

JUNE 2024 — VICTORIA & CLIMATE CHANGE

SCIENCE VICTORIA

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— pg 12

Tap vs. Bottle

Impacts of bottled water
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Climate Change and Economics

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Climate Anxiety

Modelling Climate Change

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Photograph: Roman Samborskyi via Shutterstock

THIS EDITION: VICTORIA AND CLIMATE CHANGE

The impacts of human-driven climate change are increasingly visible. Temperature records are being repeatedly broken, extreme weather events are increasing in frequency, ice sheets are melting, and coastal communities increasingly under threat. In this edition, we focus on climate change in our corner of the planet, and what needs to be done to avoid reaching a point of no return.



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A storm approaches the southern coast of Victoria. Photograph: Myles Greenwood via Shutterstock.

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JULY 2024	DUE DATE
Building Scientific Competency	5pm, 14 June

AUGUST 2024	DUE DATE
STEMM Throughout Victoria	5pm, 19 July

From the Editor

SCOTT REDDIE

Editor-in-Chief — Science Victoria

Like most human activities, climate change is chiefly a conversation about money.

It's brilliantly captured in a piece from 2012 by the cartoonist Tom Toro. It depicts a man in a tattered suit, sitting with three children around a campfire, in a post-apocalyptic landscape. The man says to the children, "Yes, the planet got destroyed. But for a beautiful moment in time we created a lot of value for shareholders."¹

Science has long indicated that the current changes in Earth's climates are the result of specific human activities. As more research is undertaken, we learn more about exactly how the planet is changing, and the consequent impacts on humanity.

Successive generations, governments, and leaders have gambled on things not really being a problem in their lifetime, let alone their term of office. However, climate change's effects are increasingly difficult to ignore.

History has shown us that major polluters will not change their actions unless market and regulatory pressures force them to. Of the fifty wealthiest companies in the world in 2023, 13 are oil and gas companies.² Another eight are in the automotive or electricity provision industries. In other words, there is still a lot of value for shareholders to be had.

The value is not just for shareholders and executives. In the financial year 2022-23 alone, fossil fuel companies donated \$1.78 million to the Labor, Liberal, and National parties.³ Donations typically coincide with election cycles, project approval timelines, and debates on policies that impact the industry.⁴

However, these political donations are dwarfed by the \$11.1 billion spent in 2022-23 by federal and state governments on annual subsidies for the fossil fuel industry and major users.⁵

The key point is that we, as a species, will only succeed in mitigating the effects of and adapting to the changing climate if we are all moving in the same direction. It means holding to account the people we elect, and the industries we support, to act in the best interests of our communities.

In this edition, we've focused on climate change in our corner of the world. Amelia Pearson tells us about the 'shield' keeping warm water away from Antarctica, while Gordon Noble discusses climate change and economics.

Dr Catriona Nguyen-Robertson presents the climate science of Prof David Karoly, and Dr Don Williams looks at the impacts of bottled water.

We hope you enjoy this month's *Science Victoria*.

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Acknowledgement of Country

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



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Photograph: Wes Warren via Unsplash.



Victoria and the Changing Climate

ROB GELL

President, The Royal Society of Victoria

This month, *Science Victoria* returns to the most important of topics and the RSV’s first strategic pillar: addressing climate change. Specifically, how we mitigate it and help Victoria adapt to it.

Since the first Intergovernmental Panel on Climate Change (IPCC) report in 1990(!), the warnings of climate scientists have been repeatedly ignored.

There is little doubt that climate change is with us now:

- ▶ global sea-surface temperatures and Arctic air temperatures reached record highs in 2023;^{1,2}
- ▶ record-breaking rain and catastrophic flooding on the Arabian Peninsula, East Africa, and southern Brazil have been intensified by climate change;^{3,4,5}
- ▶ There’s been an ‘impossible heatwave’ in April this year across Asia, from Gaza, through Delhi, to Manila;⁶
- ▶ The US government has enacted a ‘climate emergency’, with the 2024 North Atlantic hurricane season predicted to see the highest count ever.⁷

Disruptions to UK seasons are now impacting birds, as climate change accelerates extinctions.⁸ Many Australian natives face a similar fate, as we covered in the March edition of *Science Victoria*.⁹

Addressing climate change in our backyard

In Victoria, we arguably have the best emissions reduction strategy in the country. However, efforts must continue to scale up if we are to avoid the worst impacts of climate change.

Where are the programs to offer businesses with significant rooftop space incentives to fill their roofs with solar? Why don’t all of our car parks have solar panels covering them, to shade them and double as urban renewable energy generating sites?

Unfortunately, our grid system doesn’t allow either opportunity. The current ‘dumb’ distribution system is unable to monitor and satisfactorily manage that energy input, because our energy infrastructure has been constructed to accommodate centralised rather than distributed production.

The question of adaptation – adjusting our systems and practices to cope with the changing climate – is rarely discussed by our leaders. We need to see greater (and smarter) investment in adaptation of essential systems and infrastructure to cope with climate instability – electricity, water, agriculture, and housing.

Simultaneously, we need evidence-based policy development and investment in climate change mitigation. In general terms, this means meaningful action on reducing greenhouse gas emissions, and continued research and investment in carbon sequestration. Nationally we are still approving fossil-fuel gas mines, despite scientific consensus that we need to halt new fossil fuel projects if we are serious about mitigating climate change.

We finally have a fuel efficiency standard which may incentivise electric vehicle availability and uptake. Will EV's solve the climate problem? No – but we can't do it without them, either.

A collision of trust, innovation, and politics

“The 2024 Edelman Trust Barometer reveals a new paradox at the heart of society. Rapid innovation offers the promise of a new era of prosperity, but instead risks exacerbating trust issues, leading to further societal instability and political polarization.”

“In a year where half the global population can vote in new leaders, the acceptance of innovation is essential to the success of our society. While people agree that scientists are essential to the acceptance of innovation, many are concerned that politics has too much influence on science. This perception is contributing to the decline of trust in the institutions responsible for steering us through change and towards a more prosperous future.”¹⁰

The 2024 Edelman Institute report identifies business as the most trusted to introduce innovation into society, and that non-government organisations such as the RSV are more trusted than government which is, at least, more trusted than the media.

A notable group from the Potsdam Institute for Climate Impact Research has suggested that ‘achieving a rapid global decarbonization to stabilise the climate critically depends on activating contagious and fast-spreading processes of social and technological change within the next few years’.¹¹

Clearly the RSV has a role here in promoting ‘social tipping interventions [which] comprise removing fossil-fuel subsidies and incentivizing decentralised energy generation, building carbon-neutral cities, divesting from assets linked to fossil fuels, revealing the moral implications of fossil fuels, strengthening climate education and engagement, and disclosing greenhouse gas emissions information’.

There are strong roles for individuals in this, and for individuals to advocate at all levels of governance, and society to achieve them.

You will find excellent articles on these matters in this edition of *Science Victoria*.

If you have thoughts and ideas on how the RSV can build its capacity to invoke change, I'd love to hear from you at president@rsv.org.au.



Photograph: Wes Warren via Unsplash.

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Photograph: Karl Heidin via Unsplash

Science Victoria STEM Photography Prize

Win \$300 and celebrate the world of STEM.

We are excited to announce the first annual *Science Victoria* Photography Prize!

In 2023, we introduced the 'Snapshots of STEM' section to our magazine, as a way to connect the images of everyday science with a general audience.

This year, the images published each month will form a shortlist, from which a winner will be selected at the end of the year.

Applications for the 2024 round are open until 15 November (the deadline for the December edition), and a winner announced in the February 2025 edition of *Science Victoria*.

The winner will receive a \$300 prize, and a certificate.

Images must be original photographs that capture your day-to-day work in STEM. These are not stock photos or overly posed images. Instead, they show what working and studying in a STEM field is actually like.

PRIZE:
\$300 prize, and a certificate.

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

SUBMISSIONS:
Submissions can be made by emailing editor@ScienceVictoria.org.au.

CLOSING DATE:
15 November 2024

ENQUIRIES:
For any questions about submissions for the *Science Victoria* STEM Photography Prize, please contact editor@ScienceVictoria.org.au.

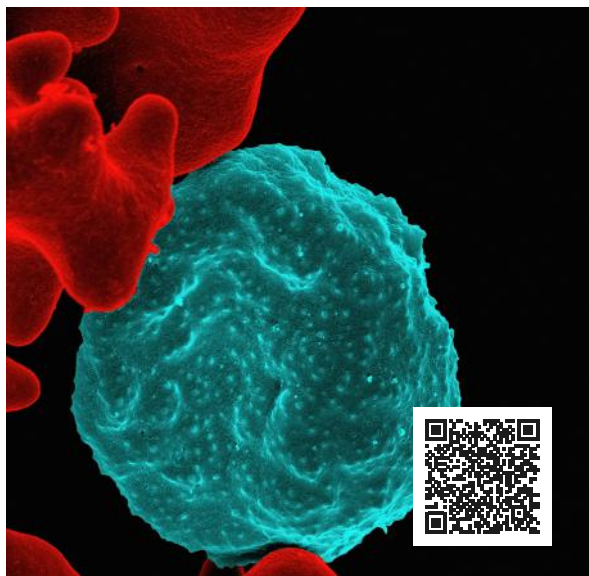


Stream ecologist Dr Richard Marchant collecting river rocks from the Cumberland River to obtain emerging adult insects. Photograph: Rodney Start/Museums Victoria.



Professor of Wildlife Ecology and Conservation Euan Ritchie working with local communities to undertake camera trap surveys of tree kangaroos and other mammals in Papua New Guinea's Torricelli Mountain Ranges. Photograph: Deakin University & The Tenkile Conservation Alliance

NAD via Unsplash



Dr Benoît Laleu – Medicines for Malaria Venture

Despite the efforts towards malaria eradication, the latest estimates from the recent WHO World Malaria Reports show that the number of cases is rising and malaria continues to have a devastating impact on the most vulnerable populations.

Medicines for Malaria Venture (MMV) is a not-for-profit Swiss Foundation acting as a Product Development Partnership (PDP) with the mission to reduce the burden of malaria in disease-endemic countries by discovering, developing and facilitating the delivery of new, effective and affordable antimalarial drugs in collaboration with international partners.

Presented as part of the WEHI Seminar Series by Dr Benoît Laleu, Director of Research Drug Discovery, Medicines for Malaria Venture, Switzerland.

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

PRICE:
Free

LOCATION:
Online (via Microsoft Teams)

BOOKING LINK:
wehi.edu.au/event/dr-benoit-laleu-medicines-for-malaria-venture

Photograph: Dr Gresley Wakelin-King



Australian Desert Rivers: So Cool, So Dry, So Dynamic

Iconic names like Cooper Creek, Kati Thanda-Lake Eyre and the dusty Diamantina have a big footprint in our national narratives. Despite this, we generally only notice them when they become least like themselves: when it's rained, the bushes are green and there's water flowing in the channels.

Australia's dryland rivers are qualitatively different from "normal" (temperate zone, perennial) rivers. It's not just that they don't often flow: it's because aridity creates special conditions for rainfall, run-off, vegetation-landform relationships, biotic life cycles, and the pace of landscape evolution. Australia's geological history has given these rivers a very specific topographic and sedimentological context.

Join geologist, geomorphologist and research scientist Dr Gresley Wakelin-King, who will challenge the misconception of this continent's "dead heart" and explore the dynamic nature of the dryland rivers that support life and land in the landscapes of Australia's arid interior.

DATE/TIME:
Thursday 27 June, from 6pm

PRICE:
In-Person: \$10 (non-members) / \$5 (RSV members)
Online: \$5 (non-members) / Free for RSV members

LOCATION:
The Royal Society of Victoria
Wurundjeri Country
8 La Trobe Street, Melbourne
(Simulcast on Zoom)

BOOKING LINK:
rsv.org.au/events/australian-desert-rivers

via Unsplash



National Youth STEM Summit

Are you 18-25 and ready to kickstart your career in science and technology?

- ▶ Gain insights from leaders in STEM from a diverse range of disciplines and career stages;
- ▶ Up-skill with workshops in communications and media, leadership, work-life balance & personal branding and interview skills;
- ▶ Connect with your peers and exchange ideas on the current trends in STEM fields;
- ▶ Network with business, government & senior representatives in the STEM sector;
- ▶ Celebrate NYSFs 40th anniversary at a Gala Dinner at the Australian Parliament House.

DATE/TIME:
17 - 19 August 2024

PRICE:
\$295 - \$625

LOCATION:
The Australian National University, Canberra

BOOKING LINK:
nysf.edu.au/programs/national-youth-stem-summit

What's On

The RSV hosts many STEMM-related events, public lectures, and meetings throughout the year.

