



Chief Scientist

AUSTRALIA 2025: SMART SCIENCE

THE CONVERSATION



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Australia can nurture growth and prosperity through biology

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Further comment: Professor Andrew Cockburn and Dr Marguerite Evans-Galea

AUSTRALIA 2025 – Smart Science: How will science address the challenges of the future? In collaboration with The Conversation, we’re asking how each science discipline will contribute to Australia now and in the future. Written by luminaries and accompanied by two expert commentaries to ensure a broader perspective, these articles run fortnightly and focus on each of the major scientific areas. Today, we put biological science under the microscope.

One of the 20th century’s most famous scientists, physicist Ernest Rutherford, explained:

When we have found how the nucleus of atoms is built up we shall have found the greatest secret of all — except life.

The 21st century is set to be the time when the study of life – biology – steps up. Once, as Rutherford also said, it may have been true that “Physics is the only science, all else is stamp collecting” but now physics, chemistry and mathematics have combined and ignited a revolution in biology.

The work of Darwin on evolution and Mendel in genetics provided understanding of how all living things are connected and a fundamental mathematical framework for inheritance.

James Watson and Francis Crick used physics to reveal the chemical nature of the DNA code, and their followers have used the tools of chemistry, physics and informatics to sequence genomes at an ever increasing rate, and most critically have shown how genes work and can now be manipulated in the lab for experimental or therapeutic purposes.

The tools that have brought about the revolution in genetic engineering came from broad studies in biology, from work on bacterial viruses, green fluorescent jellyfish, yeast, fruit flies, tiny weeds and nematode worms, as well as from medical science projects directed at specific diseases.



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The stage is now set to dissect in order to understand, and to connect and build.

Discoveries of note (and coin)

Fundamental discoveries in biology are now laying a foundation on which future advances in agriculture, environmental science, and medicine will be built.

This knowledge will help Australia maximise food security and implement biosecurity to minimise the spread of pests and foreign diseases. At an environmental level our understanding of ecology is improving. One hopes we can preserve rich ecosystems to enjoy and share with tourists from all over the world.

The molecular knowledge of how our bodies operate informs our understanding of infectious, chronic and genetic diseases. This knowledge provides hope for future drugs and other cures, as well as the minimisation of health costs through better targeting of therapies and personal medicine.

So if we are talking about productive agriculture, rich environments, and drug companies, about the future prosperity of Australia, then one thing we're talking about is money. It is difficult to make forward looking economic or scientific predictions but I do know that looking back can inform us about the future – so let's look at money in the past.



Front (left) and back (right) of the Australian \$2 note

Let's look at Australia's first banknotes. The Australian \$2 note has now been replaced by a coin but in the past it pictured John Macarthur on the front and William Farrer on the reverse.

Macarthur was instrumental in developing the first sheep breeds to prosper in the Australian environment and for many years wool has been a core product in the Australian economy. One wonders how the new colony would have fared without practical Australian approaches to selective sheep breeding. The wheat strains developed by Farrer, particularly the Federation strain, have fed our nation and the world.

In the future, having players in the international quest for more productive, more resilient and less environmentally damaging livestock and crops will be critical to our nation, especially as the climate warms.



Sir Howard Florey on the old \$50 note. Wikimedia Commons

On the old Australian \$50 note there was Howard Florey, who developed the first widely effective antibiotic, penicillin.

It is easy to forget how antibiotics have revolutionised human health. One wonders how many Australians have not benefited directly from antibiotics – from time to time I certainly have.

In addition to those that have featured on our banknotes, other Australian biologists have been on our stamps, such as the Nobel Prizewinner Peter Doherty, who revealed secrets of the immune system, and the late Nancy Mills, a leader in industrial microbiology.

Then there are others who may not yet have been immortalised in currency but who may be in the future:

- Barry Marshall and Robin Warren who identified helicobacteria as causing stomach ulcers and who thereby helped myriad sufferers worldwide
- the late Frank Fenner, who combatted the rabbit plagues using myxomatosis
- those who defeated prickly pear by introducing the *Cactoblastis* caterpillar
- Don Metcalf and others at the Walter and Eliza Hall in Melbourne and the drugs they have produced have saved many people from blood cancers
- Ian Fraser's Gardasil vaccine, which arose from his ability to understand and grow disease viruses, is protecting the next generation from papilloma virus-triggered cancers.

