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Editorial: *Gravy* waves, serendipity, and regeneration

Robert Marks

Editor

This issue includes eight papers, one book review, two obituaries, and nine abstracts from recent PhD theses. Following Hugh White’s paper in the June issue on Australian–Chinese relations, the December issue has two related papers: one, by Gus McLachlan and Andrew Condon, which brings their active service experience to the Society, in their discussion of how the war in Ukraine has spurred the use of different weapons. The second, by James Renwick, is a paper on the evolution of the international law of war crimes, prompted by the Russian attack on Ukraine. There is a paper on an exhibition to celebrate the Darlinghurst Gaol and its history, as revealed through the scrapbook of John Cecil Read during his tenure from 1861 to 1888.

Another paper in this issue provides two examples of the role of serendipity in commercial life. It raises the question: just how important is luck in life? Is Mr A truly talented in his success, or has he been merely lucky? What of Ms B? Is she “down on her luck” or does her poverty reflect her lack of talent or drive? To discuss this, two observations: first, human attributes (including intelligence, height, strength, athletic prowess, etc.) have been measured as normally (Gaussian) distributed in the population (that is, a frequency plot is bell-shaped). On the other hand, consider the distribution of success in life — wealth, for example. Adult

wealth is not normally distributed on a bell curve. Instead, wealth exhibits a power-law (Pareto) distribution:¹ the vast number of people have low or medium incomes; vanishingly few are billionaires.²

This issue — luck or talent — has been addressed by several authors, including Frank (2016). An approach close to my simulator’s heart is that of Pluchino, Biondo, and Rapisarda (2018), who developed a simple agent-based simulation model in which talent is normally distributed across agents, but in which there are random elements (“luck”) affecting agents’ outcomes. They find that, if it is true that some degree of talent is necessary to be successful in life, it is almost never the most talented people who reach the highest peaks of success, rather they are overtaken by luckier individuals of average talent.

The late Stephen Gaukroger won the 2022 the Royal Society History and Philosophy of Science Medal. At our request, he submitted a paper which was due to appear in the June issue, but with other papers was held over to the December issue. Stephen had signed off on the galleys before his unfortunate death. He asks to what extent technical progress has resulted from engineers solving problems rather than from scientists’ theories.

Another paper held over was a report from Len Fisher of a conference, “Complexity, Criticality and Computation,” held

1 https://en.wikipedia.org/wiki/Power_law

2 A good example of a power-law distribution is the spread of per-capita greenhouse gas emissions across the world. See Oxfam (2023). And read the paper by Falk et al. (2023) in this issue.

earlier in 2023 on Heron Island, Qld., which brought together complex-systems experts from around the world to discuss the latest in complex-systems research. Nothing daunted, the participants discussed three questions: first, are there universal principles across both physical and biological phenomena; second, what are the principles underlying the emergence of consciousness, language, and intelligence; and, third, are there fundamental physical constraints guiding the rise and fall of civilisations?

A recent decision of the NSW Government is to allow culling of the up to 15,000 feral horses at large in the Kosciuszko National Park. This has been a contentious issue (see “The Man from Snowy River”) for years, with some vested interests appealing to “heritage” values. And yet there was an earlier use of the Park involving sheep and cattle, not horses. This managed summer grazing was ended after the ecological damage was realised, and extensive rehabilitation and regeneration of the fragile alpine ecosystem was undertaken over some years (Good and Johnston 2019).

So another paper in this issue is of topical interest: Coyne (2023) describes how three islands in the South Pacific — Phillip Island (near Norfolk Island), Lord Howe Island, and Macquarie Island — were infested by exotic species of animals (rats, rabbits, cats etc.) and plants, which degraded the local ecosystems. After some time (years, centuries) successful attempts were made to eradicate the invaders, and then to regenerate the islands’ ecosystems. Despite the almost complete denuding of Phillip Island, a blanket of green has covered the small island, including the discovery of a plant new to science. On Lord Howe Island a relic population of stick insects was discovered and is now thriving around the world. And

on Macquarie Island the populations of birds are recovering. All this suggests that removal of horses from Kosciuszko National Park will also reveal the survival of plants and animals now at risk of extinction.

Falk and 29 others (2023) is the (reprinted) consensus statement from the Regional Action on Climate Change Symposium (RACC-15) held on September 30, 2023, as an adjunct session of the 20th Annual Meeting of the Science, Technology and Society Forum (Kyoto), which included participation of nearly 1,500 global leaders in science and technology, policymaking, business, and media from over 80 countries, regions, and international organisations. This statement is a timely input for the 28th session of the Conference of the Parties (COP28) to the UN Framework Convention on Climate Change (UNFCCC) held at Expo City, Dubai in the United Arab Emirates (UAE), on November 30 to December 12, 2023.

Finally, the issue includes a review by Wilfred Prest of the 2022 book, *The Search for Truth: History and Future of Universities*, by Max Bennett.

What is the speed of gravity?

How fast does gravity travel? I don’t mean how fast objects move under the influence of gravity: the rate of acceleration is a function of the two masses. What I mean is how fast does gravity propagate through space-time? The question would have been purely hypothetical until the existence of gravity waves (the ripples through space-time from the interactions of massive objects in space) was confirmed in 2015 by the use of extraordinarily sensitive detectors. Einstein was right. These instruments provide a new dimension of observing the heavens — detecting via gravity waves the collisions of neutrons stars and even black holes, the end products of

pairs of neutron stars as they circle inwards and then collide.

But, until recently, there has been no concurrent observation of electro-magnetic radiation (light, gamma rays) associated with these collisions, and so no way to compare the speed of gravity waves with that of light. Would the light and gravity waves (we need a better term than “gravity waves” my suggestion is *gravy* or *gravvies*) from these collisions arrive here simultaneously, or might gravvies lag?

Following Siegel (2023), on August 17, 2017, the signal from an event that occurred 130 million light-years away finally arrived on Earth. From somewhere within a distant galaxy, two neutron stars had been locked in a gravitational dance where they orbited one another at speeds that reached a significant fraction of the speed of light. As they orbited, they distorted the fabric of space owing to both their mass and their motion.

Whenever masses accelerate through curved space, they emit tiny amounts of radiation that’s invisible to all light-based telescopes: gravitational, rather than electromagnetic, radiation — that is, *gravy* rather than light. *Gravvies* behave as ripples in the fabric of spacetime, carrying energy away from the system and causing their mutual orbits to decay. As time went on, the two neutron stars began to in-spiral, with *gravvies* carrying orbital energy away, causing the two objects to migrate closer and closer together. At a critical moment, these two stellar remnants spiralled so close to one another that they collided.

Immediately, the *gravy* signal came to an abrupt end. The gravity-wave instruments LIGO and Virgo detected *gravvies* from the in-spiral phase up until that moment, followed by total *gravy* silence. Accord-

ing to our best theoretical models, this was two neutron stars in-spiralling and merging together, likely resulting in the formation of a black hole.

But then, 1.7 seconds later, after the *gravy* signal had ceased, the first electromagnetic (light) signal arrived here — gamma rays, which came in one enormous burst. From the combination of *gravy* and electromagnetic data, the location of this event was soon calculated, the galaxy known as NGC 4993.

Now, NGC 4993 is 130 million light years away. The waves — both light and *gravy* — had taken 130 million years to get here. This gave us the most impressive physical measurement of the speed of gravity ever: it is equal to the speed of light to better than 1 part in a quadrillion (10^{15}), as 130 million years is around four quadrillion seconds, and the signals arrived less than two seconds apart.

Before 2017, we had excellent theoretical reasons for believing that the speed of gravity was equal to the speed of light, but only had indirect constraints that the two were equivalent to within 0.2% or so. The improvement in measurement of more than 12 orders of magnitude, with one single observation, represents the most significant leap from a single measurement of all time.

Why didn’t the two events — the end of the *gravvies* and the arrival of the light — occur simultaneously? Siegel (2023) discusses possibilities: for instance, the black hole took a second or two to form from the colliding neutron stars. Further observations might shed light (no pun intended) on these events, but Siegel believes that the observation of what is now known as the *gravy* event GW170817 reveals that *gravvies* propagate at the speed of light.

In a related piece, Siegel (2019) discusses whether we could ever detect gravity particles — so-called gravitons — analogous to light particles, photons. Since all objects can exhibit the characteristics of both particles and waves, suitably measured, gravities likely do comprise gravitons oscillating, but it will take great technical advances in our devices to detect them. After all, we have only just developed the technology to detect gravities, or gravity waves.

Housekeeping

There are two obituaries in this issue of the *Journal*: Stephen Gaukroger FRSN died after his article in this issue had been signed off on; his obituary was written by a colleague, Conal Condren. The second obituary is for Adrian Lee FRSN, whose long piece on his role in verifying that *Helicobacter pylori* was the cause of gastric ulcers was published two years ago (Lee 2021). This paper laid out Adrian's research career in a very clear way, but it did not reflect his passion for quality teaching. In the obituary, I borrowed from Mitchell et al. (2023) to gather more information on his life and interests. But how useful it would be to have, from the horse's mouth, so to speak, the deceased's judgments of their best achievements. At the request of Council, I have contacted all 19 Distinguished FRSNs, asking what accomplishments of theirs they would wish to be known for. So far I have heard from several Fellows. The responses will be kept for the future.

I have also started contacting our Exchange partners, asking whether they want to continue exchanging printed copies of their journals with ours. Seven years ago

I did the same thing, after taking over the editorship. So far, one yes and one no.

I am very glad to note here that my long-time collaborator on producing the *Journal & Proceedings*, Jason Antony, has been honoured for his work here and on the *Bulletin* with a Royal Society Citation. Thank you, Jason, and congratulations.

Balmain, November 26, 2023.

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Does science get the credit for too much?

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Abstract

Engineering and technology have traditionally been included under the rubric of “applied science,” but this has been questioned in recent scholarship, which has drawn attention to the independence of these. They are typically not at all mere applications of science but in many cases motivate scientific enquiry. I draw attention to the criticisms of the “applied science” model that have been raised, and ask what consequences this has for our understanding of science.¹

Introduction

At the end of the nineteenth century, science was considered to lie at basis of the progressive enhancement of civilization: railways, piped water, sewerage systems, steam-powered shipping, better food, warmer homes, softer clothing, and the massive transformation of domestic life and working hours brought about by the introduction of gas and electric lighting. But was it science as such that delivered the goods? When people thought about the benefits of modernity, for example, what they thought about were technological and medical achievements affecting the domestic and working environment, not an increase in the theoretical understanding of natural processes.

What is the connection between the two? The traditional answer is that technology is simply “applied science.” There is “pure science,” the search after truth, and the by-products of this, practices wholly dependent

on it. Consider the statement (1956) of the historian of science George Sarton, for whom “the chief aim of scientific research is not to help mankind in the ordinary sense, but to make the contemplation of truth more easy and more complete,”² or that by Charles Eliot, president of Harvard University from 1869–1909, when he claimed that the goal of science had nothing to do with its practical applications, but the fact that science “enables and purifies the mind.”³ “Purity,” of course, needs to be protected. When the Regius Chair in Civil Engineering and Mechanics was instituted at Glasgow in 1840, there was staunch opposition to the subject from the professors of natural philosophy and mathematics, who argued that any theoretical questions were exclusively theirs, and that practical skills could be taught outside the university through the apprenticeship system. The chemistry professor was particularly obstructive and managed, as a matter of principle, to prevent

¹ Emeritus Professor Stephen Wallace Gaukroger died on 3rd September, 2023. Stephen Gaukroger won the Royal Society 2022 History and Philosophy of Science Medal. See his obituary below.

² Sarton (1956), p. 188.

³ Quoted in Kevles (1971), p. 24.

the teaching of engineering in any of the university rooms for the whole of the first year.

Three questions

This conception of the relation between science and technology prompts three questions. First, can one have technology without science? Second, rather than technology just being applied science, can it actually precede and initiate scientific investigation? Third, in cases where technology and engineering interact with scientific investigation, what actually happens? I've dealt with these questions in some detail in my *Civilization and the Culture of Science* (2020), and I'll look briefly at each of them.⁴

On the first question, it is pretty clear that much technology has been independent of science. The historian of technology, Channell, sums up the situation in these terms:

As historians began to examine the history of technology they found little evidence for a strong dependence upon science. A detailed historical analysis of such major technological inventions as movable type printing, the mechanical clock, guns and gunpowder, metallurgy, the steam engine, textile machines, machine tools, railroad, and the automobile led to the conclusion that such inventions depended little, if at all, on scientific knowledge, skill, or craftsmanship. Historians of technology also began to challenge the common assumption that the Scientific Revolution of the sixteenth and seventeenth centuries has been primarily responsible for the Industrial Revolution of the eighteenth and nineteenth centuries. Almost

every important technological development that contributed to the Industrial Revolution — such as Abraham Darby's production of iron using coke, Richard Arkwright's textile machinery and Thomas Newcomen's steam engine — owed little to any scientific theory or discovery. Even when some connection between technology and science could be identified, the connection many times turned out to be either indirect or much more complex than the applied science model indicated.⁵

Some confusion has resulted from the idea that any advances in technology must *ipso facto* be the result of science. Vannevar Bush, an engineer who directed U.S. wartime research and headed the Office of Scientific Research and Development, said that when he came to discover that his British counterparts considered that the engineer was a kind of second-class citizen compared to the scientist, he decided to designate all wartime researchers working in the Office of Scientific Research and Development as scientists. He noted that even after World War II the public was led to believe that such an achievement as the landing of the first astronauts on the moon was a great scientific achievement when in fact "it was a marvellously skilful engineering job." Such engineering jobs depend on skills that scientists do not necessarily have. The early years of aeroplane design are a good example, depending strongly on visualization and hit and miss tests. In 1917 the editor of *The Aeroplane*, Charles Grey, wrote that we should "trust the man who guesses, and guesses right," rather than the scientist, who turns "out strings of incomprehensible calculations resulting from

⁴ This paper draws on my *Civilization and the Culture of Science: Science and the Shaping of Modernity 1795–1935* (Oxford, 2020). The themes explored briefly here are dealt with in detail there.

⁵ Channell (2017) p. 10.

empirical formulæ based on debatable figures acquired from inconclusive experiments carried out by persons of doubtful reliability on instruments of problematic accuracy.”