Most RSV events are hybrid, held both in person (at 8 La Trobe St, Melbourne) and broadcast online via Zoom and Youtube. Our public lectures comprise the "Science in Focus" component of the *Inspiring Victoria* program in 2024.

2024

Australian Desert Rivers (2024 A. W. Howitt Lecture)

The 2024 A. W. Howitt Lecture, presented in partnership with the Geological Society of Australia (Victoria Division). Join geologist Dr Gresley Wakeling to challenge the misconception of this continent's "dead heart" and explore the dynamic nature of the dryland rivers that support life and land in the landscapes of the arid interior.

DATE
27 June 2024

TICKETS
rsv.org.au/events/australian-desert-rivers

RSV Phillip Law Postdoctoral Award Lecture

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

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

DATE
TBA

TICKETS
rsv.org.au/awards-and-prizes/phillip-law-award

Missed an RSV event?

You can catch-up on presentations from world-leading minds at youtube.com/@RoyalSocietyVic

Don't have time to watch a full presentation? Try one of the summary videos to catch the highlights.

[YOUTU.BE/JL6SIKT9JSI](https://youtu.be/JL6SIKT9JSI)

Aiming Higher: Improving Science Education in Victorian Schools

[YOUTU.BE/ODSSDCSU000](https://youtu.be/ODSSDCSU000)

Reimagining Humanity in the Age of Generative AI

Awards & Prizes

crcCARE High School Essay Competition

APPLICATIONS CLOSE

12pm, 31 July 2024

The crcCARE High School Essay Competition aims to inspire students to recognise the importance of a clean environment to our wellbeing, and to understand how easily human activities can jeopardise environmental sustainability. crcCARE performs scientific research to help stop or clean up contamination of our soil, water and air. Your essay can help!

Who can enter and what can you win?

Entries are open to Australian school students in Years 7 to 12. The two best essays (one for each topic listed below) will be judged on writing quality, interest, newsworthiness, and scientific accuracy.

Winners will receive a cash prize and a trip to Adelaide for the CleanUp 2024 conference gala dinner on Tuesday 17 September 2024 (prize winners must be accompanied to the gala dinner by a parent/legal guardian, at their parent/guardian's expense).

How do I enter?

To enter, download the entry form and write an essay of 500 to 1000 words in either of two categories below:

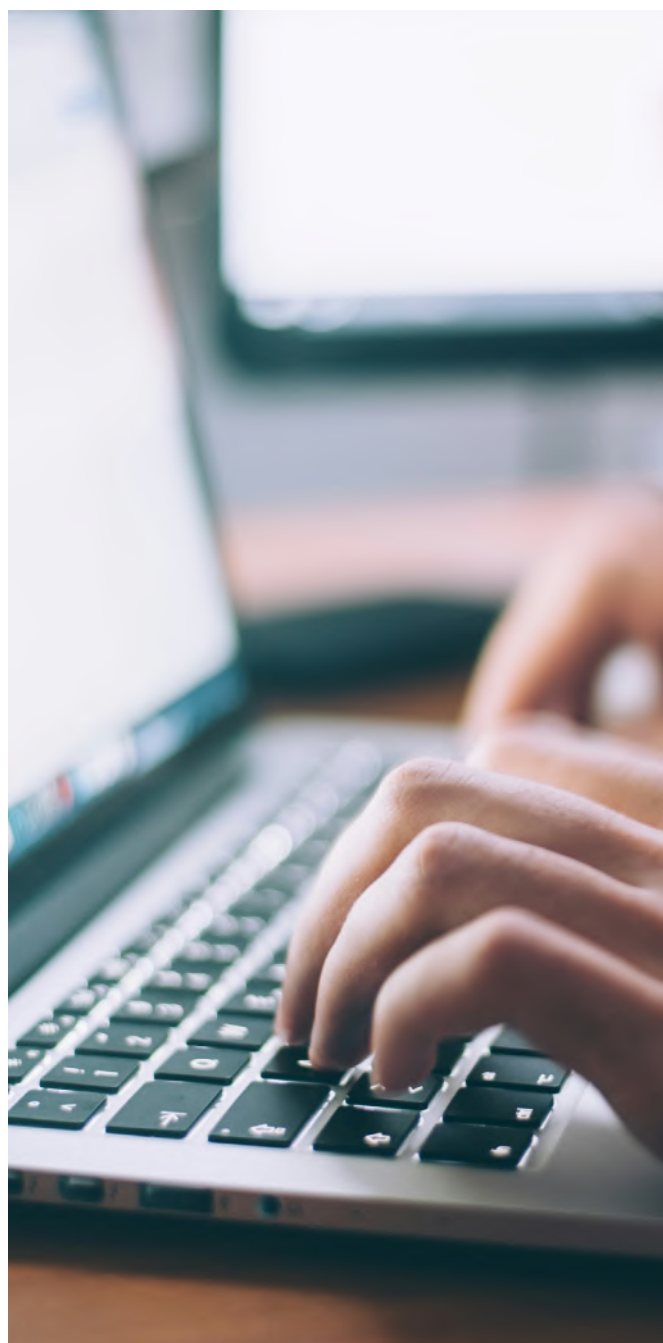
The Dr Roneal Naidu Award - How can innovative technologies help clean up emerging contaminants, such as pharmaceuticals and micro-nano plastics, to protect human health and the environment? (\$1000 prize)

The crcCARE Award - How can packaging be redesigned to facilitate a circular economy, and can Indigenous knowledge help guide modern environmental practices? (\$500 prize).

You are welcome to submit entries in both categories, but you are limited to only one (1) entry in each category.

Entries (comprising the completed entry form and the essay) should be emailed to Cintya Dharmayanti at Scientell (cintya@scientell.com.au) by 5pm on Wednesday, 31 July 2024.

- ▶ For more information, and to download the entry form, visit adelaide2024cleanupconference.com/high-school-essay-competition



via Unsplash

MRFF 2024 Early to Mid-Career Researchers Grant Opportunity

SUBMISSIONS CLOSE
MINIMUM DATA REQUIRED BY

24 July 2024
26 June 2024

The objective of this grant opportunity is to provide grants of financial assistance to support medical research and medical innovation projects that:

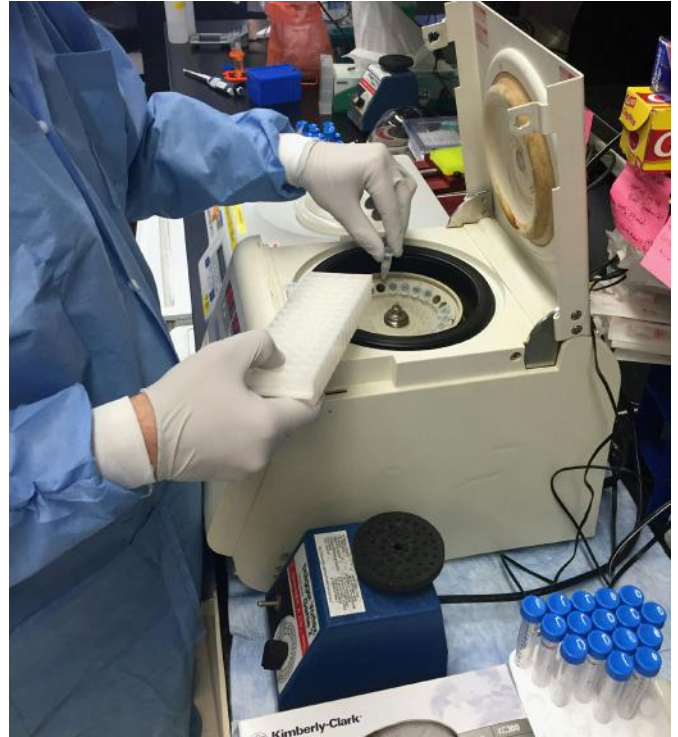
The objective of this grant opportunity is to provide grants of financial assistance to support medical research and medical innovation projects that:

Stream 1 (Incubator): conduct early stage, small scale research, led by early-career researchers, that seeks to assess the potential and feasibility of novel strategies to address a critical or intractable health issue in one or more Priority Populations.

Stream 2 (Accelerator): establish a large-scale interdisciplinary research program, led by mid-career researchers, that drives implementation of substantial improvements to health care and/or health system effectiveness for one or more Priority Populations.

Stream 3 (Targeted Call for Research): utilise co-funding between the MRFF, a sponsoring academic organisation and other organisation(s) to accelerate translation of research led by early to mid-career researchers.

- ▶ For more information, visit grants.gov.au and search 'GO6748'.



NIAD via Unsplash

ATSE Elevate Program 2025

APPLICATIONS CLOSE

5pm, 30 August 2024

Applications for the 2025 Elevate program are currently open.

ATSE's Elevate: Boosting women in STEM program will award up to 500 undergraduate and postgraduate scholarships to women and non-binary people in STEM.

The Elevate program provides:

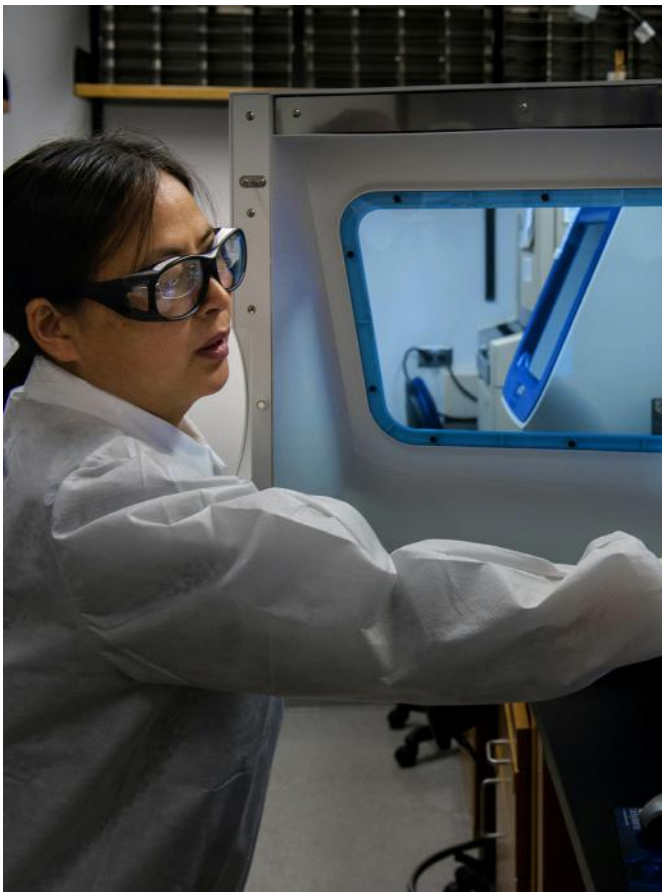
- ▶ A scholarship
- ▶ Access to events and networking
- ▶ Mentoring
- ▶ Ongoing support during scholars' university studies

The strategic objectives of Elevate are to:

- ▶ Encourage women and non-binary people to pursue education and careers in STEM,
- ▶ Foster industry-academia collaborations in applied research and business,
- ▶ Extend qualifications and professional skills in STEM and business,
- ▶ Propel women and non-binary people into leadership, and
- ▶ Award up to 500 undergraduate and postgraduate scholarships to women and non-binary people in STEM over six years.

- ▶ For more information, and to apply, visit atse.org.au/career-pathways/elevate/elevate-scholarship-guidelines

CDC via Unsplash





Scientists Sail the Southern Seas

Oceans absorbing the heat of climate change.

