☐

Name on Card: _____ **Signature of Card Holder:**_____

☐ **Cheque or Money Order**

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

Electronic Funds Transfer (EFT)

I have transferred my donation to the Royal Society of Victoria as follows:

BSB: 083-019
Account No: 51-515-2492
Account Name: The Royal Society of Victoria
Reference: Your Surname and "donation"

The Royal Society of Victoria