On the second question, whether technology can precede science, there are a range of views. For the philosopher Peter Janich, writing in the 1970s, “in place of the musty ideology of the researcher who unravels nature’s secrets, the physicist will understand himself to have just one task: *enabling technology*,” and that natural science “is to be understood as a secondary consequence of technology rather than technology as an application of natural science.” These are fighting words, and we do not have to subscribe to a complete reversal of the relations of priority between science and technology to appreciate that there are cases where technology has in fact preceded science. A good example is the Giffard steam injector, devised in 1858 by Henri Giffard, an engineer whose main interest was in the construction of steam-powered dirigibles. Giffard sought a feed apparatus for his dirigible that would not be subject to friction, by contrast with force pumps, which were hindered by friction, thereby absorbing power from the engine. It worked by delivering cold water to a boiler against its own pressure, using the boiler’s own exhaust steam, and by the early 1860s it had completely replaced mechanical pumps. From the point of view of physics, however, the device presented a seemingly intractable problem: the process looked, *per impossibile*, to be a case of perpetual motion, and physicists struggled to understand how the injector worked. The task was to reconcile scientific understanding with an established body of technological knowledge, but it was 50 years before a satisfactory thermodynamic explana-

tion was offered. Gifford’s steam injector was a case where the technological development preceded the scientific understanding. Nor was it so unusual. As Joel Mokyr notes, the Industrial Revolution of the first half of the nineteenth century created a chemical industry without chemistry, an iron industry without metallurgy, and power machinery without thermodynamics.⁶

Just how independent of science technology can be is highlighted by the Nobel Prize-winning physicist Robert Millikan in his 1950 autobiography, where he suggests that results in the nineteenth- and twentieth-century physical sciences derived largely from developments in engineering, providing some revealing examples:

Historically, the thesis can be maintained that more fundamental advances have been made as a by-product of instrumental (i.e. engineering) improvement than in the direct and conscious search for new laws. Witness: (1) relativity and the Michelson-Morley experiment, the Michelson interferometer came first, not the reverse; (2) the spectroscope, a new instrument which created spectroscopy; (3) the three-electrode vacuum tube, the invention of which created a dozen new sciences; (4) the cyclotron, a gadget which with Lauritsen’s linear accelerator spawned nuclear physics; (5) The Wilson cloud chamber, the parent of most of our knowledge of cosmic rays; (6) the Rowland work with gratings, which suggested the Bohr atom; (7) the magnetron, the progenitor of radar; (8) the counter-tube, the most fertile of all gadgets; (9) the spectroheliograph, the creator of astrophysics; (10) the relations of Carnot’s reversible engine to the whole of thermodynamics.⁷

6 Mokyr (1999), p. 219–245.

7 Millikan (1950), p. 219.

The third question, that of what actually happens in cases where technology and engineering interact with scientific investigation, is especially complex. Such cases differ from one another significantly, as might be expected, but the early stages of the design of the aerofoil will at least give some flavour of the general issues. When the Wright brothers undertook the first sustained and controlled flights between 1903 and 1905, they had worked largely by trial and error. In the wake of these flights, those constructing aircraft continued in a trial-and-error fashion, building on the practical expertise of their predecessors. But at the same time there began attempts to develop a theoretical understanding of the action of the air on wings. The aim was to understand lift (the force on the wing that keeps it in the air), drag (the resistance of the air to motion), and stability (the ability to correct for pressure producing turning moments that would cause the wing to pitch). The basic mathematical resources derived from hydrodynamics, the study of bodies moving through fluids. The area was mathematically challenging, and in order to make it tractable numerous simplifying assumptions had to be made, resulting in a mathematical theory of ideal fluids. But ideal fluids are non-viscous, and so not a model for real fluids such as air. The subsequent mathematical development of a theory of viscous fluids by George Stokes provided very limited help, since they could only be solved in a few simple cases.

In the light of this, the task was to find a way of making ideal-fluid theory more realistic, and there were two basic approaches to this. The problem with perfect fluids arises from the fact that they are continuous and irrotational (they do not rotate around the

body immersed in them). Two different approaches attempted to solve the problem by introducing discontinuities in the one case, and circulating vortices around the moving body in the other. The approaches were associated with very different conceptions of what the understanding of physical phenomena consisted in. The first one maintained that any account must be anchored in — and ultimately be deducible from — mathematical physics, particularly as conceived in the Cambridge Tripos tradition, the nineteenth-century home of applied mathematics/theoretical physics. The second approach, which was in the tradition of “practical mechanics,” particularly as conceived in the tradition of the German technical college, the *Technische Hochschule*, rejected such foundational aspirations, and manipulated mathematical and theoretical resources in such a way as to achieve a particular engineering result.

The resistance that advocates of the first approach demonstrated to the success of the second is revealing. They worked with a model of science as something comprehensive and certain, and to a large extent, the resistance arose from the fear that this conception would be compromised by abandoning the idea that the physical nature of the world can ultimately be derived from a unified set of fundamental, mathematically-formulated physical laws. A pioneer of the engineering approach, Frederick Lanchester, started from the observation that birds’ wings, which have evolved into a shape that conforms to the pattern of airflow necessary for lift, have an arched profile with a slight downward inclination at the front edge. What must happen, Lanchester argued, is that the air must be moving upward as it approaches the

leading edge of the wing and downward as it leaves the trailing edge. There is an exchange of momentum: the initial upward vertical component of the motion must be reduced to zero as the air passes over the wing, and then replaced with a downward vertical component. His solution worked with the notion of an ideal fluid, but critics pointed out that in a stationary perfect-fluid setting a body in motion could not create a flow at all. But Lanchester was well aware that mathematical idealizations wouldn't work in the real world; the important thing was to learn what one could from the idealized case but not be imposed upon by it. When, in 1936, well after his circulation theory had been accepted as the correct account of lift and drag, Lanchester wrote that his work had not been taken seriously 20 years earlier because it had been judged by Cambridge-trained mathematicians.

Conclusion

Does it matter, other than in terms of professional pride, if science gets the credit for engineering and technological achievements? From the point of view of our understanding of the scientific culture of the modern world, it matters a great deal. At the end of the eighteenth century, the West's sense of its superiority had shifted from its religion, Christianity, to its science. It was the French philosopher and political theorist the Marquis de Condorcet who, in an essay published in 1795, offered the first fully fledged statement of the view that scientific progress is distinctive of Western civilization, that it was the intellectual and cultural achievements of its science that shaped modern culture. Accordingly, in the course of the nineteenth century, the notion of scientific progress was mapped on to the

understanding of civilization. All cognitive values — and subsequently moral, political, and social ones — come to be modelled around scientific values.

As I argued in my *Emergence of a Scientific Culture* (2006), a crucial ingredient in the plausibility and success of this notion has been the idea that science, by contrast with religion for example, appeals solely to reason and experience, and is as a consequence untinged by historical or cultural factors, which can therefore be ignored, making science something which in essence has no context, historical or otherwise. Science is thereby protected in advance from the historicization and contextualisation that, coming to a head in the middle of the nineteenth century, eventually undermined Christianity's claims to *sui generis* legitimacy. The problem is magnified by the cultural standing that science has taken on in virtue of this image. In particular, the notion of science as something answerable to nothing but reason and experience has done much to encourage the otherwise somewhat unlikely association between scientific values, morality, and democracy.

This association began in earnest with the Darwinism debates of the late nineteenth century, and it became a dominant cultural theme in the twentieth century. In the Anglophone world, this development starts with Herbert Spencer, who, in his *Principles of Ethics* (1892) set out explicitly to derive ethical principles from scientific ones, and from the late nineteenth century onwards there have been recurrent attempts to guide morality scientifically. In 1916, for instance, Richard Gregory, the editor of *Nature*, singled out the scientific values of selflessness and love of truth to act as the basis for morality. He was followed in 1923

by the contributors to the volume *Science and Civilization*, who called for moral values based upon science to replace those based on religion, with Julian Huxley's contribution identifying the next great task of science as the creation of a new religion. By 1931, the science columnist John Langdon-Davies was taking up the defence of the moral values of science with an attack on the use by religion of emotionally loaded words to describe abstract concepts. In 1957, a member of the Mental Health Research Institute at the University of Michigan was arguing that the ethical system derived from scientific behaviour was a "superior" ethical system, and 18 years later the biologist E.O. Wilson was writing that the time might have come for "ethics to be removed temporarily from the hands of philosophers and biologized."

The question is whether, once it is realised that the supposed practical benefits of science were in fact not due to science at all, this bloated view of science would remain so well-entrenched. There are indeed benefits from science, and values associated with science: for example, those of objectivity and impartiality are a crucial part of our culture. But the idea that all values can be anchored in those of science is both wrong-headed and dangerous. As Nietzsche put it: "As long as what is meant by culture is essentially the promotion of science, culture will pass by the great suffering of the human being with pitiless coldness, because science only sees problems of knowledge, and because within the world of the sciences suffering is really something improper and incomprehensible."

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The Governor's scrapbook

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Abstract

At a crucial time in Sydney's colonial history, the Governor of Darlinghurst Gaol, John Cecil Read, started collecting cuttings, postcards, photographs and drawings, and glued them into a large scrapbook. For 130 years, this book was passed down through generations of his family, until the Read family donated it to the National Art School Collection during a major exhibition about the history of Darlinghurst Gaol. It was first put on display for the public in September

2022. Originally thought to be full of reproductions, on close examination 53 original artworks and 15 photographs were identified amongst the prints. They include some of the earliest examples of art by prisoners to be found in Australia.

Introduction

Darlinghurst Gaol [Fig 1] was Sydney's principal gaol for 73 years, from 1841 to 1914. After the gaol closed, the site continued to be used as a Military Detention

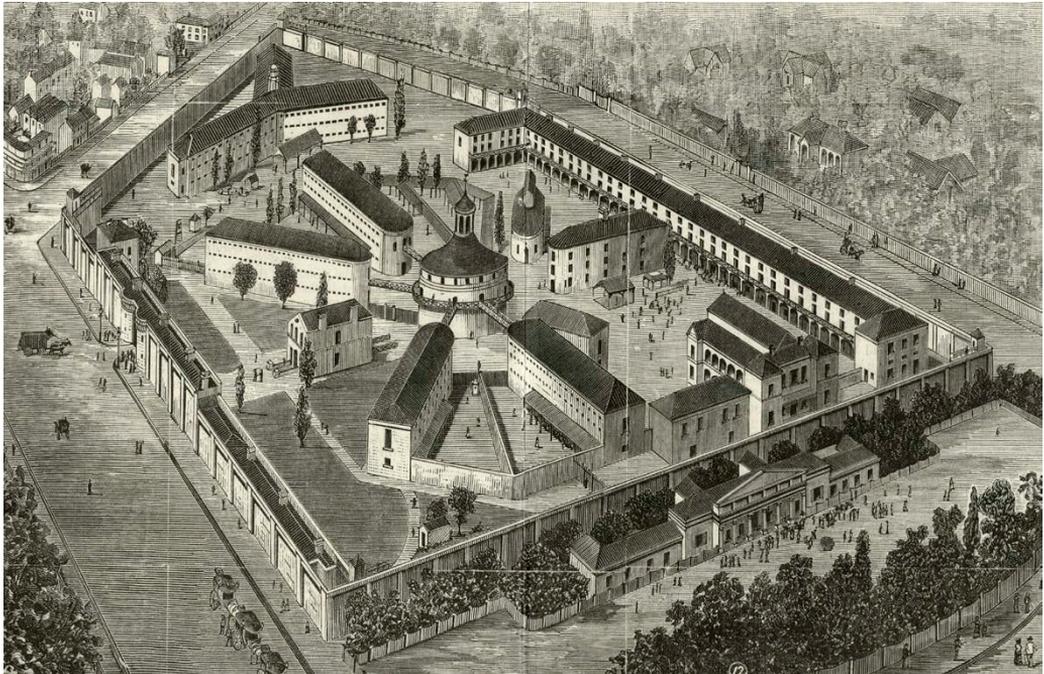


Figure 1: Darlinghurst Gaol (detail from engraving in the *Illustrated Sydney News* 21.II.1883). Original by Arthur Collingridge de Tourcey. National Art School Collection. Notice that the gaol embodies Bentham's panopticon architecture, see Semple (1993). [Ed.]

Barracks, holding Irish, German and Russian detainees during the Great War. It was not until 1921 that a decision was made to remove all the prisoners and convert the buildings into East Sydney Technical College, which opened in February 1922. The art department of Sydney Technical College moved to the former gaol site at this time, and was later renamed the National Art School. All other technical college departments were moved to alternate campuses in Sydney in 2005, allowing the National Art School to expand into the remaining buildings of Darlinghurst Gaol.

In 2022 the National Art School celebrated two important milestones: the 100-year anniversary of the Art School's presence on its current site in Darlinghurst, and 200 years since the first stones were quarried and laid for the walls of Darlinghurst Gaol in 1822.

To mark this significant occasion, the National Art School produced a major new publication *CAPTIVATE: Stories from the National Art School and Darlinghurst Gaol* (Beck 2022), and curated an exhibition with the same title. Many rare items made or used in Darlinghurst Gaol were returned to the site for the first time since the gaol closed in 1914. These were either borrowed from public institutions, or donated to the National Art School Collection, which has been held on site since the 1920s. One of the most significant items exhibited in *Captive*, was a 212-page scrapbook compiled by John Cecil Read during his tenure as gaol governor from 1861 to 1888.

Governor Read and his family

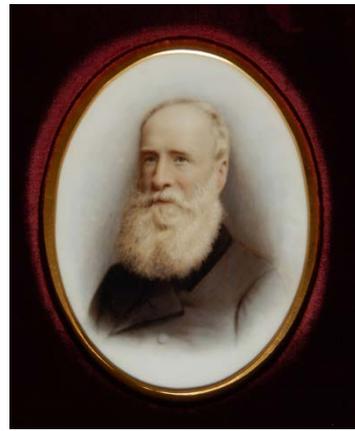


Figure 2: Sir John Cecil Read c. 1880s, Governor of Darlinghurst Gaol 1861–1888. Hand-coloured photograph on glass. Courtesy John Read.

Sir John Cecil Read (1820–1899) [Fig 2] was the longest-serving governor of Darlinghurst Gaol, holding the position for almost 28 years. When he became governor in 1861, the gaol had been operating as Sydney's gaol for twenty years, but was in a parlous state.

Read was descended from Sir John Read of Ireland, and although he was actually the 9th Baronet, he chose not to use the title.¹ The family moved from Ireland to England, and in 1838 John Cecil Read married Anne Egan, daughter of Michael Egan from Dublin. All their children were born in England.

After a distinguished service of 15 years with the London Metropolitan Police, in 1854 Read resigned from the police department. The following year he was offered a position as inspector of the Sydney Police in Australia. After accepting the position, he travelled with 86 British police and his large family, on the ship "Exodus." They sailed

¹ Sir John Read of Ireland was created the 1st Baronet of the Read family on the 16th of March 1641. This hereditary title is awarded by the British Crown.

from England in April 1855 and arrived in Sydney in July.²

After his arrival in New South Wales, in 1858 Read was sent to take charge of police arrangements at the great gold rush at Canoona, near Rockhampton. He was praised for helping prevent serious riots by disappointed diggers at the time.³ On returning to Sydney he became Inspector of Police at the Station House in George Street South. This covered the area of Surry Hills and Darlinghurst.⁴

In 1861, after the suspension of the previous governor, Henry Beverley, John Read was appointed Governor of Darlinghurst Gaol, which was at the time in a neglected state. The buildings were incomplete, with only four of the proposed seven cell-wings built. As well as supervising the building works, he soon introduced reforms to the gaol system, including setting up a manufacturing wing in the gaol where prisoners could learn trades. While profitable for the Government, they also taught the prisoners how they might earn an honest livelihood for themselves after they were released. Mat-making, bookbinding and shoemaking were the chief trades taught, and these were expanded in later years. Though always a strict disciplinarian, it was reported that Read was a humane man, who took a keen interest in the prisoners. Some of them were proud of telling how, after they had left gaol,

he had taken them in hand and helped them to lead better lives than they had previously done.⁵

Keen to promote the inmates' achievements, Read entered their work into exhibitions. He displayed the medallions and awards he received in the 1875 Agricultural Society of NSW exhibition, and the 1876 International Exhibition in Philadelphia (USA) for "Mats and Matting made by Australian Aborigines." A photograph of this award is printed in the scrapbook. Mats by Aborigines from the gaol were also shown in the Amsterdam (1883) and Calcutta (1883–84) Expositions, listed under "Applied Arts," but shown in the Ethnographic sections.⁶ Photos of the showroom in the manufacturing wing of Darlinghurst Gaol (now Building 11) show some of the complex woven mats on display as well as paintings on the walls. In the 1879 Sydney International Exhibition, Read was also awarded a medal for Mats and Matting made by Darlinghurst Gaol inmates.⁷

Although no documentation has been discovered about Read's interest in art, he certainly allowed some prisoners to paint in their cells, and from the evidence in the scrapbook, he also collected their work. Despite the gaol and colony being principally a place of punishment, Read gave prisoners the chance to pursue other interests while serving their sentences.