AMELIA PEARSON

Monash Climate Change Communication Research Hub



INVESTIGATOR

IMO 9616888

DREGGEN

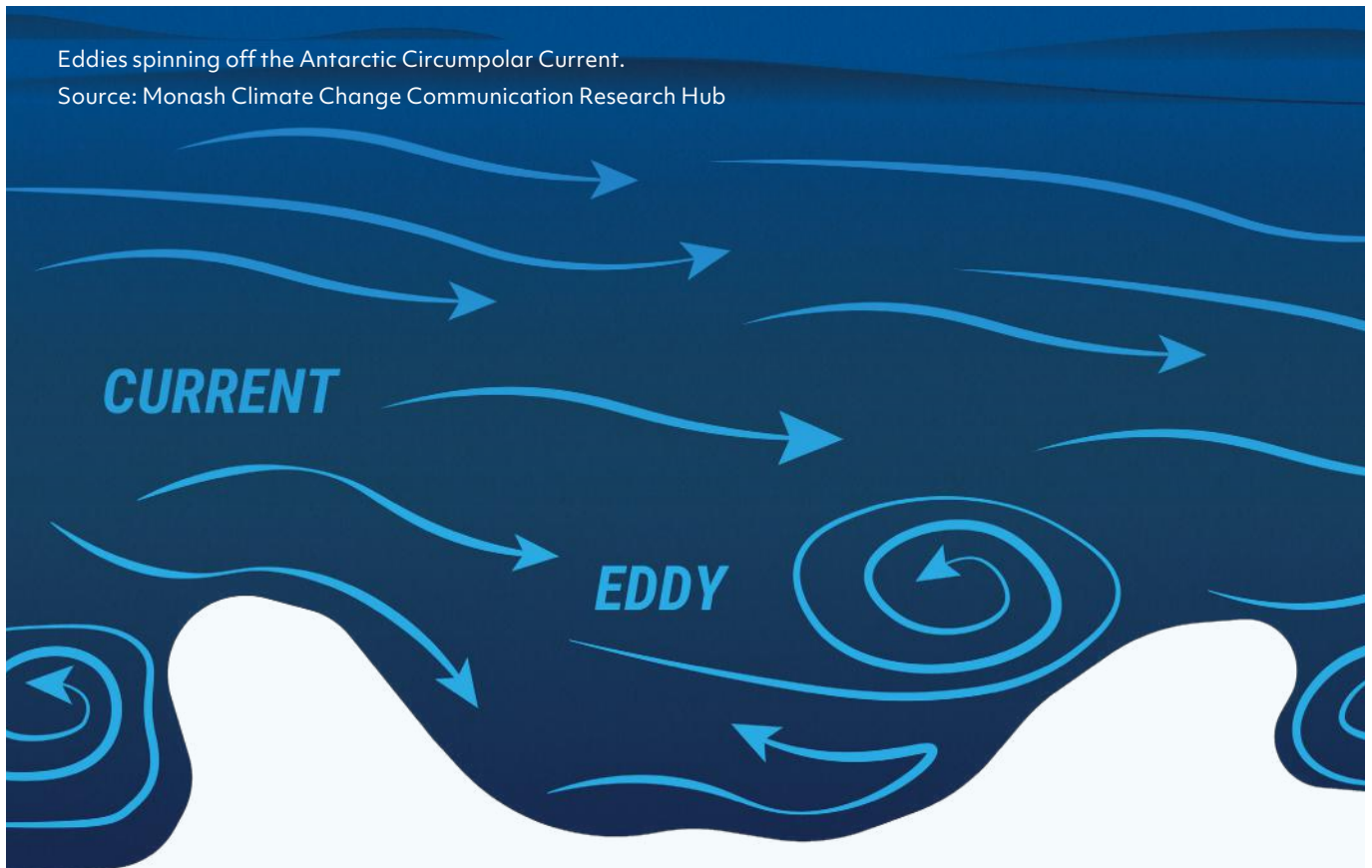
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1.2M UNDER SHIP'S KEEL



Eddies spinning off the Antarctic Circumpolar Current.

Source: Monash Climate Change Communication Research Hub

The Southern Ocean is a ‘natural laboratory’ for vital scientific research, impossible to achieve anywhere else on the planet.

The Southern Ocean

The Southern Ocean surrounds Antarctica, boasting colossal waves that even the bravest sailors find daunting.

The dangerous waves, volatile weather, and distance from any land make it inaccessible, and one of the least observed regions on the planet.

However, these stormy seas are key to our survival and are critical for us to understand in the face of global climate change.¹ Of all the oceans, the Southern Ocean absorbs the majority of human-generated heat and carbon,² helping to slow the pace of climate change and keep our Earth liveable. In addition, Antarctic sea ice acts as an ‘air conditioner’ for our planet, reflecting 50-70% of incoming solar radiation.^{3,4}

Together, these factors influence ocean circulation and climate on a global scale, and control the rate that the Antarctic ice sheet is melting – the greatest uncertainty in projecting future sea level rise.

The Antarctic Circumpolar Current

At the heart of the Southern Ocean is the Antarctic Circumpolar Current (ACC) – Earth’s strongest current, driven by westerly winds. It flows clockwise around Antarctica, and for millions of years it has acted like a shield, keeping heat away from the icy continent.

The ACC is up to 2,000 km wide, and runs through the ocean from the surface to seafloor. Where it encounters underwater barriers like seamounts or ridges, 'wiggles' are created in the water flow, forming eddies.

We can think of eddies – water spinning off in the opposite direction to the main current – as the weather systems of our oceans, playing a vital role in moving heat through the ACC to the waters around Antarctica and also into deeper layers.

Although the ACC has always let some warmth through, changing winds over the Southern Ocean are expected to increase the southward transport of heat, accelerating ice melt in Antarctica and sea level rise.⁵

Ocean mapping has identified five eddy hot-spots, thought to be the primary "gateways" for this heat transfer, and one of these sits about half way between Hobart and Antarctica.

FOCUS on the high seas

On 15 November 2023, a team of 54 scientists and crew set sail from Hobart aboard CSIRO's state-of-the-art research vessel (RV) *Investigator*, and voyaged south to the heart of this eddy hotspot in the Southern Ocean.⁶

Their mission: to collect high resolution data that will help us understand the ocean dynamics happening now, and how they may change in the future.

The newly named FOCUS voyage – Fine-scale Observations of the (Antarctic Circumpolar) Current Under SWOT – was co-led by CSIRO and the Australian Antarctic Program Partnership, in collaboration with NASA and France's space agency (CNES), Woods Hole Oceanographic Institution (WHOI), and the California Institute of Technology (Caltech).^{7,8}

Over five weeks, the ship sailed 850 nautical miles south, to reach the 100 km by 200 km survey area.

Here, the interdisciplinary team of oceanographers, hydrochemists, biologists, geophysicists, and engineers aimed to track down and measure the small-scale features they think can explain the heat seeping polewards.

To do this, they needed to collect data from both above and below the waves.

Science from space

Orbiting over 890 km above us, the SWOT satellite plays an important role in this research. Co-designed by NASA and French space agency CNES, it measures the height of the ocean surface from space, providing vital information on the density and speed of ocean currents.⁹

The SWOT satellite has 10 times better resolution than preceding satellites, and can detect differences in sea surface height down to just a few centimetres.

Co-chief scientist Assoc Prof Helen Phillips, from the Australian Antarctic Program Partnership at the University of Tasmania, likens it to a short-sighted person looking at a tree in the distance and then putting glasses on to reveal all the leaves.

As the SWOT satellite flies over the ocean, it records the shape of the ocean surface and captures the eddy hotspots spinning off the ACC.

This means scientists can see the smaller-scale circulation features, which are thought to be responsible for most of the ocean's heat and carbon transport from the surface to the bottom of the ocean. In turn, it will allow them to turn daily

maps of ocean sea surface height from satellites into daily maps of heat movement in the Southern Ocean towards Antarctica.

CSIRO researcher and voyage chief scientist Dr Benoit Legresy says that "this new capability to map the ocean will boost our capacity to monitor and forecast the ocean very much like we forecast the weather".

The SWOT satellite will also provide an eye in the sky for the deep south when researchers are not at sea, surveying the entirety of the Southern Ocean.

Exploring below the waves

At sea, the team relied on the scientific capabilities of RV *Investigator* to peer below the surface.

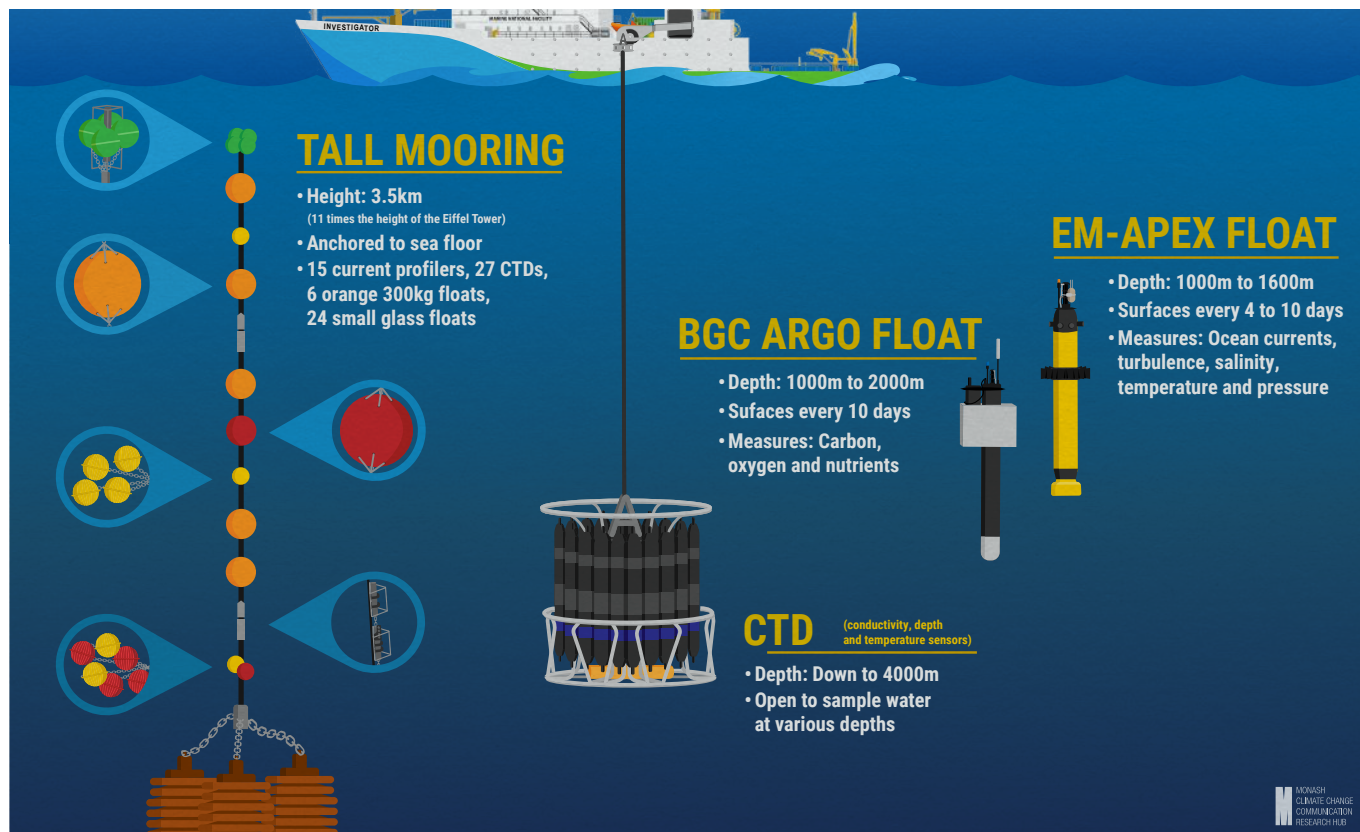
At the core of the operation is a 3.5 km tall mooring – 11 times the height of the Eiffel Tower. This vertical string of over 50 oceanographic instruments acts as a central point to connect what's happening below the surface of the ocean with what the satellite observes above.

Around this central feature, CTDs (conductivity, temperature, and depth sensors) and floats survey the depths of the ocean, while remotely piloted gliders are used to target specific ocean features like eddies.

Graduate student from Caltech, Luna Bai, says that the gliders "are like a more versatile CTD that take high frequency measurements of temperature, salinity, particles in the ocean, and dissolved oxygen".

The path of the RV *Investigator* from Hobart to the survey area in the ACC. Source: Monash Climate Change Communication Research Hub





Instrumentation used by scientists to monitor the Southern Ocean. Source: Monash Climate Change Communication Research Hub

Moving towards the surface, we find two final pieces of equipment. During satellite passes, the box-shaped Triaxus is towed behind the ship to map the upper ocean. And, at the surface, drifters hitch rides with swirling eddies and give us information about current speed and direction as well as surface pressure and temperature.

Together, this state-of-the-art toolkit provides insight into the vertical movement taking heat and carbon out of the atmosphere and putting it into the ocean. And when paired with SWOT's high definition view of the surface, we're able to put together a three-dimensional picture of what is driving these processes.

Connection to climate and life on land

Changes in the Antarctic region are happening much more rapidly and on a much larger scale than we ever thought possible. And now, we're in a race against time to understand why. Antarctica is like a 'sleeping giant', beginning to wake up and show its destructive potential as the planet warms.

Rapidly melting polar ice sheets and glaciers have contributed around two-thirds of our observed global sea level rise in the last few decades, with the other third comes from thermal expansion of the ocean waters.^{10,11} In addition, nearly 50 Antarctic ice shelves have shrunk by 30% or more since 1997.¹²

Let's zoom in on the past few years. In 2022 East Antarctica experienced an extraordinary heatwave, with temperatures up to 40 degrees above average, while in 2023 we witnessed Antarctic sea ice reach its lowest winter extent on record.^{13,14}

Unfortunately, the start of this year followed a similar trend, with sea ice extent during February reaching another near-record low.¹⁵

These record-breaking lows may be the new normal and the beginning of the inevitable decline in Antarctic sea ice, which has long been projected by climate models.