Our banknotes do not currently feature any prominent ecologists or environmental scientists but the coins certainly attest to the beauty of our natural fauna.

One and two cent coins are no longer in circulation but fortunately the feathertail gliders and frill-necked lizards featured on them certainly are, as are the echidnas, lyrebirds, platypus, emus and kangaroos on our other coins.



The preservation of our ecosystems is critical to our well-being as a nation. Over the first two hundred years of European settlement land clearing, water usage, grazing practises and introduced species have had a profound effect on our fauna and flora, but a rich network remains.

Australian biologists are continuing to work to understand how to minimise negative impacts so that we can preserve important ecosystems, including our deserts, rainforests and the Great Barrier Reef. These are places that we and tourists can enjoy, while other areas can be sustainably managed for food or wood production as appropriate.

Biological attraction

The advances in biology and the parade of illustrious biologists in Australia has drawn a generation of new students and the general public to the study of biology.

For complicated reasons the number of students studying maths, physics and chemistry is not increasing as it should in this increasingly technological world. This is a problem that Australia must address, but happily at least biology is thriving.

Science is vital not just for generating material prosperity, or for enriching our own experiences, but also for providing material by which we can each develop skills in critical thinking, in understanding evidence and argument. Science tells us that not everything is relative – in some cases there really are right and wrong answers. In many instances, biology will be the only science our citizens formally study, so it will remain a very important illustrator of the scientific method.

The ability to understand scientific thinking and evidence, helps societies to choose between snake oil salesmen and practical leaders.

Biology is also valuable at an individual level, as human biology underlies all health and medicine. Knowing biology is critically important for our own personal health choices.

Since its beginnings Australia has had to be a resolutely practical and realistic country. We have a beautiful but in many ways a harsh and fragile home. Through scientific understanding and rational argument we have found ways to survive and prosper. Biology and the other sciences will remain essential to our future successes.

Further comment: Andrew Cockburn

Merlin Crossley rightly lauds biology's profound role in the health and prosperity of Australians – but biology is a broad church, and nobody can master it all.

So how can Australia ensure we nurture and retain the expertise to lead us into – and beyond – 2025?

We need to acknowledge that while our extraordinary fauna and flora and our long history of success in agriculture are huge advantages for our nation, they are also a vulnerability demanding expertise in many disciplines to exploit and protect those advantages.



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It takes an expert to recognise myrtle rust and that it could be a threat to our forests and woodlands, or that a tiny scale insect could devastate a crop vital to our economy, and we need to find a way of preserving that breadth of expertise.

It is increasingly hard for the scientists that have such skills to thrive in metric-driven universities or a CSIRO dealing with immediate funding problems, threatening our breadth of knowledge in the biology of whole organisms.

There are solutions. Some years ago I was asked to review a submission from Canadian universities to their research council about how funds should be deployed to support ecology. I was delighted to see that they recognised that the expertise in the taxonomy of arctic plants was about to be lost to retirement, which, given their frozen north, was a national imperative demanding support.

Our own extraordinary biological diversity makes the need for expertise even more compelling.

Further comment: Marguerite Evans-Galea

Like no other discipline, biology integrates the enabling sciences of physics, chemistry and mathematics to address the hard questions – including those we have yet to ask.



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All of the sciences, but particularly biology, rely heavily on technology for their ongoing and future success. In the throes of the “omics” era – such as genomics and proteomics – we have never had a bigger picture of life at the nanoscopic level, than we do today. A clear understanding of this “big data” and successfully translating that into everyday practice is essential to transforming our economy.

In the next decade, personalised medicine and specialised drug development will take front seat. Biotechnology, nanotechnology and affordable genome sequencing are already revolutionising medicine at a rapid pace.

They are also central to ensuring a safe, secure food and water supply in the context of climate change. Already, we are creating alternate

bioenergy sources, discovering new agricultural pests, fighting antibiotic resistant bacteria and maximising the conservation of our natural flora and fauna.

Such cutting-edge developments in biology will require a well-educated, highly skilled scientific and manufacturing workforce – creating jobs and exports. With visionary leadership and strategic investment, 2025 will see biology leading Australia well into the 21st century.