2 Pulling (2011).

3 Although it was rumoured that a large deposit of gold had been found, the gold rush only lasted a few months when it was found that this was untrue. <https://www.slq.qld.gov.au/blog/gold-fever-canoona-delusion-near-rockhampton>

4 Waugh (1861).

5 Anon. (1899).

6 De Lorenzo & Chanin (2022, p. 747).

7 Although the winning exhibits were made by prisoners, the awards were presented to the governor of the gaol. The original medals are held in the Cooma Museum and repository for Corrective Services NSW.



Figure 3: Maria Read, December 1872. Courtesy John Read.

John Read lived in the Governor’s Quarters on site (now Building 22) with his wife Anne, four sons and two daughters, and the family recall that his youngest daughter Maria Read (1850–1914), painted in watercolours. [Fig 3] Indeed one watercolour of a landscape in the sketchbook does have “M.READ” inscribed in the corner. In 2023 the Read family also donated 25 of Maria’s signed works, completed in Darlinghurst Gaol, to the National Art School Collection, and it can be presumed from the style of these that at least five of the watercolours in the sketchbook are painted by her. [Fig 4] Many of the recently donated sketches and watercolours have titles and dates; one intriguing drawing depicts a wooden gazebo, surrounded by fences and a Norfolk Island Pine in a garden, titled *Darlinghurst Gaol*, 10.6.1876.

Although Read chose not to use his title, he was obviously proud of his Irish heritage, and he glued copies of the Read crest on the outside and inside of the marbled cover of the scrapbook, inscribed with the family



Figure 4: Maria Read. Watercolour from John Cecil Read’s scrapbook p. 87.

motto *Cedant Arma Togæ* (interpreted as: let military power be subject to civil authority).

The scrapbook

Governor Read’s scrapbook was compiled during the 1800s, at a time when the emergence and increased accessibility of printed material sparked a trend in collecting a variety of images. Blank, bound books — previously used for journals or artwork — were filled with clippings, cards, photographs and printed memorabilia. Some of these books contained a mix of personal journal entries, hand-drawn sketches, and watercolours, along with various scraps of printed material.⁸

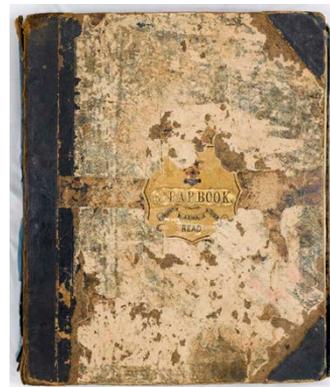


Figure 5: Cover of the Read scrapbook 1861–1888.

⁸ <https://www.scrapbook.com/articles/history-of-scrapbooking>

The Read book [Fig 5] is quite large — 34 × 29 × 7 cm — leather-bound with an extremely worn marbled cardboard cover. The scraps appear to have been glued in with a starch paste, which although brown in colour, fortunately has not discoloured the images. It appears to have been designed specifically as a scrapbook, as there is a separator strip between each double page, which allows room for the collaged scraps to be added without affecting the spine. As these scrapbooks were commercially available at this time, it can be assumed that Read bought the book from a stationery shop, or else commissioned a bookbinder to make it especially for him.

Like other Victorian scrapbooks, the Read book contains a haphazard arrangement of literary and pictorial cuttings from a large variety of sources. The scrapbook has a lot to tell us about Read, his family, the other people around him, and more generally about his times. It was assembled for roughly three decades in the late 19th century, when the colony was between adolescence and maturity as a society. His descendants believe that that Read compiled it himself during his time at Darlinghurst Gaol, but it is also possible that other members of his family added to it as well.

Many images display notions of sentimentality and nostalgia, and some of the caricatures reveal racist, sexist and anti-Semitic tropes. These were common at the time, but quite offensive today. Some images were cut out of popular magazines, like *Punch* and *Harper's Bazaar*. Others are stereotypical images bought from a stationery supplier and assembled for various reasons or of interest to the family. As there

is so little documentation in the book, the conclusions we can make about their provenance involves much conjecture, but it is particularly intriguing to try and solve this complex puzzle.

Most images are of British locations, possibly because the Read parents used the pictures to educate their children about "home." There are over 30 prints by the English printer and engraver George Baxter (1804–1867). In 1835, Baxter invented and patented a process of colour printing that made reproductions of paintings available on a mass scale. His process incorporated the aquatint method and involved superimposing the colours using wooden blocks. Baxter used carefully etched plates, a hand press, and the finest colours, oils and paper. Examples of his work in the scrapbook are mostly rural scenes and tourist attractions in Britain, such as Brougham Castle and Tintern Abbey. They are finely produced and each bears Baxter's stamp and patent number.⁹ [Fig 6]

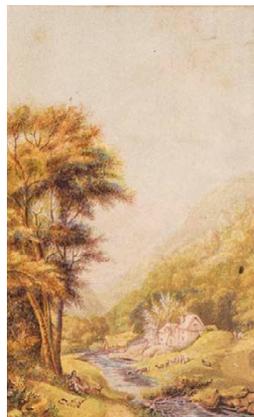


Figure 6: George Baxter, *Water Mill on the Rye*. Print from John Cecil Read's scrapbook p. 49.

⁹ <https://www.npg.org.uk/collections/search/person/mpo6663/george-baxter>

Other pages contain many coloured prints by the Swiss printer Auguste Thez, depicting European scenes and illustrative prints which appear to have a narrative, although there is no information with these. They are juxtaposed with stock images of men and women from magazines, cartoons, mountain scenes with waterfalls, caricatures of animals and people — in fact anything that seemed to take the fancy of those who collected them.

Some prints are of the British royal family, and there are quite a few relating to Napoleon I and St. Helena. Some appear to be copies of engravings of exotic landscapes, and others show “natives” from America, Africa, and other continents. There is a decided lack of Australian subject matter displayed in the book. Read collected some small clipped-out images of Melbourne landmarks, and apart from the original artworks by gaol prisoners, there is only one other antipodean image, a sepia photo of a painting which depicts a kangaroo hunt, as opposed to many of English hunting scenes.

In all, there are 456 items glued onto the blue pages of the scrapbook. Despite its age, some are in excellent condition, and others are badly foxed. Tears in the blue backing paper have been repaired over the years, and some pages are empty. It looks as though family members have deliberately removed over 35 images, perhaps to make copies of them or give them to prisoners to copy. Some of Maria Read's loose artworks have a similar pattern of brown glue in each corner, so may have been removed by her at a later date to keep with her other sketches. There are also four loose printed devotional cards containing Bible verses

inside the back cover, as well as a piece of pink blotting paper with sepia ink blots and a pressed plant, possibly pine needles. This sepia reversed text on the blotting paper looks similar to writing by prisoner Henry Louis Bertrand describing the artworks in the book.

Artworks

The most fascinating works in the scrapbook are the original sketches and watercolours by gaol inmates. Although quite a few artworks by convict artists from the 18th century have been identified in State collections, 19th century artworks by prisoners who had been convicted of crimes in Australia are rare.¹⁰ As this book was compiled within the walls of Darlinghurst Gaol, we can conclude that the original works are all by inmates, apart from those by Read's daughter Maria. The Read sketchbook contains a number of images of particular interest that are to do with people at Darlinghurst, bushranging scenes, people in gaol waiting for trial, and caricatures of local Sydney identities.

There are two long-term prisoners who are most likely to have made these works and given them to John Cecil Read: Henry Louis Bertrand and Frank Pearson. Some are definitely by Bertrand (signed “*HLB*”), and others bear a close resemblance to known works by Pearson. These two prisoners were held in Darlinghurst Gaol at the same time, although Pearson was only gaoled for 11 years, as opposed to Bertrand's 28. Both men were serving life sentences for murder, and were of a similar age. Both were well educated, with some knowledge of Latin and an interest in art and music.

¹⁰ Convict artworks are referenced in Anemaat (2019).

Henry Louis Bertrand (1841–1924)

Some long-term prisoners turned to art as a way to survive their long years in gaol. There were no art classes, but several inmates were already skilled artists, and shared their skills with fellow prisoners. In 1891, convicted murderer Henry Louis Bertrand was the first known painter to depict the site from the inside. [Fig 7] His now-iconic watercolour of the buildings of Darlinghurst Gaol is held by the State Library of New South Wales. Known as the notorious “Demon Dentist of Wynyard Square,” Bertrand became one of the longest-serving prisoners in Darlinghurst after being sentenced to death and later reprieved for killing his lover’s husband in 1866. His time at Darlinghurst Gaol ran almost concurrently with that of the Governor John Cecil Read, and it appears that Read encouraged Bertrand’s artistic pursuits.

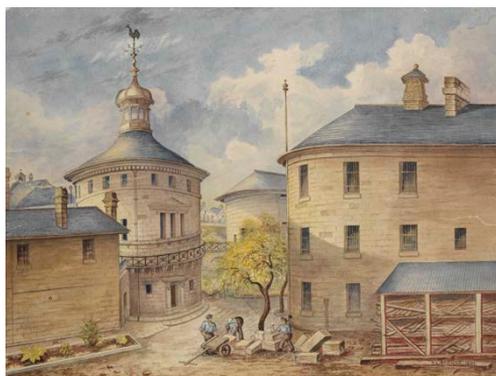


Figure 7: Henry Louis Bertrand, *Darlinghurst Gaol* 1891. Watercolour. State Library of NSW, Mitchell Library SV1/Gao/Darh/2.

While in gaol Bertrand played the organ in the chapel, carved delicate bone objects, worked as a dentist in the hospital and used the paints his mother supplied him with to paint a life-sized crucifix in his cell. Along

with his fellow inmate Frank Pearson, he is often credited with designing the stained glass windows for the chapel but probably only painted the frieze above the windows.¹¹ Bertrand was 53 on his final release on 17 June 1894. At this time he gave some of his artworks to the Gaol chaplain, Rev. William Cuthbert. Cuthbert’s grand-daughter later donated some of these to the Mitchell Library, and kept four others in the family. These watercolours have remarkable similarities with paintings in the Read scrapbook, and also with other works by prisoner Frank Pearson. Some appear to be copies of postcards or magazine clippings of exotic landscapes, perhaps a way of escaping the drab walls of Darlinghurst Gaol.



Figure 8: Henry Louis Bertrand, *A very respectable individual*, c. 1880s. Watercolour from John Cecil Read’s scrapbook p.196.

Bertrand’s works are the most numerous in the scrapbook. Although only four are signed “HLB,” a full page of 15 caricatures in pencil towards the back of the book shows duplicates of many of the watercolour caricatures scattered throughout the sketchbook. This proves that these watercolours were also done by Bertrand. Another giveaway is his handwriting. He

11 Edwards (2016).

had a distinctive style, signed in sepia ink, and wrote often satiric or sarcastic notes under each drawing. For example, one of his drawings of a policeman is named “A very respectable individual.” [Fig 8]



Figure 9: Henry Louis Bertrand (signed “HLB”), *Safer in than out*, c. 1880s. Watercolour and ink from John Cecil Read’s scrapbook p. 168.

One signed watercolour is titled “Safer in than out,” and it depicts a mouse in a cage with two dogs staring at it. The space they are in looks very similar to a sandstone cell in Darlinghurst Gaol, and the buildings outside could be those in Burton Street outside the gaol. The title of the drawing may have a double meaning, and relate to the prisoners in the gaol itself, rather than the animals portrayed.[Fig 9]

Bertrand served another five years in Darlinghurst after Governor Read retired. Towards the back of the Read scrapbook is a full-page watercolour which looks very similar to Bertrand’s other work, and it is possible that Bertrand gave it to Read before he retired. Titled “Our Ancestors: Novel Theory of Human Pedigree by an Intelligent German,” it illustrates evolution from single-cell animals to primitive man, via a kangaroo, monkeys and other animals.¹²

[Fig 10] Its Latin inscription translates as “The fool has said to his heart, there is no God”. As an educated but sceptical man, it sounds like something Bertrand could have written, possibly referring to the German scientist and explorer Alexander von Humboldt (1769–1859), who was such an influence on Charles Darwin. Darwin’s book *On the Origin of the Species* was published in 1859. Throughout the sketchbook are other printed images of engravings by Humboldt, showing that Read might have also been drawn to his research.

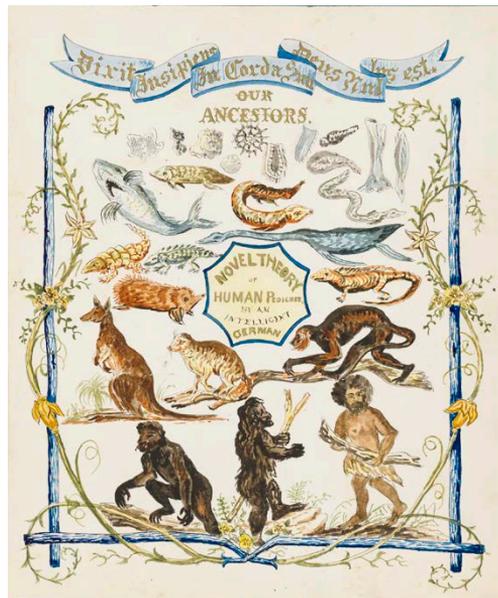


Figure 10: Unidentified artist. *Our Ancestors: Novel Theory of Human Pedigree by an Intelligent German*. Gouache from John Cecil Read’s scrapbook p. 100.

Frank Pearson (Captain Starlight)
(1837–1899)

Frank Pearson was an enigmatic character, who consistently lied about his background,

¹² Read retired in 1888, which means that Bertrand’s sketch of evolution is very early. See Moyal & Marks (2019) [Ed.]

used many aliases, forged signatures and stole other prisoners’ identities. As the bushranger Captain Starlight, he ranged the countryside in northern NSW, bailed up travellers and eventually killed a policeman, Senior Constable John McCabe, in a shootout. He was sentenced to death by hanging, later commuted to life imprisonment. Pearson arrived in Darlinghurst Gaol in 1873, and for many years he became an exemplary prisoner, serving as an assistant to the Catholic Chaplain. [Fig 11]



Figure 11: Frank Pearson (Captain Starlight), from the Darlinghurst Gaol Photograph Description books, 1873. Museums of History New South Wales — State Archives Collection. MHNSW-StAC NRS 2138 [11/17378] p. 251.