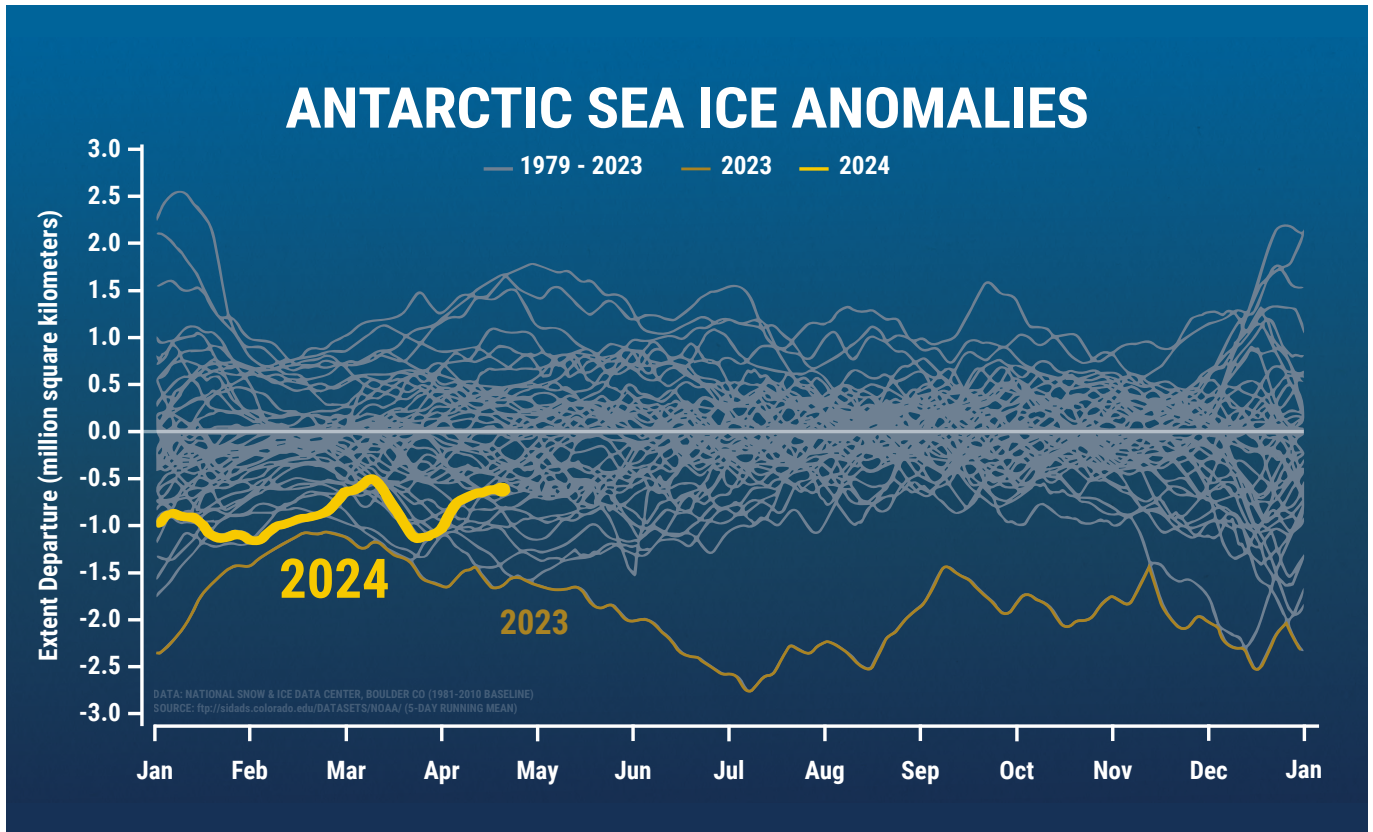
A study published in Nature said that warming has increased to the point that some ice sheets will now experience "unavoidable" melting – regardless of how much greenhouse gas emissions are reduced.¹⁶ An increasingly 'leaky' ACC will likely only exacerbate these changes.

For Australia, continued ice melt exposes many of our most populated communities to the crippling consequences of sea level rise. This could include the loss of up to 50 per cent of its beaches over the next 80 years, along with damage to coastal communities from more severe storm surges, and flooding.¹⁷

Lessons for future FOCUS

The FOCUS voyage showcases the highly collaborative, international science required to better understand warming across our Southern Ocean. The data will be really valuable for helping people develop models of the Southern Ocean that reproduce what we see in the real ocean, and build confidence in those models for their other job of projecting our future under climate change.

It will also help governments plan their responses to ocean warming and rising sea levels, and hopefully motivate a faster reduction in CO₂ emissions.



Antarctic sea ice anomaly. Source: Monash Climate Change Communication Research Hub.

As we transition towards a net-zero world and atmospheric carbon levels begin to stabilise, the oceanographic toolkit used on this voyage will be essential to monitor the response of the Southern Ocean and our broader climate system.

A/Prof Phillips says, “the ocean is so enormous, and there aren’t that many oceanographers and ships out here taking observations. This means that it has to be a really collaborative, international activity, with all data shared publicly, and a strong commitment to training the next generation of scientists”.

Ultimately, the more opportunities scientists have to work in these rugged, remote locations, linking data from satellites, research ships and other monitors, the better equipped we will be to tackle our rapidly changing world.


Acknowledgement

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► *Amelia Pearson is the Operations Manager for the Monash Climate Change Communication Research Hub, which provides new content, knowledge and ideas to support the effective communication of climate change impacts and solutions. You can learn more about the Hub’s work at monash.edu/mcccrh.*

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Science vs. Branding in the Bottled Water Market

DR DON WILLIAMS MRSV



Photograph: Markus Spiske via Unsplash

Science gathers knowledge faster than society gathers wisdom

Isaac Asimov
1988

Bottled drinking water is widely consumed in Australia, despite safe and reliable drinking water being readily available from centralised urban water systems ('tap water').

Bottled water remains immensely popular despite its significantly higher cost, and scientific advice that tap water is both healthier and far less environmentally damaging.^{1,2}

This article briefly compares the safety and environmental attributes of bottled water and tap water. It examines reasons for bottled water's popularity and potential policy options to discourage bottled water consumption. The mass consumption of bottled water is identified as a specific example of a more general class of policy problem.

Impacts of bottled water vs. tap water

Australian tap water is reported to be very safe and cause far less environmental harm than bottled water.^{1,2} But what does that mean, exactly? And how is the safety and environmental impact measured?

Safety

Victorian tap water is treated by proven technologies, including detention, filtration, and disinfection. Its quality is regulated by the *Safe Drinking Water Act 2003*, which adopts the risk management philosophy of the *Australian drinking water guidelines*.³ Monitoring and public reporting of water quality is also required.⁴ This comprehensive risk-management framework means safety risks associated with Victorian tap water are minimal. Victoria's approach to managing drinking water quality typifies Australian practice.¹

Bottled water is deemed to be a packaged food and is regulated by national Food Safety standards, which are enforced by state food authorities. These standards include health-based limits for a range of substances and risk-management procedures. However, bottled water producers generally have less control over the catchments used to source their water than water utilities.¹ Recent research has identified the presence of microplastics in bottled water in Australia.⁵

Both tap water and bottled water are subject to contemporary risk management frameworks. There is no evidence that bottled water is safer than Victorian tap water – if anything, the presence of microplastics in bottled water make it a less healthy product.

Environmental Impacts

Bottled water manufacturing impacts the environment throughout the product life cycle, including bottle production, water extraction, bottling, transport, and cooling. Impacts include resource depletion, consumption of energy and water, greenhouse gas emissions, and solid waste generation.

While studies on these impacts are limited and use different methods, a recent review found the environmental impacts of bottled water exceed those of tap water across all criteria.⁶ For example, the energy required to produce bottled water is up to 2,000 times more than tap water, and greenhouse gas emissions for a 500ml PET bottle are equivalent to 3.87 kg CO₂. Additionally, the estimated 'water footprint' values for bottled water (ratio of fresh water used in production per unit of product) range from 6 to 35, compared with 2.4 for tap water.⁶ While acknowledging the limitations of available studies, it is clear the environmental impacts of bottled water greatly exceed those of tap water.

Together, this means that bottled water is no safer than drinking water, and causes far greater environmental harm. The unit cost of bottled water is also hundreds of times that of tap water, further diminishing any potential benefits.^{7,8}

It is difficult to provide rational explanations for the success of bottled water. To understand why bottled water has triumphed in the marketplace, we must turn from the physical world to the less concrete realm of human behaviour.

Consumer behaviour

Australians purchased an average of 504 litres/person of bottled water in 2021, indicating it is a mainstream practice.⁷ Research suggests there are varied reasons why some consumers prefer bottled water. These include perceptions about relative safety, which may be influenced by previous incidents with the tap water supply system; claimed health benefits; and taste preferences and appearance.^{9,10}

Bottled water is supported by extensive advertising, which seeks to connect the product with buyers' emotions.⁹ A distinct, commercially successful bottled water 'brand' has emerged.¹⁰ The success of bottled water is a striking example of the power of branding to transform a commodity into a meaningful part of daily life for many consumers.¹¹

An Australian analysis showed that even though consumers might express concerns about the impacts of disposable items such as plastic bottles, these concerns are not associated with major changes in purchasing behaviour.¹² In other words, knowing that plastic bottles pollute our environment isn't enough to stop people buying water in plastic bottles.

In the absence of interventions, the popularity of bottled water seems unlikely to weaken.





Photograph: Sue Thompson via flickr (CC BY-ND 2.0 DEED)

Bottled water as a policy issue

The adverse consequences of bottled water represent a significant public policy issue. How can science be utilised to reduce the demand?

The intersection of science with public policy is often framed as using scientific knowledge to influence governments, encouraging them to mitigate harmful outcomes by adopting explicit policies and passing laws to mandate outcomes. Examples of this approach include the introduction of strong legal regimes to zone land for conservation purposes, regulate medicines, and control radioactive materials.

However, bottled water is an example of a different type of policy issue, which requires different interventions. Bottled water consumption is determined by individual consumer decisions. Similar public policy issues associated with consumer choices include consumption of unhealthy foods, purchase of 'green' electricity, and choices about transport modes. Potential policy responses to this type of issue must recognise that proposals for government intervention in markets currently encounter strong political opposition.¹³

How can science help to mitigate the impacts of bottled water in this seemingly unpromising context?

The role of science

An Approach Based on Regulatory Theory

Regulatory theory suggests governments can influence behaviour by interventions that extend beyond direct legal controls. These interventions can include:¹⁴

1. Legal regulation: direct control via laws
2. Authorisation: use of licences/approvals to regulate behaviour.
3. Economic regulation: governments create or influence markets.
4. Transactional regulation: governments carry out transactions in markets.
5. Structural regulation: alter the physical environment to direct behaviour.
6. Informational regulation: provide information to overcome information asymmetries, and to modify behaviour.

The last two measures are particularly relevant to bottled water. The introduction of refilling stations, where bottles are replenished with tap water, alters the physical environment to direct behaviour. Studies show this measure reduced bottled water consumption at specific sites.^{2,15}

Governments at all levels could ensure that refilling stations are readily available at the extensive range of public facilities under their control, such as airports, tertiary institutions, schools, libraries, hospitals, and land transport hubs. This intervention could also have the indirect benefit of normalising tap water consumption.

Another potential intervention would be to require producers to provide information about bottled water. This could include information such as the adverse environmental impacts identified above, and health data. This would reduce information asymmetries between bottled water producers and consumers, and allow consumers to make more informed purchasing decisions.¹⁶

Given the availability of these simple, unobtrusive regulatory interventions, the scientific community could encourage governments to adopt them. If the provision of information were mandated, scientists would have a key role in ensuring the information reflects sound, evidence-based knowledge.

Or a More Ambitious Role for Science?

A precedent for strong, science-informed intervention in a market is the introduction of controls on tobacco marketing. *The Tobacco Act 1987* introduced measures such as restrictions on advertising and sponsorship, control of tobacco sales to minors, prohibiting the sale of small, cheap packets of cigarettes, and the establishment of VicHealth, funded by an increased levy on tobacco sales. A key factor in gaining

the Victorian government's support for the Act was a strong, science-based advocacy network, led by the Anti-Cancer Council of Victoria.¹⁷

A potential hurdle advocates of strong regulatory controls should recognise is that contemporary government practice usually requires quantitative economic assessment of these interventions, including cost-benefit analysis to show that regulation would provide net positive outcomes. These requirements are typified by the Victorian government's *Victorian Guide to Regulation*.¹⁸

A complex case study

Bottled water consumption is an example of a more general type of policy issue associated with consumer behaviour. Advocates for intervention are faced with a general reluctance of governments to impose direct legal controls on consumers. However, measures such as installing refilling stations and providing comprehensive information to consumers could be used to discourage bottled water consumption. The scientific community could place pressure on governments to recognise



Photograph: via rawpixel (Public Domain)



Water Bottle Refilling Station, Queens Park, Moonee Ponds. Photograph: Don Williams.

the impacts caused by bottled water and could help to design, implement, and review appropriate interventions.

There is no absolute barrier to introducing a more ambitious approach to regulating bottled water consumption: the introduction of controls on tobacco in Victoria provides an example of what is possible under the correct circumstances. However, direct government intervention in retail markets would require a very strong scientific and economic case to justify regulatory controls. This is true for the bottled water issue and other policy issues related to consumer behaviour.

- *Dr Don Williams MRSV worked for 30 years in the water quality management, wastewater regulation and water efficiency fields. Don then completed a PhD examining how planning laws influence the adoption of sustainable urban water practices. Don has a long-standing interest in how scientific knowledge influences public policy.*

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Climate and the Economy

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EARTH



more

valuable than money

“ I’ve heard that there is a new version of Trivial Pursuit... it’s called the economist’s edition. In this one, there are 100 questions, 3,000 answers.”¹

Economics – the “dismal science”² – is renowned for its differences of opinion. The challenge for economics today is whether economists as a profession will be able to reach consensus on how to manage climate change. The good news on that front is that a new economics field is quietly emerging: climate economics.

Calculating the costs of climate change

In November 2023, the UK’s Royal Society produced the report, “*New horizons for understanding economic consequences of climate change*”, following a two-day discussion that the Society held earlier that year.

The report was led by eminent economist, Lord Nicholas Stern. Lord Stern’s work included a landmark study, “*The Economics of Climate Change: The Stern Review*”, which was produced back in October 2006. At that time, The Stern Review argued that there was still time to avoid the worst impacts of climate change - if strong action was taken immediately.

Almost twenty years after the Stern Review’s publication, its simple conclusion still holds true: the benefits of strong and early action far outweigh the economic costs of not acting.

With input from over 70 economists, the Royal Society’s 2023 report was blunt about the way economists are considering climate change impacts, stating “many economic assessments do not adequately reflect the scientific evidence of current and future climate change. As a consequence, economic assessments can often lead to misleading portrayals of the possible economic consequences of climate change.”³

The report’s themes, which are briefly discussed, represents a blueprint on changes the economics profession can make to incorporate climate change into economic assessments.

1. Challenges estimating economic impacts of climate change

Whilst economists have made some progress in better understanding and modelling the interactions between climate change and the economy, there are problems with current approaches to economic assessments of climate change. Overall, many economic analyses and models do not factor in all the latest scientific evidence of current and future climate change.

2. Earth system tipping points

Earth system tipping points are thresholds where a small change can alter the state or development of a system, resulting in the acceleration, irreversibly, or inevitability of serious impacts. The report argues that if economic assessments of climate change do not consider these tipping points, then they underestimate the magnitude of their impacts.

Consequently, decision-makers may therefore not adequately consider them in their climate response strategies, despite their significance for both mitigation and adaptation.

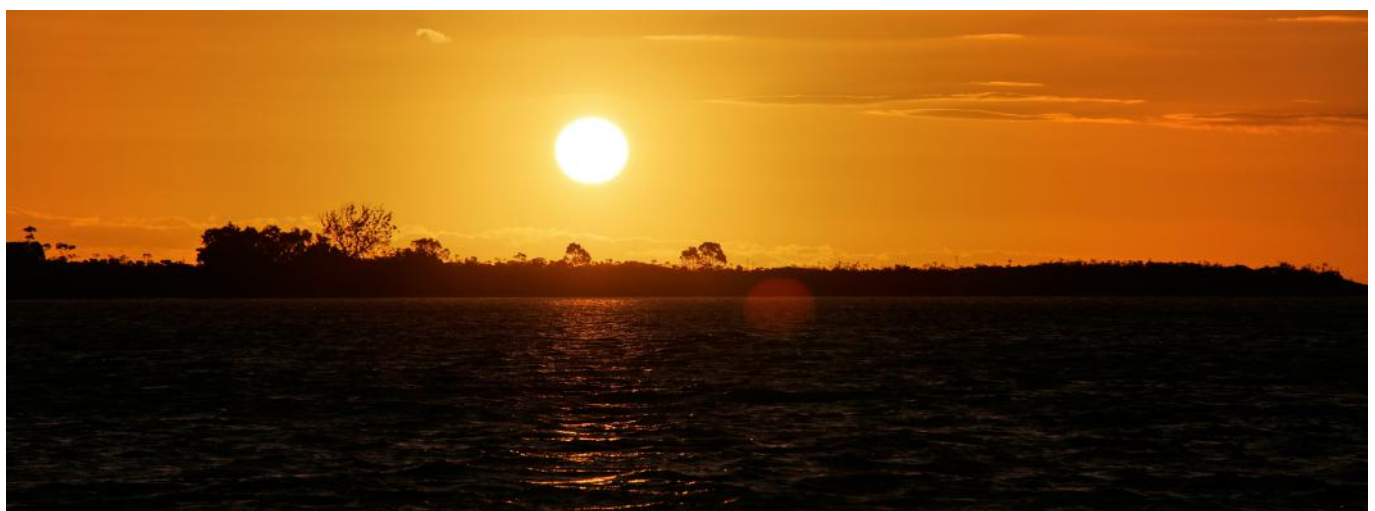
3. Economic impacts of extreme events

A limitation of many economic models is that they either exclude entire climate-induced hazards such as flooding, wildfires, and extreme heat, or consider them in a limited fashion. Economic models may also fail to capture the costs of increases in uncertainty, as well as broader impacts of risk changes on behaviour and the economy.

4. Economic effects on non-marketed goods

Climate change, nature, human health, and the economy are fundamentally connected. By excluding nature and health from economic assessments, it underestimates the economic impacts of climate change, and the co-benefits of mitigation and adaptation action.

This can result in unreliable estimates, which affects the ability of decision-makers to take appropriate action to address climate change.



Patrick McGregor via Unsplash

Photograph: via Pixabay



5. Ethical issues within current approaches

The economic analysis of climate change is sometimes presented as being “free of values”. However, economists have to make decisions on which data to include or exclude, and make assumptions about the weights to place on different impacts, on different people, and at different points in time.

Economic assessments that estimate the economic impacts of climate change typically only consider the consequences of climate change on human welfare, expressed through the consumption of goods and services. This is a narrow lens through which to consider the entire consequences of climate change.

6. Population displacement, migration, and violent conflict

Population displacement can occur in response to natural disasters, including extreme weather events such as floods, droughts, and storms. It can also exacerbate factors, such as political unrest, that can lead to conflict.

Population displacement, migration, and violent conflict are inadequately represented in current assessments of the economic impacts of climate change.

7. Interweaving mitigation, adaptation, and development

Current approaches to analysing and modelling the economic impacts of climate change are overly focused on a ‘top-down’ global perspective, and neglect ‘bottom-up’ regional and local perspectives.

By too often focusing on global scale, and not including more localised, granular data, economic assessments can fail to provide the information required to support successful local adaptation and development policies.

Where to for Australia?

There are moments in time when small actions can have large impacts. Australia collectively has many decisions to make that will influence the pathway we take to decarbonize. We also have many decisions to make on how we manage climate change impacts that are already upon us. The reality is that these decisions are economic. The decisions that are made today will impact allocation of capital across the economy, and ultimately influence the jobs that are created and lost.

The challenge is that we have a very narrow window to get things right. If we get things wrong, then we will lose our chance to keep climate warming under 2 °C, with the potential of +3 °C warming.

The Royal Society’s report argued that “enhanced interdisciplinary collaboration between physical scientists, economists, and other social scientists can overcome the long-term disconnect that has existed between these disciplines in the context of climate change.”³

This is true for Australia. Many of the investment decisions on decarbonization depend on a depth of knowledge of science, with examples including hydrogen as a fuel, biotechnologies based on algae technologies, and battery technologies.

There is a need to urgently create bridges between science and finance. The dismal science of economics may offer us a pathway, and the Royal Society has demonstrated that an organisation advocating for science can play a leadership role in the process. They brought the UK’s leading economists to the table to understand and address the way that economics can contribute to addressing climate impacts, and the resulting report is a model for interdisciplinary collaboration on climate change.

There is an opportunity for Australian economists to follow the Royal Society’s lead, and convene to consider how we ensure our own economic models, which underpin many decisions in our economy, are fit for purpose for a new climate era.

► *Gordon Noble is a Research Director at the Institute for Sustainable Futures, University of Technology Sydney.*

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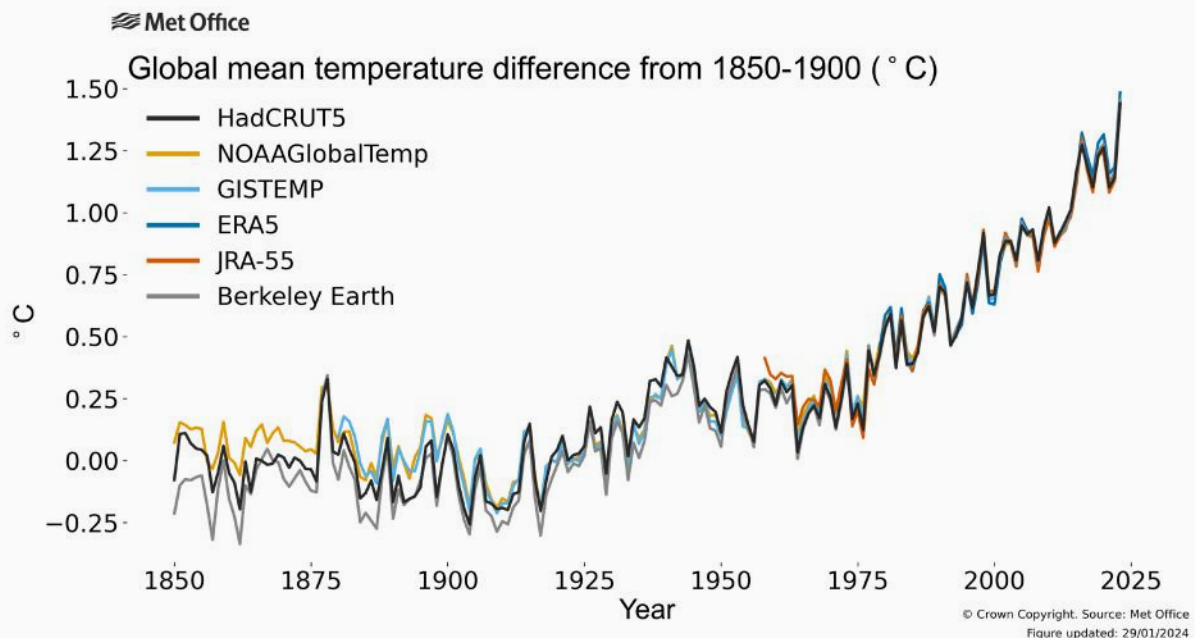
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Deciding the Future of our Climate

DR CATRIONA NGUYEN-ROBERTSON
Senior Editor, Science Victoria

With **PROF DAVID KAROLY**
Professor Emeritus (Honorary), The University of Melbourne

The climate is changing, and it is influenced by human activity. These are undeniable facts. Professor David Karoly, an internationally recognised expert on climate change, warns that it is a growing threat to human wellbeing, environmental ecosystems, and the entire planet. ‘There is much damage to come in the future’, he says, ‘but we can limit it to avoid complete catastrophe’.



Annual global mean temperature difference from pre-industrial conditions. Source: The Met Office (licensed under the Open Government Licence v3.0)

The changes that come with “climate change”

Last year (2023) was the warmest year on record, with the global average temperature 1.44 °C above the pre-industrial levels (prior to ~1850).¹ We often discuss “global average temperature”, but global land temperatures are often neglected, even though they impact us most. As David points out, “most people are not fish – we live on land”.