While in gaol he converted to the Catholic faith, and was visited by the Sisters of Charity. Sr. Gertrude Davis and Sr. Mary de Sales Phillips were two of the sisters who visited Frank Pearson. They would walk to Darlinghurst two or three times a week from their convent in Potts Point to minister to prisoners.

Possibly encouraged by his fellow inmate Henry Bertrand and Governor John Read, Pearson learnt to draw and paint while in gaol, and completed many artworks in the 11

years he was held in Darlinghurst. Upon his release in 1884, Pearson presented the Sisters of Charity with a sketchbook containing dozens of his original artworks, as a token of his gratitude for the care and attention the Sisters had afforded him. The artworks have remained in the possession of the Sisters of Charity ever since. His sketches and watercolours cover a broad range of subjects: copies from postcards and magazines, drawings of his fellow inmates, and many flower studies. Like Bertrand’s works, they often have a descriptive note underneath in Pearson’s hand, such as “A Gaol Bird,” and “Ye Bold Trooper.” Most were completed towards the end of his sentence 1882–1884, and signed with an “A,” possibly referring to one of his aliases, Arnold.



Figure 12: Frank Pearson (Captain Starlight). Painting and collage of addressed envelopes. 1890. Gouache and ink. National Art School Collection, Gift of Allan Harding 2021.

After his release, Pearson continued to paint and draw for the rest of his life. Six years after leaving Sydney he turned up at “Yarawa” station at Mungindi, near Moree in northern NSW, using the alias “Patrick Pelly.” While stuck on the property during the 1890 flood, he entertained the family with stories

of his bushranging exploits, and painted a series of watercolours which he left as a thank-you for their hospitality. Relatives of the family he stayed with recently donated these original artworks by Captain Starlight to the National Art School collection. Like the Bertrand watercolours, they depict idyllic scenes of landscapes and seascapes, and bear similarities with the unsigned works in the Read scrapbook.



Figure 13: Unidentified artist. Painting of envelopes and notes c. 1880s. Gouache and ink from John Cecil Read's scrapbook p. 86.

Pearson also painted some *trompe l'oeil* images of letters and stamped envelopes in which he successfully achieves an optical illusion that the envelopes are torn and glued onto a page. [Fig 12] His skills as a forger and adoption of fellow prisoners' names can be seen in these works. They look surprisingly "modern" and are quite distinct from Bertrand's work. One work in the scrapbook is remarkably similar to these, and because of this it can be assumed that it is also by Pearson. [Fig 13] Others in the scrapbook, particularly of sailing ships, have many characteristics which appear in his later work as well. [Fig 14]



Figure 14: Unidentified artist. Two ships in a storm. Watercolour from John Cecil Read's scrapbook p. 16.

Unknown artworks

Many interesting drawings in the book are unsigned. There are eight delicate paintings of flowers, three pencil copies of other artists' paintings, and eight drawings of what look to be people in the street who are a variety of ethnicities. Any of these could be by Bertrand or Pearson, or by other prisoners who enjoyed drawing.

The rare depictions of bushrangers in action are strangely stilted with little understanding of perspective, but overall the subject matter of horses, mail coaches and men on horseback are quite competently drawn. Two in pencil are named "Driving Cattle Overland 'Camped'" (signed "FS"), and "Scene near Jugiong, Murrumbidgee". This work could refer to the bailing up of the mail coach by Ben Hall and his gang in November 1864.¹³ This event did occur near Jugiong, and indeed some of Ben Hall's gang ended up incarcerated in Darlinghurst Gaol. If drawn by one of the 33 bushrangers held in Darlinghurst Gaol in the 19th century, they are significant and rare examples of

13 Anon. (1864).

bushranging exploits as depicted by the bushrangers who were there.¹⁴

Another shoot-out is depicted in a very similar style on page 96. This one is in pen and ink and wash, and has the title, "Sticking up the Lambing Flat Coach," in a script that looks like Bertrand's. [Fig 15] Lambing Flat was an early name for the town of Young, NSW, and a place where bushrangers, including the outlaw and Darlinghurst Gaol prisoner, Frank Gardiner, were known to roam. It is also known that Gardiner himself was adept at drawing horses, as he made a mat in the gaol manufacturing wing in 1866, with an image of his favourite horse "Darkie."¹⁵



Figure 15: Unidentified artist. *Sticking up the Lambing Flat coach*, c. 1870s. Pen and ink from John Cecil Read's scrapbook p. 96.

On the same page as the Lambing Flat drawing, another pen, ink and wash drawing is titled "Waiting for Trial." This is almost certainly by Bertrand, as some of the characters re-appear in his signed drawing on page 211, and the text is very similar to Bertrand's. The group of 12 men and one boy are from various social classes, ages and races, and it is most likely a scene that Bertrand witnessed many times, as new prisoners were brought in for trial in the courthouse adjacent to Darlinghurst Gaol. In fact, Bertrand himself

was held in the trial wing (A Wing) for many months after his own trial, while waiting to see if his death sentence would be commuted to life. [Fig 16].



Figure 16: Henry Louis Bertrand. *Waiting for trial*, c. 1870s. Pen and ink from John Cecil Read's scrapbook p. 96.

Photographs

Of the fifteen original photos found in the scrapbook, only three have titles. As governor of Darlinghurst Gaol, John Cecil Read travelled to other gaols in the colony, and there are three unique sepia photographs on page 74, probably taken by Read. The top one is a stereo-view of a river valley and town, which looks like Parramatta. The centre photo is of Darlinghurst Gaol taken from the northwest, looking across the terrace houses of Surry Hills towards the Forbes Street gate. The photo was taken before 1871 when the original Forbes Street gate was replaced. Although in poor condition, it is the only known early photograph taken from this angle. A third photograph with five people in the foreground is of Berima Gaol in country NSW. It shows the front gate and wall, built by convict labour and opened in 1839.

¹⁴ Beck (2014).

¹⁵ Gardiner's hand-loomed mat "Gardiner's Darkie" was exhibited in the Melbourne Intercolonial Exhibition. Anon. (1866).

Other photographs scattered throughout the book include images of unknown Aboriginal or Maori men taken in the 1860s, some originals of which can be found in Te Papa Tongarewa (the Museum of New Zealand). There are also some personal photographs: one of a dog with a large stick in its mouth sitting on a chair; one of five elegantly dressed women, who could be members of the Read family; and one of a gentleman, who could be John Cecil Read himself when he was young. Unfortunately there are no names on these, and the current family cannot recognise who they are.

A beautiful photograph of a large two-storey Victorian house with iron lace on the verandah is glued onto one of the last pages of the book. Two women are standing on the balcony of the top floor, and the woman on the left bears a resemblance to known photos of Anne Read, John Cecil Read's wife. This could be Read's residence after he retired, "Arawa," in Nelson's Bay Road, Waverley, where he lived from 1889 to 1899. [Fig 17].



Figure 17: Photograph, unidentified, possibly of John Cecil Read's house *Arawa* from John Cecil Read's scrapbook p. 200.

Conclusion

The discovery of a hitherto unknown scrapbook compiled in Darlinghurst Gaol is a major find, which deserves many more hours of research and analysis. As the documentation accompanying the book is so sparse, many of the conclusions in this paper involve informed speculation, raising more questions for future exploration.

The appearance of the Read scrapbook certainly reveals its age. The well-worn cover is in poor condition, the spine of the book itself has been broken and some pages are coming loose. It is currently being conserved and restored, and will be a much treasured item in the National Art School Collection. The fact that the Read family have kept this significant book for so many years means that it can continue to contribute to our knowledge of the past.

Acknowledgements

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The rôle of serendipity in biotechnology start-up companies — two case studies

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Abstract

The process of starting and building a biotechnology-based company in Australia in the 2020s is now well documented and supported by a number of programs designed to support founders on their start-up “journey.” However, what is often under emphasised in these programs is the importance of timing and serendipity, or luck, in determining the success of the start-up company. In this article, using the story of the founding of two companies that the author has personally been involved in their foundation, the importance of these two elements — timing and serendipity — is demonstrated.

Introduction

In Boston-based biotech guru Peter Kolchinsky’s excellent handbook on establishing and running an early-stage biotechnology company, *The Entrepreneur’s Guide to Biotech Start-Ups*, 4th Ed.,¹ he sets out the key ingredients needed to maximise the chances of successful growth of new biotechnology companies. These include: evaluating the commerciality of the idea; writing the business plan; finding the right people; protecting the intellectual property, and so on. It really is a valuable guide that should be on every biotech entrepreneur’s reading list.

But what is lacking is any mention of serendipity (the word does not appear anywhere in the document), luck, timing (in terms of being in the right place at the right time), or of resilience.

I have been involved in founding two biotechnology companies, and of leading several other biotechnology start-ups. And in almost every case, the companies would have remained a mere idea, had it not been for a fair slice of serendipity in the discovery phase, and being the right time for the idea to take root.

In 2022 I accepted the role of Entrepreneur-in-Residence at UNSW’s 10X Founders Program, mentoring the next generation of biotech start-up founders, and this caused me to contemplate the key factors that are critical to the success of such ventures.

This essay explores the role of serendipity, or luck, in the founding of two Australian biotechnology companies, proving the old adage “fortune favours the prepared mind.”²

BCAL Diagnostics

BCAL Diagnostics Limited (BCAL) listed on the Australian Securities Exchange in

¹ Available at <https://www.evelexa.com>

² During an 1854 lecture at the University of Lille, French microbiologist and chemist Louis Pasteur said, “le hasard ne favorise que les esprits préparés.” Gibbons (2013) refers to other cases of chance discoveries in science and biology [Ed.]

2021 (ASX:BDX). The company is developing a blood test for breast cancer. This is the story of its origins.

In 1999 Australian physicist Professor Veronica James and colleagues reported that synchrotron X-ray diffraction patterns of hair from individuals with breast cancer differed from those of healthy subjects (James et al., 1999). They reported that the patterns of hair from cancer patients contained a ring of comparatively low intensity which was superimposed on the normal α -keratin pattern obtained from healthy control subjects. This was followed over the next six years by further publications from Professor James and colleagues extending the results (e.g. Meyer & James, 2001).

After the initial excitement, the finding soon became controversial as several groups independent of Professor James failed to replicate the original results. The inventor responded by publishing technical explanations for their replication failures. In 2005, Professor James and other scientists reported on the results of 503 blinded hair-sample analyses and demonstrated a sensitivity of 100% (no false negatives) and a specificity of 86% (14% false positives by comparison to mammography) for breast cancer (James et al., 2005).

A company, Fermiscan Limited, was formed in 2006 to develop the “hair test for breast cancer,” as the discovery became known, and to commercialise it. The company was back-door listed into a former mining company shell. The name paid homage to Enrico Fermi, a Nobel Prize-winning particle physicist who was involved, amongst a range of other achievements, with the high-speed particle accelerator in Illinois, the FermiLab. The X-rays used to examine the hairs for the tell-tale breast-

cancer ring needed to be generated from a synchrotron, a high-speed particle accelerator. I was appointed Chief Scientist of Fermiscan. Coincidentally, my PhD research in the 1980s was focussed on understanding the keratin structure of the wool fibre, so, perhaps serendipitously, it could be assumed that I had a very appropriate background to develop the technology.

In January 2008, Gary Corino (who had worked with Professor James in the early days of the research) and I reported the results of synchrotron-generated X-ray diffraction analysis of samples from women whose breast-cancer status was known (Carino & French, 2008). In the study, 39 hair samples were examined. Nineteen hair samples were collected from women presenting at a radiology clinic, 14 positive controls (samples from women known to be diagnosed with breast cancer) and six samples from women assumed negative by mammography, were analysed. Synchrotron-based X-ray experiments were carried out at the Advanced Photon Source at the Argonne National Laboratory, outside of Chicago, USA. Analyses were conducted on two beamlines which had been previously used for studies on detection of cancer by hair diffraction and therefore offered the greatest opportunity for a successful replication of the original finding. Diffraction images were analysed using two different image-processing programs.

We reported that we were able to successfully and consistently generate the basic α -keratin pattern in hair, which was a primary requirement of the process, and more importantly, that we were able to identify the circular feature in the pattern that correlated with the presence of breast cancer in 13 of the 14 positive controls at

the defined spacing. In this small study, we had confirmed the existence of a correlation between an altered X-ray diffraction pattern of hair and the presence of breast cancer. However, we reported one subject with invasive cancer whose hair failed to produce a diffraction ring in the zone of interest. In addition, two of the samples were classified as indeterminate due to the presence of interfering features. This meant that our specificity and sensitivity were both less than 100%.

Having independently confirmed that there was an association between the presence of breast cancer and the ring in X-ray diffraction images of hair, I started to investigate the origin of the circular feature in the X-ray diffraction patterns. X-ray diffraction relies on high-speed particles being fired at the sample, and bouncing off the molecules that comprise that structure. When they bounce off, they will sometimes interact with other deflected particles, thus causing a diffraction pattern. The harder the molecules that they hit, the more they will bounce, and the resulting diffraction patterns are mainly ordered arrays of spots. This is typical of a crystal structure, as can be seen for example in crystals of sodium chloride (see for example Kemp & Alcock, 2017).

X-ray diffraction was used by Rosalind Franklin in the 1950s to try to understand the structure of DNA. Known as “Photo 51,” “probably the most famous XRD (X-ray diffraction) photograph of the 20th century” (Kemp & Alcock, 2017) was taken by Rosalind Franklin’s PhD student, Raymond Gosling in 1952, at King’s College, London.

In this image there are no spots, but there are regular repeating elements indicating that DNA is a highly ordered oriented fibre rather than a single crystal. This was key information utilised by James Watson and Francis Crick for determining that DNA forms a double helix (Watson & Crick, 1953).³

X-ray diffraction of hair had been conducted for many years (even prior to the use of synchrotron-derived X-rays) (Astbury & Street, 1932), and the patterns indicate that hair is a semi-ordered structure, with several short arcs being the predominant feature.

By contrast, if a substance has no order or structure, what does the X-ray diffraction pattern look like? X-ray diffraction patterns of amorphous water are perfect rings (Kim et al., 2015).

At the stage when Fermiscan was formed, no-one had any good explanation for what was giving rise to the distinctive circular feature in hair from women with breast cancer.

A possible solution presented itself by chance, in March 2008, when I and other staff of Fermiscan visited the Diamond synchrotron in Oxford, UK. I was accompanied by a young laboratory technician, a recent BSc (Hons) graduate of Sydney University, Dharmica Mistry, who had been hired by the company to load patients’ hairs onto special holders for exposure to synchrotron-derived X-ray beams. We met Gary Corino in the laboratory attached to the facility the day before we were due to test-run a number of hair samples as part of the clinical study that had been established by the company in order to test the accuracy of the technology. Gary had been working on the SAXS beam line in the synchrotron in Chicago, and in the course of his work, he had run

³ Famously, for discovering the structure of DNA, Crick and Watson shared a Nobel Prize with Franklin’s colleague, Maurice Wilkins, but not Rosalind Franklin. [Ed.]

some “negative control” hairs, from women with no history of breast cancer, including Dharmica. When Dharmica and I met Gary in Oxford, the conversation proceeded as follows:

Gary Corino: “Dharmica, what do you do to your hair?”