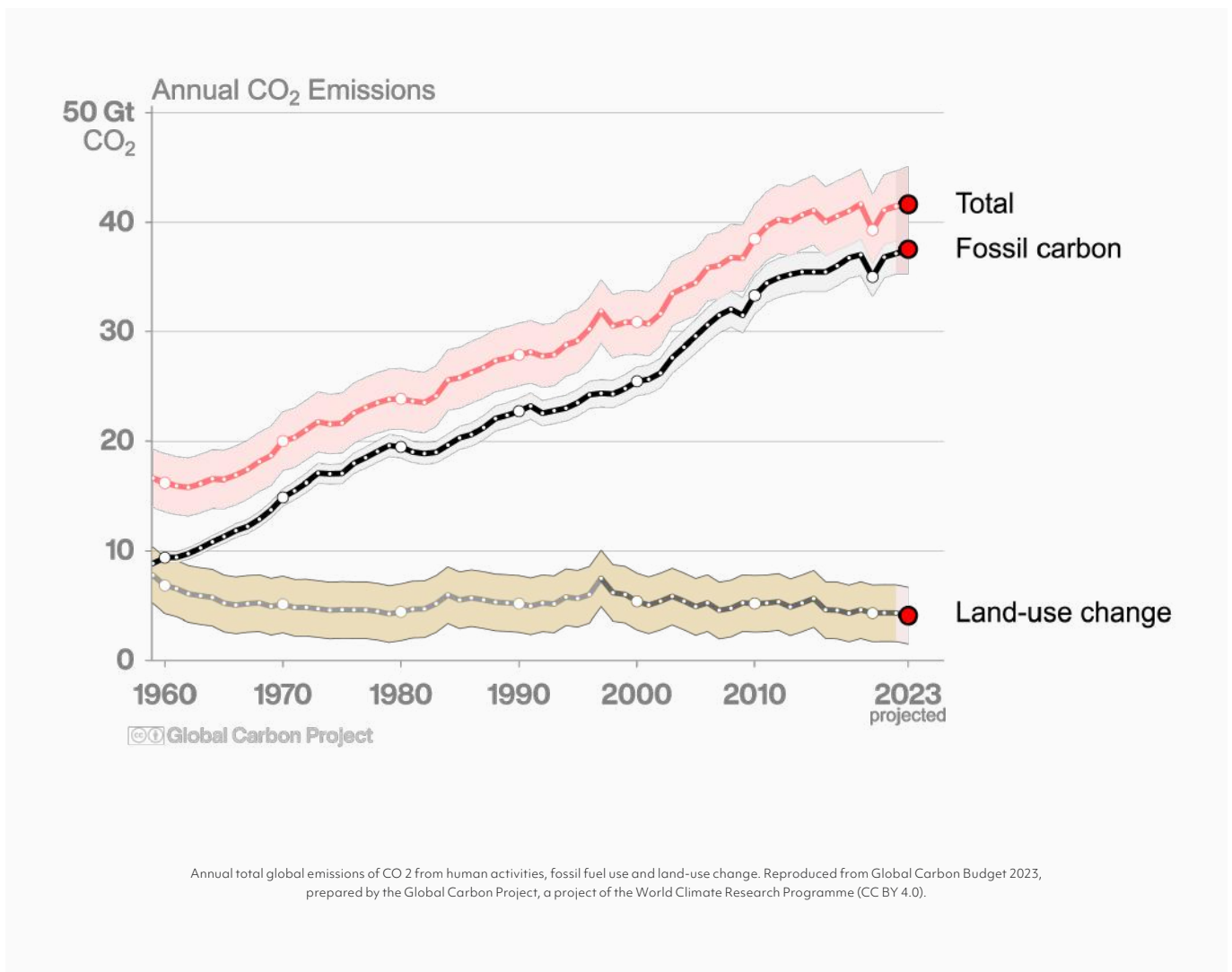
On land, 2023 was also the warmest year on record, reaching 2.10 °C above the pre-industrial average.² The warming of land is considerably faster than the warming of the planet as a whole, as water in the oceans is slower to increase in temperature. With land warming nearly double the warming of the entire globe, even if we limit global warming to 2 °C, by the time we reach that, temperatures on land may have already risen by about 3.0 °C.³

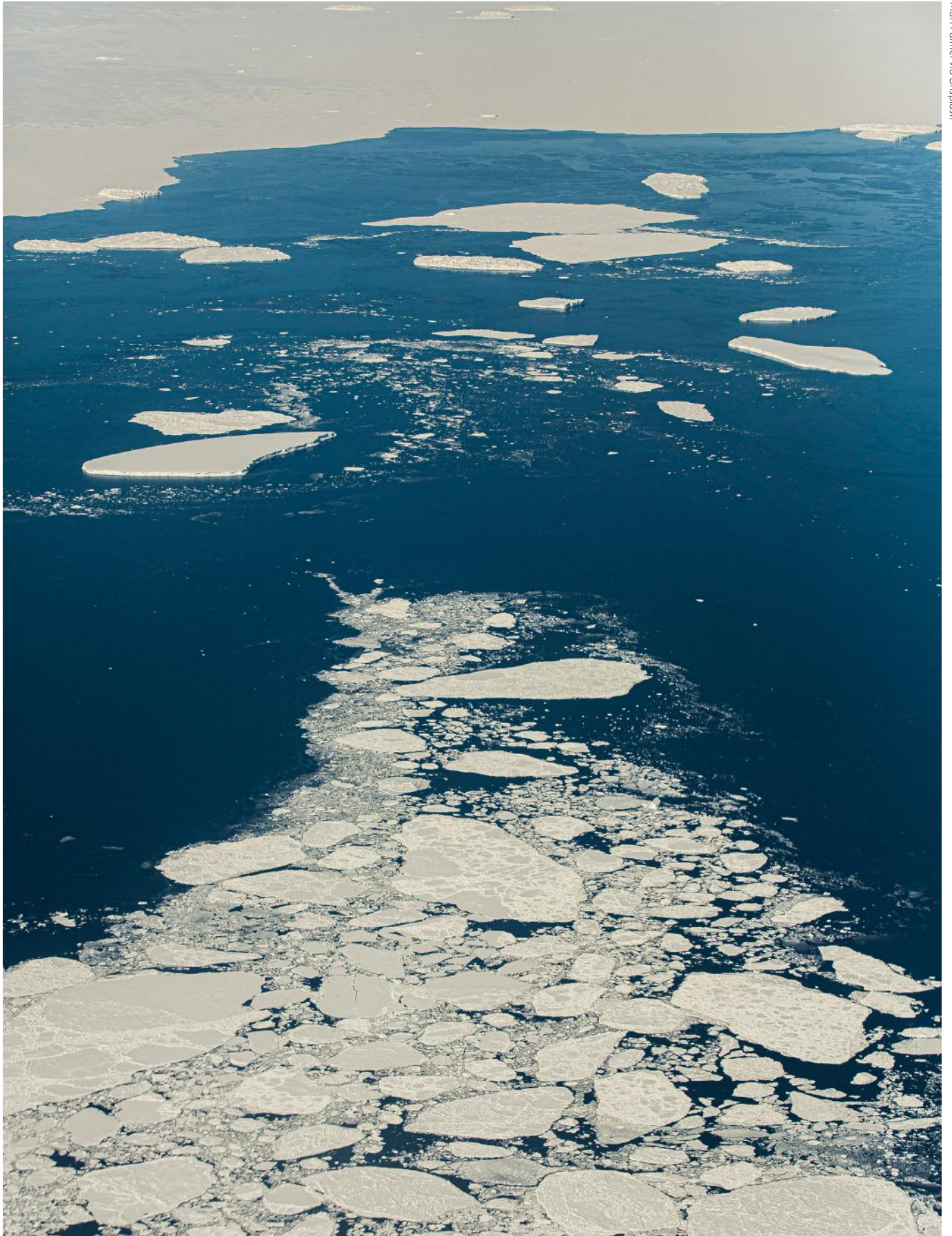
Rainfall is another important factor to consider in climate change. Long-term trends show less rainfall in southern and eastern Australia, while rainfall in much of the north has increased. Australia’s lowest recorded rainfall was recent – in 2019 – yet extreme rainfall events are likely to be more intense. In addition, the 2023 August to October period was Australia’s driest three-month period recorded since 1900.⁴

Together with high temperatures, these dry conditions contribute to unprecedented fire danger across much of Australia, particularly in south-eastern Australia. The forest fire danger index in December 2019 was the highest on record in most parts of the country, and for Australia as a whole.⁵ This was partly due to global warming and partly due to natural yearly variation, combining for catastrophic results.

In Victoria, the average temperature in 2023 was 0.69 °C above the 1961-1990 annual average, while rainfall was 5.3% below average.⁴ Changes in rainfall and temperature trends may appear small when compared to daily, monthly, or seasonal climate variability, however, the changes accumulated over decades have a large influence on the health and wellbeing of communities and ecosystems.

CSIRO’s most recent State of the Climate report projects an increase in the frequency and/or intensity of extreme weather events such as tropical cyclones, heavy rainfall, drought, and fire danger.⁶ Australia needs to plan for and adapt to the changing climate now and in the years ahead. With this knowledge, we can make informed decisions and be better prepared.





Matt Palmer via Unsplash

We're heating things up

There is an undeniable relation between an increase in greenhouse gas emissions from human sources and the increase in average global temperatures. The annual rate of increase in atmospheric carbon dioxide (CO₂) over the past 60 years is about 100 times faster than previous natural increases.⁷ Atmospheric CO₂ levels remained relatively stable for centuries (with natural, cyclic variation), but over the millions of years that we can trace, levels never exceeded 300 parts per million. Until now. CO₂ levels have been climbing since the mid-1700's, and reached a new record high in 2023 of 419.3 parts per million.⁷

The increase in atmospheric greenhouse gases, coinciding with the emissions from the industrial revolution and land clearing, provides powerful evidence that human actions are contributing directly to climate change. This rapid, human-driven increase gives ecosystems less time to adapt to changing climates. We are introducing a sudden shock into the system.

Earth's "last chance"

The latest Intergovernmental Panel on Climate Change (IPCC) report makes it clear that we are almost out of time to change the planet's trajectory.⁸ In its sixth iteration, there are few surprises: the alarming warming trends continue and the scientific evidence of the influence of human activity on the climate is only becoming stronger. The decisions that we make now, and the actions of this decade will determine the future.

Our window to avoid the worst of climate change is rapidly closing – by the time the Seventh Assessment Report is released, and if we work towards targets in 2050 as opposed to earlier time frames, a better or worse future will be locked in.

CSIRO uses the Australian Community Climate and Earth System Simulator (ACCESS) to model future climate scenarios based on our possible carbon emissions.⁹ According to the models, there are two paths that we can take: either emissions continue as they are and global warming continues, or we reduce them to stabilise the average global temperature. The very low emissions scenario gives us a chance of limiting warming to around 2-2.5 °C.⁹ But if we do not make changes to reduce emissions, the global average temperature could climb by over 6 °C by next century.⁹

Concerningly, even if temperatures do stabilise by 2050, sea levels will continue to rise for the next 300 years. This is because the melting of Arctic and Antarctic ice sheets and glaciers is difficult to stop, as they will no longer be stable.¹⁰

ACCESS presents us with two possible future worlds: one where carbon emissions are reduced, and another where carbon emissions continue and the global mean temperature shoots in the order of 6 °C and global land temperatures in the order of 10 °C higher – "that is a very different planet," says David.

It is not all doom and gloom, however. The climate has been set on a warming path – the long-lived greenhouse gases that are now in the atmosphere and the extra energy soaked up by oceans have guaranteed that warming will continue for the next few decades. But the sooner we act, the sooner we will see reduced impacts, and the greater our chance of avoiding the 'worst case scenario' projections in climate models and simulations.

Choosing our future

The future climate is in our hands. Energy production remains the primary driver of greenhouse gas emissions, followed by agriculture, forestry and other land uses, followed by industry and transport. Countries in the southern hemisphere are expected to experience the largest economic impacts from global warming, and it is therefore imperative that Australia takes leadership and responsibility for making change.

There are possible solutions for these sectors to reduce their production of greenhouse gases. We need more efficient use of energy, a transition to zero carbon energy sources, improvement of carbon sinks (e.g., uptake of CO₂ by soil, and algal farms in oceans), and lifestyle and behavioural changes on both individual and community scale.

The United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement to combat climate change requires commitment and action towards a sustainable, low carbon future.¹¹ The original target set was to limit global warming to 1.5 °C – and we have nearly surpassed that.

"We've got to limit global warming," says David. "We can do it. We can be sustainable. The choices we make will create different outcomes." The climate will continue to change if we do not change. Climate scientists have provided us with a choice for which planet we want based on our carbon emissions. The future is in our hands. Which future will you choose?