Dharmica Mistry: “Nothing special, why?”

GC: “Well, when I run your hair as a negative control, I see a clear ring in the right position for breast cancer.”

DM: “Oh! I am only 22, and there is no history of breast cancer in my family. It must be a false positive.”

GC: “Well, that’s why I asked what you do to your hair when you wash it.”

DM: “Nothing. I just wash it with shampoo, and some conditioner, that’s all.”

GC: “Nothing else?”

DM: “No ... Oh, wait. Sometimes I spray olive oil on it to make it shiny.”

There was a pause. I knew that olive oil is very similar to many human fatty acids (lipids). In fact, as a hobby, I was a small olive oil producer myself. Lipids are amorphous substances. I immediately suggested that the breast cancer ring was due to lipids from the tumour accumulating in the hair fibre. There was some discussion about this idea, and it was agreed that we should test the idea as soon as we could.

We couldn’t do anything about it at the time, but when Dharmica and I returned to Sydney, we discussed how we could test the idea that the circular feature was due to a lipid (or lipids) incorporated into the hair fibre. Later that year, we travelled to the Australian synchrotron in Melbourne, armed with several hundred hair samples from the Fermiscan clinical trial to analyse on the SAXS beam line, as well as a bottle

of acetone and a bottle of olive oil. We had booked the beam line for an all-night session, as the process of loading the hairs into the beam line, scanning them with the X-rays and collecting several images per hair was quite time consuming.

When we had finished running the samples for the clinical trial, at around 3 am Dharmica suggested we run the lipid test experiment. Being much older, I was feeling exhausted, so she offered to do the work. First, she took a hair sample that we had previously analysed in the beam line and had found no ring in the diffraction pattern. She soaked it in olive oil, dried it, and then loaded it into the beam line. Sure enough, on the diffraction pattern we could clearly see a circular feature in the correct location for the putative breast-cancer feature. Next, she took a hair that had a clear breast cancer circular feature and soaked it in acetone. She then dried it and loaded it into the beam line. The previous circular feature had disappeared, but the other features were still intact, indicating that the circular feature had been removed by the acetone, a solvent that dissolves lipids. She repeated this on other hairs and confirmed the result. We were convinced that the breast-cancer-associated circular feature in the X-ray diffraction patterns was most probably caused by one or more lipids being incorporated into the hair fibre as a result of the cancer being present.

There was one more test that we wanted to conduct. After our Melbourne experiments, we found a paper by Bertrand et al. (2003) that demonstrated that treatment of hair with lead nitrate or lead acetate enhanced lipid features observed using synchrotron X-ray diffraction. They concluded that lead fixation could be a powerful tool to evaluate the lipid organisation in human hair.

We therefore wanted to see if treatment of hairs that contained the breast-cancer-associated ring with lead nitrate would enhance the feature when subjected to X-ray diffraction.

Dharmica travelled to the Australian synchrotron in Melbourne to test that in 2009. Mr Joseph Haklani was based in Melbourne at that stage, and he and Dharmica ran the experiment and confirmed that the breast-cancer ring was indeed amplified by treatment of hairs with lead nitrate. We were therefore convinced that the circular features first identified by Professor Veronica James in hairs from patients with breast cancer resulted from incorporation of lipids into the hair from the cancer. These findings were published in 2012 (Mistry et al., 2012).

Prior to publication of the 2012 paper, we drafted a patent application based on this finding, and Dharmica commenced a PhD to determine the nature of the lipids. Unfortunately, shortly after she commenced her PhD, the company went into administration, and the project ceased.

A few months later, a consortium was formed (of which I was a member) to acquire the patents and a new company was formed — SBC Research — and Dharmica was hired to continue her PhD project on investigating lipids in hair and serum, and their association with breast cancer. At that stage she and I were focussed on isolating lipids from serum, as we hypothesised that the tumours were releasing a cancer-associated phospholipid into the circulation and it was being taken up by the hair follicles and incorporated into the fibre. However, in the course of her project, we did not find as strong a correlation as we were expecting. Initially we thought this might have been due to the complexity of lipid extraction

and analysis (a mass spectrometer is needed), and of the vast number of lipid species that were obtained.

Towards the end of her project there was a breakthrough. Dharmica came across a (then) recent (2011) patent that was available for licensing from the University of Louisville entitled “Methods for detecting cancer” with the following abstract:

Methods to determine the absence or presence of one or more cancer types in an animal are disclosed herein ... Amounts of lipids in a sample (e.g., a bodily fluid or treatment thereof) ... are used with a predictive model to make the determination. The lipid amounts can be measured ... using mass spectrometry ...

Reading further, suddenly it was clear that Dharmica and I were on the right track, but were lacking one key piece of information: the lipids were not free-floating in the bloodstream as we had supposed. The inventors stated in the patent application that they were derived from “lipid microvesicles.” Microvesicles are tiny particles shed from most cells, including cancer cells. One of the best-known sub-groups of microvesicles are exosomes. Exosomes are 30–120 nm particles that contain DNA, RNA and proteins enclosed within a lipid membrane. Whilst exosomes had been identified since the 1980s, by 2011 exosome science was still fairly nascent. In 2011 there were only 333 papers published on the subject of exosomes. By 2021 this had grown to 5,073 (Source: PubMed). In the earlier years, microvesicle research was difficult, as it was hard to distinguish the small vesicles from cell debris or apoptotic bodies, and long and complex ultracentrifugation techniques were required to isolate them. This was predominantly still the case in 2011.

SBC Research negotiated with the University of Louisville to license the patent, as this was clearly the vital missing link in Dharmica's and my joint hypothesis (i.e. that lipids shed from tumours were a key unique biomarker for breast cancer). The key difference was that the lipids were not free-floating in the bloodstream as we had assumed; rather, they were associated with microvesicles! SBC Research successfully negotiated the licence, and the company focussed on exploring the specific vesicle-associated lipids that could be used as markers of breast cancer.

SBC Research changed its name to BCAL Diagnostics — BCAL standing for Breast Cancer-Associated Lipids — and ultimately listed on the ASX in 2021.

There were two key serendipitous breakthrough moments critical for BCAL's progression. The first was employing a research assistant who used olive oil on her hair, and the second was the parallel work and timeliness of the patent from the University of Louisville. If we had taken longer to understand the lipid basis of the circular feature in the X-ray diffraction pattern, we would have missed the window of opportunity to license the patent and thus understand the key association with extracellular vesicles and breast-cancer lipids.

Cryosite Pty Ltd

Several years earlier, in 1997, I was employed as Manager of the Centre for Immunology at St Vincent's Hospital in Sydney. St Vincent's had been at the epicentre of the HIV/AIDS epidemic in the 1980s and 1990s, and researchers and clinicians had cared for a large number of AIDS patients. The Centre for Immunology had accumulated a very large archive of patients' serum samples, that

formed an invaluable resource to understand the disease and its progression. They were stored in over twenty -80°C freezers in the Centre for Immunology's building. They were individually fitted with alarms that fed back to the hospital switchboard for 24/7 monitoring. One night, at 3 am, I was roused from my sleep by a call from the hospital informing me that one of the freezers' alarms had triggered. I immediately got dressed and drove to Darlinghurst to address the problem (by moving the samples to an empty, back-up, freezer). On the way home, I thought that there must be a better way of managing such a collection. So, the next day I started to call around various cold-storage companies to find out whether I could outsource the storage and monitoring of ultracold storage of biological samples. One call I made was typical of all of them, but this one stood out for the no-nonsense approach:

PF: "Hello, I am wondering if you have facilities to store several thousand samples at -80°C in your facility?"

The manager of the cold storage facility: "Sorry, we only go down to -40°C here. What type of samples are we talking about?"

PF: "HIV-positive serum (blood) samples."

Manager: "We store food in our freezers. Our clients are not going to want your blood samples anywhere near their food!"

PF: "Do you know of anyone who can do this type of storage?"

Manager: "No."

In thinking about this, I wondered whether there might be a market opportunity here. And so, after talking to some colleagues with a commercial background, the concept — and ultimately the company Cryosite Pty Limited — was born, and listed on the ASX in 2000. Cryosite Limited still

exists today (ASX:CTE), having expanded and changed its business model to include stem-cell storage and clinical-trial logistics.

If the freezer alarm had triggered during working hours, I might have been less motivated to find an outsourced solution. Again, as in the case study above, serendipity and timing were critical to the initial founding of the company.

Conclusion

The above case studies clearly demonstrate that, without unplanned or unforeseen occurrences, the key breakthroughs leading to company formation and on-going success would not have happened. That chance favours a prepared mind is a truism. In the case of BCAL, I was aware of the similarity between human lipids and olive oil from my olive-oil production experience. This helped me to quickly make the link between lipids from olive oil and breast-cancer-derived lipids. In the case of Cryosite, I had been undertaking an MBA, so I was aware of the elements of establishing a business based on market need, so when the market need presented itself, via the early morning call, I could see the business opportunity.

Of course, luck is not the only element of success, but it can play a key part in company formation or advancement. The other elements, identified by Kolchinsky, are obviously very important as well. Luck may not be a strategy, but it can certainly help in the high-risk field of biotechnology company establishment and growth.

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Ferals — some remote Australian island experiences

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Abstract

Australia's remote islands present striking examples of the impacts of feral animals and demonstrate dramatic ecological responses when feral animals are removed. Though posing daunting challenges, they have been the targets of remarkably successful pest eradication programs at the forefront of invasive species management. Norfolk Island had feral animals 600 years before James Cook discovered the island. Nearby Phillip Island was severely impacted by 1796. Lord Howe Island's fauna had been depleted by mid-1788 but the worst impacts occurred after rats arrived in 1918. Sub-Antarctic Macquarie Island, discovered in 1810, was the haunt of sealers who brought a suite of feral animals before 1900, with catastrophic results for the island's birds. The stories of these islands provide some lessons of global importance.

Introduction

Islands are an important resource for preserving biodiversity, but the value of many has been compromised by the accidental or deliberate introduction of invasive species (Dowding et al., 2009).

Island species and communities are in the forefront of the precipitous decline in biodiversity. Island biotas, especially oceanic islands, characteristically differ from continental biotas in four ways. First, they have small numbers of species; they are “impoverished.” Second, they have relatively few species for the available environmental range; they are “unsaturated.” Third, they exhibit taxonomic bias (meaning they have an uneven sample of those taxonomic groups to be found on mainland source areas); they are “disharmonic.” Finally, they harbour disproportionately numerous endemic species. High endemism means that island species are crucially important to global biodiver-

sity, while the first three traits are often seen as causing island species and communities to be particularly fragile. A disproportionate fraction of endangered and recently extinct species are island species. This is the island dilemma: great biodiversity, much not found elsewhere, but in great danger (Simberloff, 2000).

The islands discussed here conform well to the general pattern. Macquarie Island has only 45 native plant species, in contrast to, for example, Murrumbidgee National Park (NSW) which is a similar size but has more than 400 species. Australia has 70 genera of the family Myrtaceae, amounting to about 1700 species, including about 900 eucalypt and related species dominating a wide variety of environments, yet Lord Howe Island has only 5 native species of the Myrtaceae (two of which have links to New Caledonia or New Zealand, not to Australia), while the family is unrepresented in the native flora

¹ The author established the Australian National Parks and Wildlife Services (ANPWS) office on Norfolk Island in 1978, but is now retired. [Ed.]

of Norfolk, Phillip and Macquarie Islands. Phillip Island, less than 3 km², has at least six endemic species, while Norfolk Island has 40 endemic plants (22% of its plants) and almost half of Lord Howe Island's plants are endemic. Norfolk and Lord Howe Islands have remarkably rich, endemic land snail faunas, with a combined total of about 130 unique species (Hyman, 2022).

Invasive species are the greatest threat to Australia's biodiversity, in terms of the proportion of species threatened (Legge et al., 2023).

The islands discussed here have all demonstrated ecological fragility when invaded by feral animals. Only two of Australia's 89 biogeographic regions have comparable numbers of extinct species to Norfolk and Lord Howe Islands (Legge et al., 2023), but those bioregions have vastly more species (5654 and 4234 plant species, including introduced species, compared with Norfolk Island's 182 and Lord Howe Island's 241 native plant species). Despite the extinction of some species, the islands retain great biological value, which has been recognised in the extremely difficult but successful programs to eradicate the feral animals from three of them: Phillip Island, Lord Howe Island, and Macquarie Island.

Norfolk Island — the first report

2 April 1788, 66 days after the First Fleet arrived in Sydney Cove, must mark the first Australian record of harm from feral animals. With just six months of provisions, the British settled on Norfolk Island, half way between Sydney and Fiji, on 6 March 1788, only six weeks after British settlement of mainland Australia began. The island was uninhabited, yet four weeks later, the tiny

community on Norfolk Island was already troubled by feral animals.

A week after arriving on the island, the settlers had already cleared and fenced an area, prepared a garden and sown vegetable seeds — of high priority to secure a critical food supply. On 2 April the commandant, Philip Gidley King, wrote, "I was this day so unfortunate as to discover that the Rats had eaten a number of ye Indian Corn Shoots, close to ye ground." This must be the first recorded impact from feral animals in Australia.

Although unrecognised, the rats were evidence of prior settlement of Norfolk Island. Polynesian voyagers and *Rattus exulans* colonised Pacific islands together (Roberts, 1991). About 800 years ago, Polynesian travelers arrived at Norfolk Island and established a small settlement there. Possibly additional separate Polynesian arrivals and settlements followed over the next two centuries. They must have brought the Polynesian rat, *R. exulans* (Smith et al., 2001).

To understand the impact of the Polynesian rats, it is necessary to consider the geophysical history of the broader Norfolk Island group of islands and the climate during the last 100,000 years or more. Norfolk Island is the largest of three neighbouring islands and other offshore rocks. These islands sit near the centre of the eroded top of a shield volcano dating from twenty million years ago. The volcano's top forms a platform about 100 km long and 35 km wide, up to 75 m below the present sea level. Norfolk Island and Phillip Island, 6 km away, were created by volcanic activity between 3 million and 2 million years ago and geologically they are very similar. The channel between the two islands is up to 40 m deep. The third island in the group,

Nepean, was largely formed from wind-blown sand dunes during the last two ice ages (Coyne, 2009).

Several ice ages, which climaxed about 350,000, 250,000, 150,000 and 20,000 years ago, each lowered sea level by more than 100 m, exposing the entire platform and creating a single island about 100 km long, with Norfolk and Phillip Islands being the highest of ten conspicuous hills or mountains. At sea levels 50 m below the present level, the exposed island would have been about 35 km long, with the two present islands surrounded and connected by land. Thus Norfolk and Phillip Islands were joined as part of a much larger island for more than half of the last 600,000 years and for 66,000 of the last 76,000 years. They have most recently been separated for less than 10,000 years.

These two islands (Figure 1), only 6 km apart, have similar geological composition (mainly basalt and tuff of similar age) and fairly similar topography, so they must have provided similar habitats. It therefore seems unlikely that plant or animal species would be endemic to just one of them. Possibly, even probably, two plant species recorded only on Phillip Island originally also occurred on Norfolk Island. They are *Strobilorrhiza speciosa* (an endemic legume genus in the family Fabaceae, now extinct) and *Hibiscus insularis* (Phillip Island hibiscus). *Achyranthes margaretarum* (Amaranthaceae) discovered on Phillip Island in the 1980s, might also have once been on Norfolk Island



Figure 1: Norfolk Island (front) contrasted with Phillip Island in 1980, although they were joined as parts of a single, much larger, island for 66,000 of the last 76,000 years (photo by author)

too. Animals living on Phillip Island but never seen on Norfolk Island include two lizards — a skink *Oligosoma lichenigerum* and a gecko *Christinus guentheri*; a large centipede *Cormocephalus coynei*;² a cricket *Nesithathra philipense*, and two snails *Mathewsoconcha philippii* and *M. grayi*. The gecko also lives on Nepean Island and some of the vegetated rock stacks off the north coast of Norfolk Island. Fossils show *M. grayi* was

² The specific name is not a coincidence. The author explains, “Although the centipede was known from convict times, apparently I was the first to collect a specimen for science, which I sent to Lou Koch at the WA Museum. He asked me to collect more specimens in order to describe it (Koch, 1984). He recommended searching at night in wet conditions. Descending the cliffs at 2 a.m. in the rain was a bit too exciting. Although the centipede was known, it was extremely rare while the rabbits prevented almost any plant growth. Six hours searching by two of us that night in optimal habitat produced only one juvenile centipede. It seems amazing that now the centipedes are significant nutrient recyclers on Phillip Island.” [Ed.]

once common in the Cemetery Bay area of Norfolk Island. These fossil deposits date from prior to Polynesian settlement. The key historical threat to *M. grayi* was predation by introduced rats. *M. phillipii* appears to have been known only from Phillip Island so might never have been on Norfolk Island, but the lizards, centipede and cricket are sufficiently mobile that they could be expected to have also been on Norfolk when Polynesians arrived. Paleontologists have confirmed the gecko was present on Norfolk Island when the rats arrived (Rich et al., 1983) but it was apparently absent by 1788.

In addition to those species, paleontological research has identified bird species which were present on Norfolk when the rats arrived, but no longer occur there (Holdaway & Anderson, 2001). Some — known and unknown — were probably extirpated from Norfolk Island by the Polynesian rat before Europeans arrived. Two of those species are believed to have been eliminated on Lord Howe Island by rats (DECC, 2007). The few Norfolk Island land birds are mostly endemic. Holdaway & Anderson (2001) considered that *R. exulans* was probably responsible for the extinction of several of the smaller, terrestrial birds on Norfolk Island for which no record exists, an expectation consistent with experience on other islands. Maori introduction of the Polynesian rat into New Zealand resulted in eradication of several species of terrestrial and small seabirds. The species has been implicated in many of the extinctions that occurred in the Pacific.

Extinction of the cricket *Nesithathra philipense* on Norfolk Island (genus and species

now endemic to Phillip Island), plausibly caused by rats, has also been attributed to competition from a more recently arrived feral animal, the cockroach *Periplaneta americana* (Rentz, 1988).

Campbell & Atkinson (2002) found that *R. exulans* depresses recruitment of diverse species of coastal trees on northern offshore islands of New Zealand, some to local extinction. The elimination of *Streblorrhiza speciosa* and *Hibiscus insularis* from Norfolk Island by *R. exulans* would be consistent with that experience.

Norfolk Island was abandoned from 1814 to 1825 and left to feral animals. When the island was reoccupied in 1825 for a penal settlement, pigs, goats, chickens, pigeons, cats, rats (*R. exulans*), and mice were very numerous (Backhouse, 1843). The black rat (*Rattus rattus*) reached the island in the 1940s, while *R. exulans* persists. Invasive animals have continued to arrive, the Asian house gecko and Argentine ant arriving in the last twenty-five years. Considerable effort has been devoted to the removal of the gecko and ant, and to control rats in the national park.³

Phillip Island — spectacular damage, dramatic response

By March 1790, the shortage of food in Sydney, of which no more than four months remained, was such a crisis that the governor sent both the colony's ships to Norfolk Island with 270 convicts and marines and limited supplies. HMS *Sirius*, flagship of the First Fleet, was driven onto the reef while unloading, and wrecked. The loss of the *Sirius* was catastrophic, leaving the tiny HMS *Supply*, the smallest First Fleet

³ See Evans et al. (1976), Hermes (1985), Coyne (2011), and <https://parksaustralia.gov.au/norfolk/pub/plant-brochure.pdf> for photos of birds and plants of Norfolk Island. [Ed.]

vessel, as the only means of contact between Sydney and Norfolk Island and the outside world. Worse, Norfolk Island was desperately short of food to accommodate the new arrivals, including the stranded crew of the *Sirius*, who had more than trebled the population. The people subsisted by eating seabirds — hence the name Providence Petrel — and had barely three weeks' food remaining when help arrived in August. Another catastrophic consequence of the shipwreck must be, at least partly, the feral animal damage to Phillip Island.

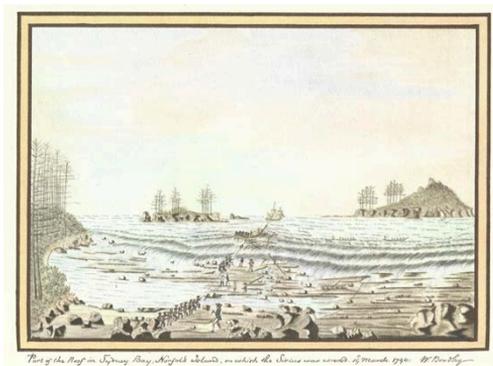


Figure 2: William Bradley's 1790 drawing showing Norfolk Island on left, Phillip Island on right and Nepean Island. Salvage efforts from the *Sirius* wreck in the foreground. Phillip Island appears covered in hardwood forest, with some Norfolk Island pines (*Araucaria heterophylla*) and the highest peaks apparently bare. Mitchell library, State Library of NSW

In 1788 Phillip Island, just 6 km away, must have been very similar to Norfolk Island, although it is much smaller (about 260 ha) and more precipitous. In 1789 King described the soil of Phillip Island as equally

as good as of Norfolk Island (ANPWS, n.d.). David Blackburn, master of the *Supply*, described the soil of Norfolk Island as “rich beyond description.” Phillip Island's soils must have been similar. Drawings by stranded *Sirius* officers William Bradley and George Raper show Phillip Island covered by hardwood forest except for the highest peaks (Figure 2).

Degradation

In August 1793, some privately-owned pigs were released on uninhabited Phillip Island. They thrived. By March 1795, Colonial Secretary Collins recorded: “Swine were increasing so rapidly on Phillip Island, now stocked by government, that Mr. King thought he should be able for some time to issue fresh pork during four days in the week.” In October 1796 the pig population on Phillip Island was at least 317, when King (cited by Nesbitt, 2009) wrote: “... a great resource for animal food has been found in Philip [sic] Island,⁴ which has abounded with the best of food for swine, many having been raised and brought from thence. The great drought during the first part of this year, and the quantity of swine on the island, has destroyed a great part of the weeds and grass on which they feed.”

Abandoned in 1814, Norfolk Island was resettled in 1825. By 1830 goats and rabbits had also been released on Phillip Island, possibly as a food source but appreciated by the officers for sport shooting.

Captain Frederick Howard, of HMS *Herald*, wrote in 1856, “Two officers landed

4 There has been some confusion over the spelling. The author explains: “Philip Gidley King named Phillip Island on 29 February 1788: ‘it was not till eleven in ye forenoon that, we made ye largest of the two Isles which lye off ye S.W. end of Norfolk Isle bearing [blank space] & to which I have given the name of Phillip's Isle, in honor of His Excellency, Governor Phillip.’ When I was on Norfolk (1978–83) it was always called Philip Island, presumably after P. G. King. The spelling was subsequently changed to Phillip, recognising that that was the original intention.” [Ed.]

on Philip [sic] Island the other day and in about an hour shot 24 rabbits ... The island is very barren, there is no grass whatever growing on it and although in one part rather thickly wooded, the whole island is of a brick red colour a great contrast to the green slopes of Norfolk Island.” (Coyne, 2009).



Figure 3: John Beattie’s photograph of Phillip Island, apparently taken in 1906, showing the remains of some of the last forest trees and two surviving remnant trees. Mitchell library, State Library of NSW

The pigs and goats died out due to elimination of food or were shot out, apparently well before 1900, their demise unrecorded. But rabbits remained, preventing vegetation developing, eating seedlings as soon as they emerged from the ground. By 1900, Phillip Island was starkly different from Norfolk, being mostly bare, eroded, ground. Photographer John Beattie visited Phillip Island in 1906. His photographs all show completely bare ground, devoid of vegetation apart from a few remnant trees and the decaying remains of a few other trees (Figure 3).

Eradication

Removal of the rabbits was attempted in 1953 by release of myxoma virus but further introductions were abandoned due to the

difficulty of landing on the island (Watson 1961). Without determined follow-up, that attempt was unsuccessful.

In 1978, when work towards rabbit eradication began, the island was very similar to Beattie’s images but with fewer remnant trees and some obvious further erosion. The rate of erosion was extraordinary. Measurements at eight locations from April 1979 showed erosion ranging from 20 mm to 62 mm, with an average of 42 mm, in just under a year. Rainfall during that period was only 83% of the mean for 1890–1974. The loss of material during the previous century is difficult to conceive. Some remaining trees stood on their exposed roots up to 2 m above the ground (Figure 4).



Figure 4: A remnant Norfolk Island pine, roots exposed by erosion, in a bare landscape (photo by author)

Because of some opposition to rabbit eradication in the island community, from some members of the elected Norfolk Island Council and even from a government scientist, a cautious beginning was necessary. In 1961, Watson wrote that “All soil has gone except from a few flat areas and screes, and removal of rabbits will not now alter the island except in a very minor way.” (Figure

5.) Also in the 1960s, the Norfolk Island Agricultural Officer, Brian a'B. Marsh, wrote that Phillip Island no longer provided a medium for plant growth. He said, "This island is a rocky arid desert incapable of reclamation" (ANPWS, n.d.). In an unpublished report for the Australian National Parks and Wildlife Service (ANPWS) in 1978, CSIRO scientist Peter Fullagar recommended no action against the rabbits on Phillip Island be undertaken because he considered the island ecosystem, as it was then, was "a balanced ecosystem of a highly modified environment." He stated, "There seems to be no reason to remove rabbits on grounds of conflict with avifauna nor for the gecko [the skink was still unknown there then] ... The flora is so depleted that there seem no real grounds so far advanced to consider grazing by rabbits as a serious impediment to gradual revegetation, if only by alien species." (Coyne 2009). The Council asked the ANPWS to undertake a three-year experimental program to assess the damage being caused by the rabbits and to investigate the potential for regeneration on the island.



Figure 5: The sea around Phillip Island turned red after rain. Photo taken in 1979 (photo by author)

That program was difficult and dangerous, in the first year requiring 600 m of

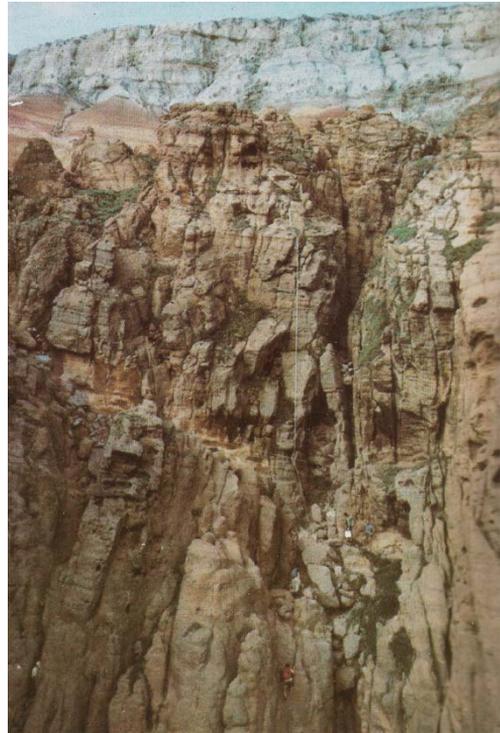


Figure 6: The access route was quite a climb. Four people are shown (photo by author)

heavy wire netting, bundles of steel fence posts and trays of potted tree seedlings to be unloaded onto the slippery intertidal rock platform from an open boat moving in all three dimensions, carrying it all up cliffs (Figure 6) and negotiating the often steep and slippery terrain. Experimental exclosures, amounting to 1900 m², were established in a diversity of environments. Some had no treatment except fencing, some had tree seedlings planted, both inside and outside, and in some, soil nutrient trials were undertaken using NPK and complete fertiliser in addition to controls. Everything planted without protection from the rabbits was quickly eaten. Despite the previous soil loss leaving a depauperate medium for planting, and the extreme exposure, native tree seedlings protected from rabbits thrived.

Unexpectedly, the exclosures soon showed abundant presence of plant seeds, with a mix of native species and weeds quickly establishing wherever protected from grazing. Two exclosures contained twenty-two and twenty species within months (Figure 7).



Figure 7: An experimental exclosure where nothing was planted, fenced in 1979 and photographed seven months later. Twenty plant species were present, five native to the island. The only difference between inside and outside is rabbits (photo by author)

The experimental program provided such spectacular evidence of the damage caused by the rabbits, and the capacity of the island to support vegetation again, that the Norfolk Island government decided after only one year to eradicate the rabbits. Rabbit eradication would be difficult, but the great benefits provided a powerful incentive to vigorous effort. The Phillip Island parrot (*Nestor productus*) can never return from extinction. Even the other land bird species which originally lived on Phillip Island might be unable to survive there again for a long time but, without cats and rats, the island could be a refuge (Coyne, 1982).

Eradicating the rabbits was sure to be very challenging. The rugged terrain meant some areas of rabbit habitat had been considered inaccessible, but that had to

change. The first method to kill the rabbits was the highly virulent, laboratory-bred, Lausanne strain of the *Myxoma* virus. It was so deadly that development of resistance was unlikely, but it was too virulent to survive in the rabbit population. An effective vector and repeated release of the virus was necessary. Before introduction of the virus, European rabbit fleas (*Spilopsyllus cuniculi*) were released in all habitat areas. One large area was accessible only by swimming, but huge underwater boulders meant the boat could not approach within 100 m of the shore — and this area is renowned for the abundance of sharks. Another large area, bound by 240 m-high cliffs, had been inaccessible, but rock-climbing experts and techniques enabled that area to be reached and, using ropes, the fleas were widely distributed there. Some other inaccessible habitat remained inaccessible. Fleas were distributed to those by fitting a glass vial containing fleas to the steel head of an arrow which was shot with a longbow. From the highest areas the range was adequate to reach those habitats and the fleas were generally released when the glass broke on impact. The well-vegetated experimental exclosures were used as traps to catch rabbits on which the fleas were released directly.

Introduction of the virus rapidly decimated the rabbit population and widespread plant regeneration was visible for the first time. Unfortunately, laboratory problems in Canberra stopped the supply of virus too early. By the time the decision was made to discontinue that approach, the rabbit population was rebounding.

A massive poisoning program began, using 1080 (monosodium fluoroacetate). Some 350 bait stations were established, with pre-feeding before poisoning commenced.