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1925

A boring existence

SCOTT REDDIE MRSV

Editor-in-Chief, Science Victoria

There are more than 8 billion people on this planet (plus ten currently in space).^{1,2} It's a massive number, and hard to visualise – even if we use the Victorian standard measurement of 'enough people to fill 80,000 stadiums the size of the MCG'.

Yet despite our numbers, humans make up only 0.01% of all biomass on Earth, when comparing the amount of carbon that each lifeform contains.^{3,4} A similar amount of biomass is contributed by a much smaller animal: termites.⁵

These insects are found on all continents apart from Antarctica.⁵ Australia has more than 300 termite species, with some of these arriving here from south-east Asia at three separate times over the course of 20 million years.^{6,7}

In December 1924, entomologist Gerald F. Hill described to the RSV nine of these species that he had newly classified. Hill was an accomplished entomologist, at the time working for the National Museum of Victoria, and later becoming the first entomologist appointed to the CSIRO.⁸ He had a particular interest in mosquitoes and termites, and had worked with the curator of the National Museum to amass a large collection of termite specimens from around the country over the previous 12 years.

His paper, "*Termites from the Australian Region: Descriptions of New Species and hitherto Undescribed Castes*", provided a significant amount of detail about the different species he had characterised. Detailed descriptions of the features, colours, habitats, and measurements of every part of the insect were accompanied by hand-drawn diagrams, as well as photographic plates of the locations that the specimens had been recovered.

As an example the level of detail he had used when describing new species:

"Calotermes (Calotermes) oldfieldi, n. sp. Soldier – Similar to C. condonensis Hill, from which species it differs in the following characters: Head shorter, wider and darker, mandibles shorter, stouter and more abruptly shouldered at the base, anterior hyaline [translucent] portion of clypeus ["face"] large, as long as posterior dark portion (hardly visible in C. condonensis), labrum ["upper lip"] much larger, gula [lower part of the head] wider, eyes larger, frons ["forehead"] less concave, antennae, 13- 18-jointed, the joints somewhat shorter and narrower, pronotum [section behind the head] more concave posteriorly, femora [part of the leg] not so thick."

Termites play an important role in ecosystems, where they decompose dead plant matter, and can even increase crop yields in dry climates.^{9,10,11} While we mostly associate termites with the estimated \$1.5 billion of damage they cause to homes in Australia each year, less than 6% of termite species are responsible for damage to buildings.^{12,13}

FROM:

Proceedings of the Royal Society of Victoria, Volume 37 (New Series), 1925. Article XIII - Termites from the Australian Region: Descriptions of New Species and hitherto Undescribed Castes

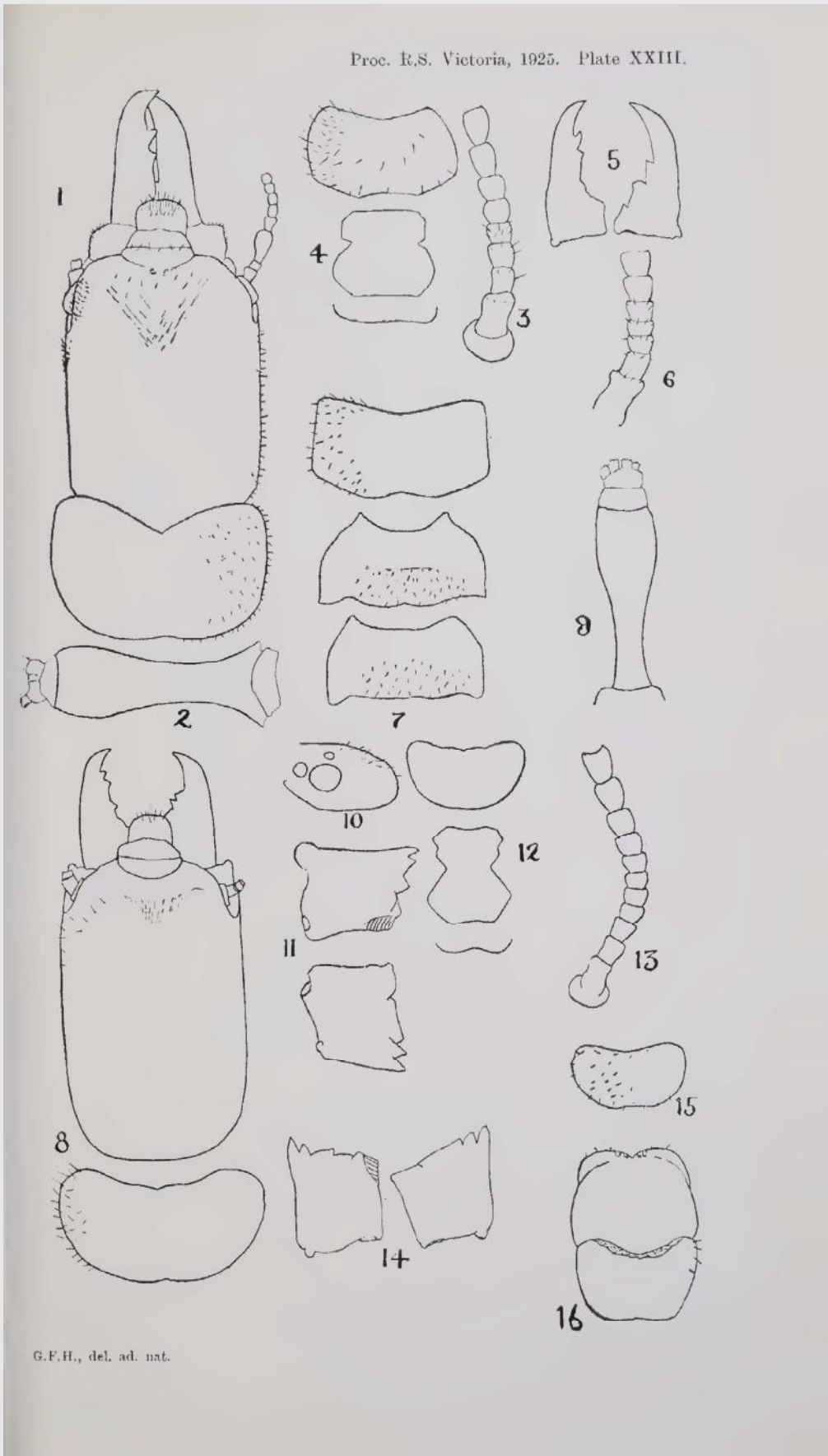
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OPPOSITE:

Drawings of termite parts by entomologist Gerald F. Hill. Source: *Proceedings of the Royal Society of Victoria, Volume 37 (New Series), 1925*.

Proc. R.S. Victoria, 1925. Plate XXIII.





Inspiring Victoria

inspiringvictoria.org.au

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

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questacon.edu.au

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





William Gibson via Unsplash

Rising Temperatures, Rising Anxieties

Supporting Youth Mental Health in the Face of Climate Change

DR CATRIONA NGUYEN-ROBERTSON
Senior Editor, Science Victoria

Climate change is not the future. It is the present.

It is making Victoria hotter and drier.¹ There are more days of extreme heat, and fire seasons are getting longer.¹ These impacts are felt by the environment and ecosystems, and our physical and mental health.

For years, climate scientists have been saying that we must reduce greenhouse gas emissions to net zero well before 2050. But the window of opportunity to limit global warming and prevent mounting damage from uncontrolled bushfires, droughts, floods, and sea level rise is rapidly closing.

The United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement set a target to limit global warming to 1.5 °C above the temperature in 1850 – and we have nearly surpassed that.² Last year (2023), the global average temperature was 1.44 °C higher.³

We needed commitment and action towards a sustainable, low carbon future yesterday – or, ideally, several decades ago.

Climate distress – anxiety over the uncertain future

The reality of climate change can be overwhelming and frightening. The situation is already dire, and will only get worse if we continue with business as usual, pumping greenhouse gases into the atmosphere.

In recent years, new terms have been coined: climate change distress, climate anxiety, and eco-anxiety.⁴ The terminology used to define the negative emotions related to climate change varies from one study to another, however, they all mean the same thing. They refer to the stress of not only *knowing* that climate is a threat, but also *feeling* that it is a threat.

There are a host of concerns and negative emotions (e.g., unease and worry) surrounding climate change, as well as the potential to feel helplessness over potential consequences for us now, and even more so for future generations.

Young people are disproportionately impacted by climate change concerns.⁵ The US Surgeon General acknowledged in 2021 that growing concerns about climate change may be contributing to increased mental ill-health for young people.⁶



Climate change is increasing the frequency and intensity of bushfires throughout Australia. Photograph: Fiona Smallwood via Unsplash.

Locally, two-thirds of young (aged 16-25) Australians consider these climate change concerns to have a negative impact on youth mental health.⁷ Similar Australian surveys indicated that most young people are concerned about climate change (78%) and are anxious about it (80%) – sometimes on weekly basis or to the point that they lose sleep.^{8,9}

With growing discussion about climate change, many are concerned about what all this means for the future. Many young people are worried about the effects of climate change on the planet, their communities, and their lives.

One young Australian surveyed by Orygen said: *“The increasing effects of climate change seriously impact my ability to think positively about the future, and sometimes it feels hopeless even planning for one.”*⁵

Another said: *“I have no future to look forward to. I fear the collapse of civilisation. I fear natural disasters like those seen increasing in frequency and severity already. This is the reality we have been told is coming, and yet nobody seems to care.”*⁵

Hope is not lost, and no one is alone

Research on effective interventions for climate distress is severely lacking, but those experiencing it are not alone. Young people’s concerns about climate change are valid – and acknowledging their concerns is a helpful place to start.⁵

Other factors that support young people’s ability to cope with climate distress include a sense of meaningfulness and optimism, an awareness of possible solutions, trust in environmental organisations, and a motivation to engage in positive environmental behaviours.¹⁰

To support youth experiencing climate distress, Museums Victoria initiated a ‘Climate Cafe’ series, in partnership with youth mental health foundations Orygen and headspace.¹¹ This series supports young people to have open discussions with science and mental health experts about the climate crisis in our shared world.

As part of the sessions, science experts and youth mental health experts lead safe group discussions around climate change and climate-related distress. Participants share their thoughts and feelings, discover things they can do to help them cope, find people they can turn to for support, and learn ways they can contribute to help the environment.

After a successful pilot program last year, Museums Victoria will run four sessions in 2024 around World Environmental Day (June), World Conservation Day (July), National Science Week (August), and National Threatened Species Day (September). In the program last year, 20 young people (aged 16-26) shared their experiences and thoughts, and many commented on the benefits of hearing each other’s backgrounds and perspectives, especially with a proportion of attendees being international students, and forming connections.



MV's Climate Cafe. Photograph: Eugene Hyland/Museums Victoria.

“We know that climate change is one of the megatrends driving the youth mental health crisis,” says Executive Director of Orygen, Professor Patrick McGorry. “This initiative gives young people the opportunity to come together with like-minded peers and share their experiences and concerns, learning from each other as well as from scientists and mental health experts.”

Understanding the short- and long-term mental health effects of negative emotions related to climate change in young people is key to supporting positive outcomes for individuals, communities, and society. This area remains understudied, and we still have a lot to learn to equip mental health professionals with evidence-based guidance. We should also be partnering with young people to develop climate distress supports and resources that they need.

“Combining Museums Victoria’s research-backed expertise in science and biodiversity with Orygen’s research-backed expertise in mental health, the Climate Cafes are a proactive initiative to empower our young people to hold a vision for a brighter future,” says Lynley Crosswell, CEO and Director of Museums Victoria.

The younger generations are our future, and they are growing up with an increasingly uncertain world due to the impacts of climate change. It’s vital that we invest in them, and support their mental health, as they face the environmental challenges left for them by current and previous generations.