This was highly effective but required access to habitat areas which had, until then, been considered inaccessible. The poisoning was supplemented by shooting, gassing and trapping. By mid-1984 the accessible parts of the island appeared to be free of rabbits and the program was complete in early 1986, with the rabbits apparently exterminated. A single rabbit was seen two years later, in a very inaccessible, cliff-bound, location — it was the last rabbit and was killed (Coyne, 2010).

Regeneration

Substantial plant regeneration began as soon as rabbit numbers declined. Seedlings which could not be identified by staff were a species (*Abutilon julianae*, Norfolk Island abutilon, Malvaceae) last seen, on Norfolk Island, in 1912 and considered extinct. It had been recorded on Phillip Island only in 1804. Another species found when the rabbits had been eliminated had never been seen before. It was named *Achyranthes margaretarum* (Amaranthaceae) in 2001.⁵ The native white oak (*Lagunaria patersonia*),⁶ the most common remnant tree, regenerated prolifically (Figures 9 and 10). While a diversity of native species regenerated, so too did weed species. African olive (*Olea europea* ssp. *strenuous*) had been present and expanding for decades before rabbit eradication but its expansion accelerated when grazing ended.

Fauna quickly benefitted too. During the experimental phase, a well-vegetated hilltop enclosure contained many geckoes, while outside it none could be found. In the summer, this enclosure also had many sooty tern (*Sterna fuscata*) chicks sheltering within

it while few were outside (Coyne 2010). The geckoes appeared to become much more abundant as vegetation developed after the rabbits were extirpated. So, too, the *Cor-mocephalus coynei* centipede. In 1980 it was extremely hard to find. Six hours' searching by two people at night in wet weather produced only one small specimen. The largest specimen then known was 15.4 cm long; now the median length is 19 cm. The centipede has become an important part of nutrient cycling on the island. It kills and eats lizards and young seabirds. The centipedes are the principal cause of black-winged petrel (*Pterodroma nigripennis*) nestling mortality, with annual rates of predation varying between 11.1% and 19.6% of nestlings (Halpin et al., 2021).



Figure 9: (top) 1981: Trees are white oaks and some small shrubby olives are shown higher up. Rabbit-resistant ground cover is *Wollastonia biflora* (syn. *Wollastonia uniflora*); (bottom) 2015: Low forest of white oaks (photos by author)

⁵ See Lange & Murray (2001). [Ed.]

⁶ Widely cultivated in Australia and abroad, this is known as the Norfolk Island hibiscus or cow-itch tree, family: Malvaceae. [Ed.]



Figure 10: (top) 1981: The ground cover is ephemeral *Commelina cyanea* or scurvy weed; (bottom) 2015: Low forest of white oaks (photos by author)

A survey of birds of Norfolk Island in November 1978 recorded thirteen species on Phillip Island. A similar survey in November 2005 recorded twenty-five species, with terrestrial species increasing from three to eleven. Much of the increase appears to be a consequence of vegetation development. In addition to the increase in species numbers, populations of some seabird species have increased considerably with development of new habitat. By 2005, black-winged petrels were nesting in burrows under the new forest of white oak where there had been insufficient soil before rabbit eradication. Red-tailed tropic birds (*Phaethon rubricauda*) nest under many white oaks in the new forest, and black noddies (*Anous minutus*) nest on new trees. Kermadec petrels (*Pterodroma neglecta*) were first recorded breeding on Phillip Island, under vegetation, after the rabbits were eliminated. White-necked petrels (*Pterodroma cervicalis*), which breed on

only one other island (Macauley in the Kermadecs) and possibly, in small numbers, on Vanua Lava, Vanuatu (*BirdLife International* 2023), began breeding on Phillip Island after rabbit eradication, but may not have been responding to increasing vegetation as they nest under remnant white oaks.

The vegetation will continue to evolve as natural succession occurs, and as currently bare areas revegetate (Figure 11). Some fauna might be adversely affected while others might benefit from the changes. For example, sooty terns were initially favoured, as vegetation provided shelter from the sun and from traditional egg collecting for consumption, but dense vegetation could restrict sooty tern nesting.

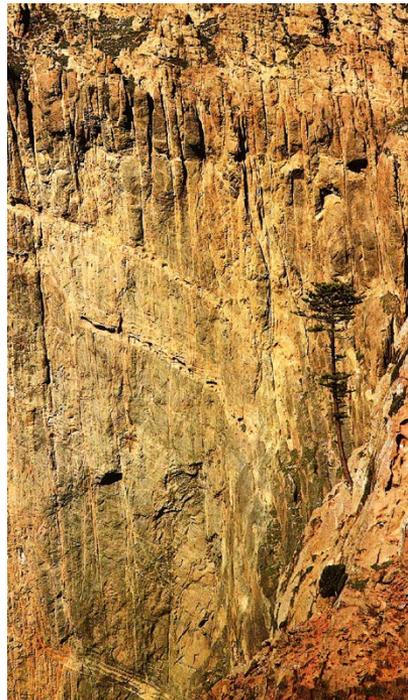


Figure 11: Dwarfed by the vast cliffs of Phillip Island, one of only seven Norfolk Island pines still surviving there in 1980 clings to life and to the rocks from which it somehow draws the water and nutrients it needs (photo by author)

Management since eradication of the rabbits has included planting of seedlings and distribution of seed but the vast majority of regeneration is natural.

Lord Howe Island — a human community

Degradation

Lord Howe Island, 780 km north-east of Sydney, was discovered on 17 February 1788 when the first colonists were on their way to Norfolk Island aboard HMS *Supply*. It was immediately seen as a source of fresh food, and *Sirius* captain Hunter recorded that the crew “Caught many excellent Turtle upon a Sandy Beach, This Island also abounded with a Variety of Birds which were so unaccustom’d to being disturbd that the Seamen came near enough to knock down with sticks as many as they wanted.” In March 1788 surgeon White wrote that they also found there, in abundance, “a kind of fowl, resembling much the Guinea fowl in shape and size but widely different in colour, they being in general all white ... These not being birds of flight, nor in the least wild, the sailors, availing themselves of their gentleness and inability to take wing from their pursuits, easily struck them down with sticks.” That species is extinct⁷ and had probably been hunted to extinction before the island was colonised in 1833. The Lord Howe Island woodhen (*Hypotaenidia silvestris*), now Endangered, also appears to have been valued for food. In May 1788 Governor Phillip recorded: “they brought off a quantity of fine birds, sufficient to serve the ship’s crew three days; many of them were very fat, somewhat resembling a Guinea hen, and proved excellent food.” The fresh food

collected on Lord Howe Island was critical for the population in Sydney, with many afflicted by, and dying from, scurvy. It was also eagerly sought by crews of some of the First Fleet ships returning to England. The decline of Lord Howe Island’s biota was well under way by the middle of 1788.

House mice (*Mus musculus*) arrived about 1860 and black rats arrived in 1918, refugees from the wreck of the SS *Makambo*. The rats quickly had a dreadful impact.

The Tasman starling (*Aplonis fusca*) had been the most common bird on Lord Howe Island, was still common in 1914, but was extinct by 1918. The Lord Howe thrush (*Turdus poliocephalus vinitinctus*) was extinct by 1924. The Lord Howe gerygone (*Gerygone insularis*) was also considered common but was last recorded in 1928. The Lord Howe grey fantail (*Rhipidura fuliginosa cervina*) declined rapidly and was extinct by about 1928. The robust white-eye (*Zosterops strenuous*), also endemic and abundant before rats arrived, was apparently extinct within ten years of the rats’ arrival.

The Lord Howe southern boobook (*Ninox novaeseelandiae albaria*) became extinct because of the rats, but by an indirect cause. Three species of owls (the eastern Australian subspecies of the southern boobook *N. n. boobook*, masked owl *Tyto novaehollandiae* and barn owl *Tyto alba*) were introduced to Lord Howe Island between 1922 and 1930 in an unsuccessful attempt to control the rats, and the native owl appears to have suffered from competition with the introduced owls. In addition, the rats may have eaten the eggs and owlets of the southern boobooks. Not only would rats have preyed on owl eggs and chicks, they also extirpated the phasmid,

⁷ Possibly the white swamphen (*Porphyrio albus*) [Ed.].

possibly one of the owl's major prey items (Priddel & Carlile, 2010).

Rats are believed to be the reason two sea bird species, the Kermadec petrel (*Pterodroma neglecta*) and the white-bellied storm petrel (*Fregetta grallaria grallaria*), which previously bred on the main island, are now restricted to breeding on Balls Pyramid (DECC 2007).

In addition to the birds, the rats are considered responsible for the loss of at least 13 species of endemic invertebrates and two plant species (Segal et al., 2022).

Saved

Probably the best-known extinction the rats caused is the Lord Howe Island phasmid, (*Dryococelus australis*). It was abundant on Lord Howe Island, with 68 individuals found inside a single tree hollow, but it disappeared rapidly from the island after the introduction of black rats. Live specimens were last seen on Lord Howe Island in the 1920s (Priddel et al., 2003).

In 1964, a rock climber found a dead adult female on Balls Pyramid, 24 km from Lord Howe Island. Balls Pyramid is a precipitous basaltic pinnacle 551 m high, much taller than it is wide. In 1969, incomplete remains of another two individuals were recovered near the summit of Balls Pyramid. An expedition to search for the phasmid was mounted in early 2001, following a relatively dry year. A daytime search found about thirty shrubs of the endemic *Melaleuca howeana*, one of which provided significant evidence of relevant insect activity. Nicholas Carlile and Dean Hiscox climbed to the area of that shrub, about 65 m above sea level, at night and found three phasmids on the shrub but none on other shrubs. Another nocturnal survey of the same area in March

2002, after a wetter year, found 24 live phasmids, all on *M. howeana* shrubs within a small area. Little other potentially suitable habitat exists elsewhere on the Pyramid, which is mostly bare rock (Priddel et al., 2003).



Figure 12: Lord Howe Island stick insect. Cropped version of photo by *Granitethighs* (https://commons.wikimedia.org/wiki/File:Lord_Howe_Island_stick_insect_Dryococelus_australis_10June2011_PalmNursery.jpg) (CC BY-SA 3.0 Deed)

In 2003, two breeding pairs of the phasmid were collected from Balls Pyramid to commence a captive-breeding program to try to save the species. One pair, named Adam and Eve, was entrusted to Zoos Victoria. After being nursed through a critical illness, Eve eventually laid 248 eggs. By the end of 2018 the entire captive population was descended from those two original founders (Zoos Victoria, probably 2019). Now nearly 19,000 phasmids have been hatched over 16 generations since Adam and Eve (Figure 12). In late 2022, 800 adults and 3500 nymphs were in captivity at Melbourne Zoo, at Lord Howe Island and at the Bristol and San Diego Zoos (NSWDPE, 2022). Reintroduction of the phasmid to Lord Howe Island was intended when rats were eliminated and conditions were suitable.

The two species of introduced rodents on Lord Howe Island continued to threaten at least 13 bird species, two species of lizard, 51 plant species, plus 12 vegetation communities, and numerous species of threatened invertebrates (DECC, 2007).

Eradication

The feasibility of eradicating rodents from the Lord Howe Island Group, assessed in 2001, found eradication was feasible. A cost/benefit analysis also considered eradication feasible and calculated that the costs of eradication would be recouped, through higher yields of palm seed, within five years (DECC, 2007). The cost/benefit analysis demonstrated the rodent eradication program would have a benefit-to-cost ratio of 17:1 (Walsh et al., 2019).

Control of rats and mice had been undertaken since 1920, and required substantial amounts of poison every year. When the eradication program was being considered, the baiting program required more than 4.5 tonnes of baits annually to treat about one-tenth of the island (Walsh et al., 2019).

Despite the promising feasibility and economic studies, the eradication program was not undertaken until eighteen years after feasibility was demonstrated. Even with the considerable physical challenges, the need to protect threatened species at risk from the program, and the presence of pets, livestock and people, the greatest impediments to eradication of rodents were the opinions of island residents. Consideration of the program caused bitter division in the island community, requiring an intensive and extensive consultation and information process from 2008 to 2015, which still almost failed to gain approval to proceed. That decision was made in 2015 after an options

paper was distributed to every person on the island registered on the electoral roll. Although rodent control had been undertaken there for almost a century, of 196 responses, 20 did not consider the island had a rodent problem which needed to be addressed. Only 108 favoured an eradication program while 93 preferred ongoing rodent control. On the basis of that slim majority, the Lord Howe Island Board decided to proceed with eradication (Greig and Alexandre, 2015; Walsh et al., 2019).

Two threatened endemic bird species, the woodhen and the Lord Howe currawong (*Strepera graculina crissalis*), were considered at considerable risk from poisoning during the rodent eradication program. The entire woodhen population (about 230 birds) and 129 currawongs (an estimated 30–40% of the population) were captured and kept in captivity on the island for the entire risky period (*Australian Geographic*, 2020; Segal et al., 2022).

About 100 beef cattle were reduced progressively to zero and all poultry were eliminated from the island before baiting began, to be replaced by imported animals afterwards. The dairy herd of 14 cows was protected from exposure to baits (Wilkinson & Priddel, 2011).

The rodent eradication program conducted in 2019 was a massive undertaking, involving:

- approval from seven government departments and agencies;
- individual property management plans for private property;
- after trials involving smaller numbers of birds, capturing the woodhens and currawongs, transported by helicopter from isolated areas;

- maintaining those birds in rodent-proof enclosures over the period of baiting and subsequent risk;
- two helicopters in June and July to distribute bait over uninhabited parts of the island, with eight ground crew;
- 19,000 bait stations in a 10 × 10 m square grid and fifty ground baiting crew May to November;
- 9,500 hand-broadcasting points in the areas of overlap between the aerial application and bait station network;
- rodent-detection dogs and their handlers for monitoring for two years after baiting (LHIM, 2022; Segal et al., 2022).

No signs of live rodents were detected from the end of September 2019 until April 2021, when an island resident saw two rodents. These were thought to be new arrivals rather than survivors of the eradication program. By July 2021, 78 rats had been caught (LHIM, 2022). The 2021 response appears to have eliminated rats from the island (Invasive Species Council, 2022).

Regeneration

The benefits from the rodent eradication are being monitored and significant increases in birds, invertebrates and plants are being recorded. By early 2023 there were more than 1100 woodhens (Siossan, 2023). Residents reported increases in emerald doves (*Chalcophaps longirostris rogersi*) and other land birds. Seabirds also appear to be increasing the range where they breed (LHIM, 2022).

With rodents removed, more than 30 threatened plant and animal species found on the island are recovering. The masked

booby (*Sula dactylatra tasmani*)⁸ is breeding on the main island for the first time since rodents arrived. The Lord Howe wood-feeding cockroach (*Panesthia lata*), presumed extinct on the main island, has been rediscovered at a site in the north of the island (Siossan, 2023).

Lord Howe Island has Australia's highest diversity of land snails, with around 70 endemic species. The snail populations suffered heavily from rodent predation. Several species are considered extinct and five are Endangered or Critically Endangered. Extremely rare species were soon more numerous after rodent eradication (Hyman, 2021).

Jack Shick, a fifth-generation Lord Howe Islander, said "There has been an unbelievable rebound of birds, plants and insects since rodents started being removed in 2019. ... The amount of seedlings from native plants popping through has to be seen to be believed" (Invasive Species Council, 2022).