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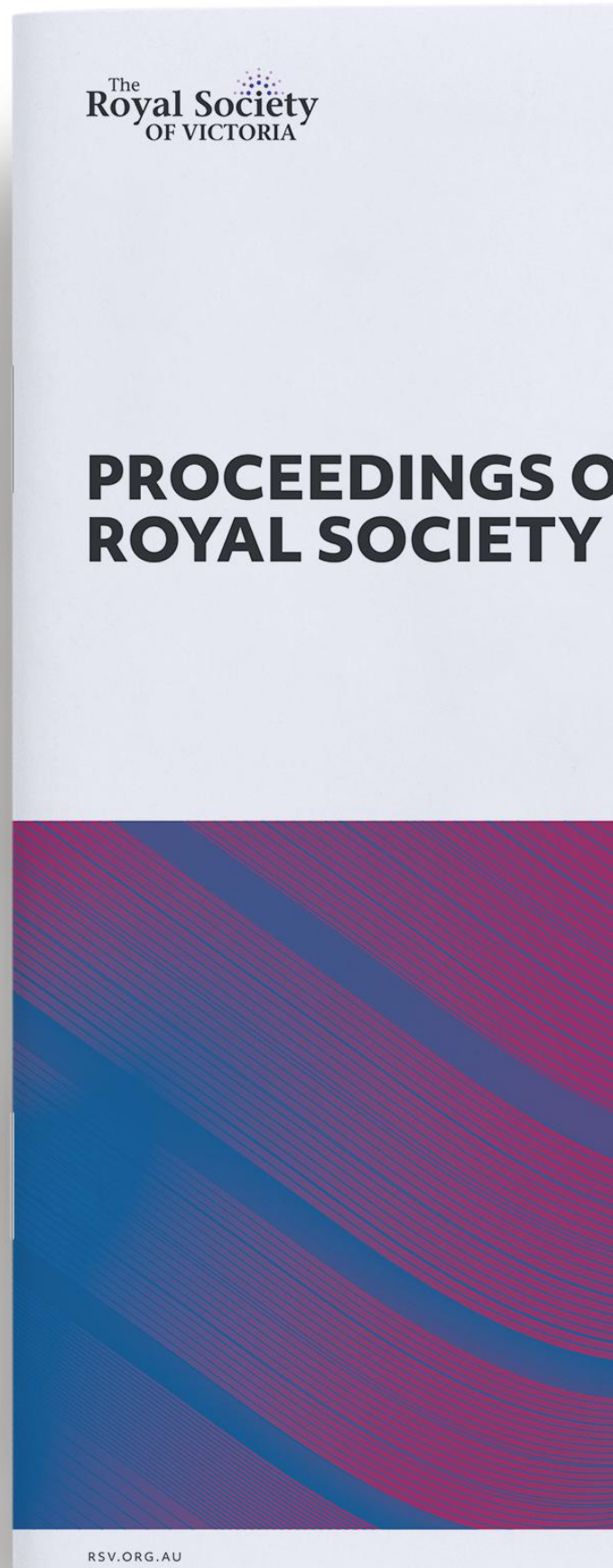
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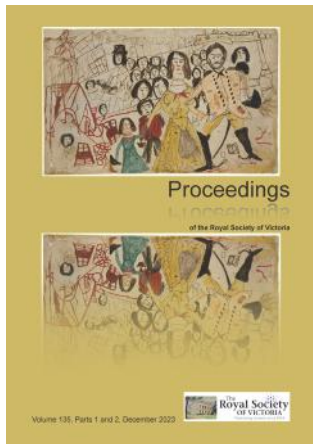


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Baron Alexander von Humboldt (1769 - 1859). Artist: Julius Schrader. Open access image courtesy of The Metropolitan Museum of Art.

Honouring Humboldt Research for a Sustainable World

Volume 135 of the Proceedings of the Royal Society of Victoria is now available online, open access from CSIRO Publishing, hosted at publish.csiro.au/rs/issue/11551.

This volume is substantively dedicated to the theme 'Humboldtian Research Towards a Sustainable World,' drawn from the proceedings of the 19th Biennial Conference of the Australian and New Zealand Associations of von Humboldt Fellows in 2022.

There is an additional paper from Dr Thomas Darragh and Dr Ruth Pullin, translating letters from the celebrated German painter Eugene von Guerrard, then based in Australia, to the Ethnological Museum in Berlin from 1878 – 1880, along with the collected abstracts from colleagues presenting at the RSV's 2022 symposium on 'Next Generation Biocontrol of Invasive Vertebrate Pests.'

Alexander von Humboldt has been referred to as 'the forgotten father of environmentalism.'¹ As early as 1844, he wrote that humans change the climate 'by cutting down forests, by changing the distribution of water bodies, and through the production of large vapour and gas masses at the centres of industry.'² Humboldt also described the greenhouse effect in his opus magnum, 'Kosmos'. And time and again in his writings and in his lectures, he emphasised the interconnectedness of all living creatures on this planet. In times when the effects of climate change become ever more visible and palpable around the globe, it is imperative that the global academic community addresses the topic of sustainability in all its dimensions.

Dr Thomas Hesse
Deputy Chair, Alexander von Humboldt Foundation

Papers from Volume 135

Australian indigenous edible halophytes — nutritious and functional for a sustainable future: antioxidant capacity and antimicrobial properties

BY SUKIRTHA SRIVARATHAN, ANH DAO THI PHAN, MARAL SEIDIDAMYEH, OLIVIA R.L. WRIGHT, YASMINA SULTANBAWA AND MICHAEL E. NETZEL

The University of Queensland

Abstract:

In recent years, edible halophytes (salt-tolerant plants) have received more attention due to their ability to tolerate a wide range of salinities. Furthermore, halophytes have long been used for food, feed and medicinal purposes. However, available information on their nutritional profile (including antioxidant compounds) and bioactivity is still very limited. Therefore, the present study investigated the antioxidant capacity and antibacterial activity of three important Australian indigenous edible halophytes. These initial results are very promising and indicate that Australian grown halophytes may have the potential to be utilised as novel sources of antioxidant and antimicrobial compounds for different food applications.

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The role of nuclear power in a sustainable future

BY ANTHONY W. THOMAS

Department of Physics, University of Adelaide

Abstract:

In an era where global warming is a major threat, nuclear power offers an alternative to fossil fuels that has a number of advantages. In this paper, the advantages and challenges associated with this source of energy are reviewed.

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GERMANTOWN REVISITED

Gabrielle L. McMullen

► pp. 7-14

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A WORLD WITHOUT BEES: NEW INSIGHTS FROM AUSTRALIA FOR MANAGING SUSTAINABILITY IN A CHANGING CLIMATE

Adrian G. Dyer, Mani Shrestha, Jair E. Garcia, Scarlett R. Howard, Malika Nisal Ratnayake and Alan Dorin

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GENOME BANKING OF ANCESTRAL HAPLOTYPES FOR FUTURE SURVIVAL

Erwin A. Paz, Lani A. Wade, Anthony J. Lloyd, Sally S. Lloyd and Roger L. Dawkins

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PHOTONIC RESERVOIR COMPUTING FOR ENERGY EFFICIENT AND VERSATILE MACHINE LEARNING APPLICATION

Kathy Lüdge

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A SUSTAINABLE WORLD REQUIRES DARKNESS AT NIGHT

John B. Hearnshaw

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SUSTAINABLE CHEMICAL SYNTHESIS: MAKING MOLECULES USING VISIBLE-LIGHT IRRADIATION

Daniel L. Priebsenow

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WHERE ARE WE AT WITH SHAPE-MEMORY ALLOYS IN THIS 'HIGH-TECH' WORLD?

Trevor R. Finlayson

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WAVES THAT APPEAR FROM NOWHERE

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SUSTAINABILITY FROM A CELL PERSPECTIVE

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WHERE ARE WE AT WITH SHAPE-MEMORY ALLOYS IN THIS 'HIGH-TECH' WORLD?

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STORIES ABOUT SYMMETRY

Rebecca A.H. Waldecker

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Tom Rumble via Unsplash



Bogomil Mihaylov via Unsplash

CONSULTATION CLOSES 30 JUNE 2024

Help Us Shape the Future for Victoria

The Department of Transport and Planning is seeking input on reimagining the future of our cities, suburbs, towns, and regions.

engage.vic.gov.au/shape-our-victoria

CONSULTATION CLOSES 31 JULY 2024

Inquiry into Women’s Pain Survey

Women face real and enduring challenges when seeking care and support for pain. The Department of Health wants this to change, and the first step is to ask you about it.

engage.vic.gov.au/inquiry-into-womens-pain-survey



Submission Guidelines

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

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

Style Guide

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

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

Feature Articles

Recommended length: 600 - 1,800 words

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

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

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

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

Pitch it to us!



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

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

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

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

Opinion Articles

Recommended length: 600 - 1,800 words

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

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

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

Letters

Recommended length: 200 – 1,000 words

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

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

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

What I've Been Reading

Recommended length: 600 - 1,800 words

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

Images and Figures

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

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

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

References

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

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

Submission Deadlines

MARCH 2024

Victoria's Fauna

DUE DATE

16 February

Everything *Animalia* in Victoria, particularly native fauna.

APRIL 2024

The Four Planetary Crises

DUE DATE

15 March

Biodiversity Loss, Climate Change, Pollution & Waste, and The Rise of Misinformation

MAY 2024

Accessibility & Inclusion in STEM

DUE DATE

19 April

Supporting the education, employment, and engagement of everyone in STEM.

JUNE 2024

Victoria & Climate Change

DUE DATE

17 May

The impacts of, research on, and responses to climate change in Victoria.

JULY 2024

Building Scientific Competency

DUE DATE

14 June

Empowering individuals and communities to understand the scientific method.

AUGUST 2024

STEMM Throughout Victoria

DUE DATE

19 July

The opportunities for learning and engaging with STEM across the state.

SEPTEMBER 2024

Pollution in Victoria

DUE DATE

16 August

The different pollutants, sources, impacts, and responses required.

OCTOBER 2024

Victoria's Ecosystems

DUE DATE

13 September

The many and varied ecological niches across Victoria

NOVEMBER 2024

Science & Policy

DUE DATE

18 October

From lab bench to front bench: how scientific understanding can positively influence policy.

DECEMBER 2023

Science & Business

DUE DATE

15 November

Creating a sustainable industry, start-ups, med-tech, patents, and ethics.

Hold Your Next Event at the Royal Society of Victoria

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

Services Available

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

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



The Burke and Wills Room

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

SUITABLE FOR

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

CAPACITY

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

The Facilities

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

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

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



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

▶ Email rsv@rsv.org.au to discuss your needs and ideas!



The Ellery Lecture Theatre

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

SUITABLE FOR

Presentations, seminars, lectures.

CAPACITY

Any Booking	≤110 people
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Support Victoria's Science Society in 2024 and help us to engage individuals and communities with STEMM

WHO WE ARE

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

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

WHAT WE DO

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

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

WHERE YOUR DONATIONS GO

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

HOW TO SUPPORT

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

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



The Millis Room

A versatile room on the ground floor, with views of the Carlton Gardens. Suitable for smaller meetings, group/individual work, or seminars.

SUITABLE FOR

Meetings, group/individual workspace, and seminars.

CAPACITY

Any Booking ≤15 people



The Cudmore Library

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

SUITABLE FOR

Meetings, seminars, and videoconferencing.

CAPACITY

Any Booking ≤15 people



The Von Mueller Room

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

SUITABLE FOR

Meetings, seminars, and videoconferencing.

CAPACITY

Any Booking ≤15 people

Become a Member of the RSV

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

	STUDENT \$40 PER YEAR	FULL \$120 PER YEAR	ORG. \$1000 PER YEAR	SCHOOL \$1000 PER YEAR	AFFILIATE \$500 PER YEAR
Special Membership rates at RSV and affiliate events.	✓	✓			
Networking opportunities – national and local.	✓	✓	✓	✓	✓
Recognition of membership through use of post-nominal affix	MRSV	MRSV			
<i>Science Victoria</i> Digital Edition (Printed copy available for an additional fee).	✓	✓	✓	✓	✓
Free monthly printed copies of <i>Science Victoria</i> for school libraries.				✓	
Recognition of achievements through awards programs.	✓	✓			
Discounted advertising in <i>Science Victoria</i>			✓	✓	✓
Discounted facility hire at 8 La Trobe Street, Melbourne.			✓	✓	✓
Discounted membership rate for eligible full-time students.	✓				
Discount on purchases from CSIRO Publishing	✓	✓			
'Schools Supporting Schools' Membership Program*				✓	
Listing of membership on the RSV.org.au website.			✓	✓	✓

New Individual Members

PROFESSOR VASYL MOSIICHUK
President, Deva Clinique, Ukraine

MR ADRIEN MAIRE
Student, RMIT University

PROFESSOR DAVID KAROLY
Emeritus Professor, The University of Melbourne

MS NATALIE CHEN
Investment Advisor, Australian Super

MR EVAN DAVEY
Country Lead, DEPT®

MR CRISPIN BLACKALL
Chief Strategy & Transformation Officer, TomorrowX



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

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

New Organisational Member



TomorrowX

Enabling the digital circular economy, TomorrowX offers a Composable Architecture Platform (CAP), which incorporates and builds upon the principles and power of Object Oriented and Functional Programming. The CAP delivers a natural and intuitive form, through visual Components. There is no code, and therefore no coding. Consequently, programmers now Compose, they do not code. Out of the box, Composers can use any of 500+ Components - and create their own.





Science Victoria
The Royal Society of Victoria
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View the Digital Edition
Scan the QR Code or go to:
rsv.org.au/news/science-victoria



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