Lord Howe Island, a World Heritage Area, is the largest populated island to eradicate rodents.

Macquarie Island — multiple ferals

Macquarie Island, 34 km long and 5.5 km wide, is spectacular. Between Tasmania and Antarctica, the outstanding significance of this remote island is recognised through its World Heritage listing, for its exceptional geoconservation significance, exceptional natural beauty, and superlative natural phenomena including extensive congregations of wildlife (PWS, 2014).

Macquarie Island supports vast congregations of wildlife, including breeding colonies of elephant seals and fur seals, and

⁸ This bird was known as *Sula dactylatra fullageri* until Steeves et al. reclassified it in 2010. [Ed.]

numerous seabird species, including four species of penguins, four species of albatrosses, two species of giant petrels, and a variety of burrow-nesting seabirds. There are also resident breeding populations of terns, cormorants and skua (PWS, 2014).



Figure 13: Royal Penguins (*Eudyptes schlegeli*) on Macquarie Island west coast. Cropped version of photo by Hullwarren (<https://commons.wikimedia.org/wiki/File:MacquarieIslandRoyals.jpg>) (CC BY-SA 3.0 Deed)

The 45 species of vascular plants, four endemic, comprise small grasses, herbs, cushion plants, ferns, orchids, mega-herbs and large tussock grasses (Bryant & Shaw, 2007).

Degradation

The island was discovered in 1810; over the next 70 years, rats, mice, cats and rabbits were introduced by sealers. Weka (*Gallirallus australis scotti*) were also introduced and established, initially as a food source for sealers.⁹ The impact of ferals was catastrophic. At their height feral cats were killing an estimated 60,000 seabirds a year (Olive, 2021).

Penguin and elephant seal populations are recovering, but invasive mammals led to the extinction of the endemic rail and parakeet, and massive declines in seabirds. By the 1970s, several burrowing petrel species were locally extinct and those remaining were declining rapidly. The birds and their eggs were preyed on by cats, weka and rats, while rabbits destroyed nesting habitat and exposed burrows more to predation by skuas. Of 14 petrel species known or likely to have bred on Macquarie Island, only three species remained on the main island by the 1970s, while another three were confined to offshore rock stacks (Brothers & Bone, 2008; NESP, 2021a).

By the 1960s concern about rabbit damage to vegetation was increasing. The catastrophic effects of rabbits were due primarily to selective grazing of the dominant and stabilising plant species. Those species were soon eliminated from plant communities. The residual short turf of mosses and minor species provided little protection for the underlying peat. On steep slopes, the conversion of only a small area of *Poa* grassland to minor herb communities often initiated a land-slip which eventually led

⁹ The weka, also known as the Māori hen or woodhen is a flightless bird species of the rail family. It is endemic to New Zealand. It is the only extant member of the genus *Gallirallus*. [Ed.]

to the stripping of an otherwise stable and undamaged slope (Costin & Moore 1960).

Eradication

Management of rabbits commenced in 1968 with introduction of the European rabbit flea but, with annual releases, it took 10 years for the flea to become widespread. The rabbit population peaked in 1978, the year when the Lausanne strain of *Myxoma* virus was introduced (Bergstrom et al., 2009; Springer, 2018). Myxomatosis caused rapid decline in rabbit numbers. By 1990 the condition of the vegetation was clearly improving. Annual release of the myxoma virus was effective for controlling rabbits for about 20 years, but production of the virus ended in 2000 and supplies dwindled. Annual releases ended in 2006 (PWS, 2014).

By 1988, weka had been eradicated by shooting (Springer, 2018).

Myxomatosis resulted in reduced food availability for cats, and cat predation of petrels intensified (Brothers & Bone, 2008). By the mid-1980s cats were having significant detrimental impacts on seabird populations. Cat eradication commenced in 1985, was expanded in 1998, and the last cat was killed in 2000. A total of 6298 field days and 216,574 trap nights were recorded in cat eradication (Robinson & Copson, 2014). After that, rabbit numbers increased rapidly and substantially altered large areas of vegetation (AAP, 2009).

The successful eradication of cats from Macquarie Island, being the second largest then achieved, provides valuable experience for cat-eradication attempts on other large remote islands (Robinson & Copson, 2014).

Some regeneration but further eradication

A number of species showed immediate benefit from the rapid reduction, then eradication, of cats. Although this implies that cats were the most destructive of these pests, it was cats in combination with rabbits and weka that were responsible for the demise of so many indigenous species (Brothers & Bone, 2008).

Eradication techniques for rodents and rabbits on an island the size of Macquarie were unavailable when cat eradication was deemed necessary (Dowding et al., 2009).

With cats and weka gone, despite rats remaining, a number of species attempted to re-establish. Such activity did not occur when cats were prevalent (Brothers & Bone, 2008).

Grey petrels (*Procellaria cinerea*) were confirmed breeding on the island in 2000 after an absence of over 80 years. Cape petrels (*Daption capense*) were recorded breeding for the first time, soft-plumaged petrels (*Pterodroma mollis*) appeared to be colonising for the first time, and blue petrels (*Halobaena caerulea*) and fairy prions (*Pachyptila turtur*) were re-colonising from refugia on off-shore stacks (Brothers & Bone, 2008).

Rabbit numbers then increased rapidly, and in about five years they had substantially altered large areas of the island. It has been suggested that eradication of cats led to an increase in rabbit abundance. However, both reducing *Myxoma* virus and variation in climate may also have affected abundance (Bergstrom et al., 2009), while rebounding vegetation after myxomatosis increased food supply (Springer, 2018).

The incidence of landslips in areas of high rabbit damage increased in 2002–2007.

Rabbit grazing and burrowing appeared to destabilise steep slopes (Bryant & Shaw, 2007).

Rabbit grazing led to loss of breeding habitat for seabirds. Loss of vegetation contributed to the exposure of burrow entrances and landing platforms (Bryant & Shaw, 2007). Rats preyed on seabird chicks and eggs, killing petrel adults and chicks in their nest burrows and predating on blue petrels, forcing them to breed only on off-shore rock-stacks. White-headed petrels (*Pterodroma lessonii*) were highly susceptible to disturbance by rabbits (Brothers & Bone, 2008). In one season half the island's albatross nests failed and the breeding success of six petrel species was impacted by both rats and rabbits (Olive, 2021).

From 1979 to 1999, there was an 89% decline at a sooty shearwater (*Puffinus griseus*) colony that originally contained about one-third of the total island population. That site had suffered severe rabbit damage over the 20-year period (Brothers & Bone, 2008).

The serious impact on petrels of habitat destruction from rabbit grazing was far more detrimental to petrels than increased skua (*Catharacta lonnbergi*) predation, predicted to occur during rabbit eradication (Brothers & Bone, 2008).

The impact of rabbit browsing on six threatened burrowing petrel species and its likely threat to five flora species supported the need to urgently commence rabbit eradication (Bryant & Shaw, 2007).

The planning phase of the project to eradicate rabbits, rats and mice was complex, with over 30 separate state and federal permits and approvals required (PWS, 2014). Approximately 29 people were employed for the aerial baiting phase, and annual field teams of up to 15 staff were used for three

years of fieldwork following aerial baiting (PWS, 2014).

Toxic baiting of rabbits, rats and mice using aerial baiting from helicopters was expected to take around four months and be completed during the winter of 2010. Late arrival due to shipping delays, followed by extended bad weather conditions, seriously curtailed helicopter flying time. Only a small portion of the island (about 8%) was successfully baited during the 2010 winter season. The decision was made to suspend the baiting program until the following year (PWS, 2014).

The baiting undertaken in 2010 was very successful in killing the target species in the areas covered but, as expected, there was incidental mortality of non-target seabirds: skua, kelp gulls (*Larus dominicanus*), northern and southern giant petrels (*Macronectes halli*, *M. giganteus*), and Pacific black ducks (*Anas superciliosa*) and mallard (*A. platyrhynchos*). Concern about non-target mortality caused refinement of the approach (PWS, 2014).

Calicivirus (or Rabbit Haemorrhagic Disease Virus) was introduced to Macquarie Island in February 2011. An estimated 80–90% of the rabbit population was killed in the weeks after the virus release (PWS, 2014). Importantly, this greatly reduced the number of rabbits killed by poison and consequently prone to causing secondary poisoning of scavenging birds.

Whole-of-island baiting by four helicopters resumed in May 2011 and was completed within seven weeks (PWS, 2014). Staff collected and buried poisoned carcasses (target and non-target species) during and after the baiting period to reduce the risk of secondary poisoning to scavenging seabirds (PWS, 2014).

The hunting phase of the project then commenced, with teams deployed to locate and kill any remaining rabbits that survived the baiting. Teams included twelve rabbit-detection dogs and three rodent-detection dogs (Springer, 2018). This follow-up phase was critically important to ensure that every individual of the three target species was eliminated. Though planned for three years, this phase took seven months (PWS, 2014). No rodents or rabbits were seen after May 2011 (rats), June 2011 (mice), and December 2011 (rabbits) (Springer & Carmichael, 2012).

After the last rabbit was killed, the monitoring phase began in April 2012 to search for any evidence of live rabbit or rodent presence on the island. Monitoring continued for two years, with staff recording more than 92,000 km travelled between August 2011 and March 2014 (PWS, 2014).

Regeneration

By 2014, vegetation regrowth was progressing well. Recovery of *Poa litorosa* was noted in areas where it was previously unreported. Extensive regrowth of *Poa cookii* occurred on areas of the plateau and escarpment where it had not previously been recorded (PWS, 2014).

Significant recovery across favourable sites has been recorded for the dominant species, muttonbird poa (*Poa foliosa*), the Macquarie Island cabbage (*Stilbocarpus polaris*, Araliaceae), and the silver-leaf daisy (*Pleurophyllum hookeri*, Asteraceae), while the prickly shield fern (*Polystichum vestitum*) is regrowing. Numerous grassland and smaller herbfield plants are demonstrating significant recovery (Springer, 2016). *Poa litorosa*, known from only four restricted populations on Macquarie Island prior to

2014, has increased dramatically. Existing populations have expanded and new populations have been recorded (Williams et al., 2016).

Some species of burrowing and surface-nesting petrels are again breeding on the main island. Notable breeding activity and increased breeding success has been recorded for the soft-plumaged petrel, blue petrel, grey petrel, white-headed petrel, cape petrel and diving petrel (*Pelecanoides urinatrix*), while the Antarctic tern (*Sterna vittata*) has begun breeding on cobblestone beach areas. Species impacted by the baiting such as northern giant petrels and kelp gulls (Springer & Carmichael, 2012) soon showed signs of recovery. Skuas were expected to reach a lower population equilibrium than previously, given the removal of one of their key prey species — rabbits (Springer, 2016).

Populations of the two species that survived invasive predators were estimated to be about 160,000 breeding pairs of Antarctic prions (*Pachyptila desolata*), and 12,500 breeding pairs of white-headed petrels. The recolonising species, blue petrels and grey petrels, had reached 5,500 pairs and 250 pairs respectively, and are increasing rapidly. Common diving-petrels are breeding on the main island for the first time, and new breeding locations were found for soft-plumaged petrels, fairy prions and grey-backed storm-petrels (*Garrodia nereis*) (Bird & Shaw, 2021).

Rabbits were an important part of the brown skua's diet during their breeding season. Skuas dropped to their lowest breeding population size on record following rabbit eradication due to prey-loss in some areas of the island but, in other areas, to secondary poisoning. Nest numbers

dropped by almost half after eradication of rabbits. In the absence of rabbit prey, penguins became the primary prey for nearly all skuas on the island. (IMAS, 2021). The brown skuas are now showing strong signs of recovery (NESP, 2021b).¹⁰

Naturally abundant petrel populations drive primary production on islands and their coastal waters by collecting nutrients over vast ocean catchments and depositing them in their guano, influencing the entire island ecosystem. Conspicuously, suitable breeding habitat on Macquarie Island is greatly under-utilised. If petrels increase to fill all suitable areas at the same densities found in their current colonies, populations could number in the hundreds of thousands or millions. Such numbers tally with other islands throughout these species' ranges (Bird & Shaw, 2021). Populations on Macquarie are not yet sufficiently abundant to fulfil this important ecological role. Full recovery of populations, and restoration of the ecological functions they provide, may take decades (NESP, 2021a).

Macquarie Island is the largest island worldwide where these three species have been eradicated (Springer, 2018).

Removal of rabbits, ship rats and especially house mice from Macquarie Island was ambitious and challenging. Its success despite many challenges is a significant milestone in global island eradications and will hopefully encourage similar measures on other islands where pests are causing significant impacts. Crucially, biosecurity measures need to be robust and maintained at a high level in perpetuity if conservation and biodiversity gains are to be realised long term (Springer, 2016).

Conclusion

The islands discussed here have suffered severely from feral animals, with consequent extinctions and spectacular land degradation. Removing the feral animals induced rapid ecological responses, although full recovery will take many decades and extinct species can never return. Biologically, the outcomes have well justified the effort and cost. The pest eradication programs on Phillip, Lord Howe, and Macquarie Islands all faced extraordinary difficulties, but they succeeded, extending the scope of what is possible. These experiences have shown the importance of thorough planning, dedicated personnel, adequate resourcing and extreme diligence in ensuring no pests remain. Trained dogs were crucial to find the last remaining pests. Lord Howe Island has shown the critical importance, for populated islands, of ensuring the island community completely understands the issues early in developing the pest-eradication program. Early community engagement (not information sharing) to gain support needs to be the top priority for future eradications on populated islands (Walsh et al., 2019). Threatened birds at risk during rodent extermination were kept secure in captivity and released when safe. With the will to try, even an invertebrate with a population reduced to about 30 individuals can be saved from extinction and, hopefully, restored to its important ecological role. The Macquarie Island program was made more difficult by different agencies having somewhat conflicting legal objectives, so while the program had a long-term purpose, some legislation was focused too narrowly. Reducing the rabbit

¹⁰ See also Travers et al. (2021) [Ed.]

population with calcivirus before beginning poisoning minimised secondary poisoning of scavenging birds. Pest control and eradication on Macquarie Island demonstrated possible cascading consequences — rabbit control increased cat predation on birds; cat eradication removed a constraint on rabbit numbers; and rabbits then caused great damage to the island and its birds. Only eradication of all the vertebrate pest species enabled ecosystem recovery. Monitoring after pest eradication is important, so planning and funding should be included in the eradication project. Comprehensive documentation of programs facilitates their contribution to future efforts.

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Drones, smart munitions and cyberspace: 21st century defence of Ukraine & implications for Australia

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Introduction

Susan Pond: This open lecture¹ delivered by Major General (rtd) Fergus or Gus McLachlan AO FRSN is on the very topical subject of drones, smart munitions and cyber space, the 21st-century defence of Ukraine, and its implications for Australia. Gus tells me he's had a busy day, including just leaving the stage of "The Drum."² Gus retired from the Australian Defence Force in 2018. He held several senior appointments in the Army, including responsibility for modernization and strategic planning. He created the first Army cyber capability, introduced reconnaissance drones, and commenced the creation of a deployable digital command-and-control system, in other words, a military Internet of things. Gus's last appointment in the Army was as commander of Land Forces Command, which comprised 36,000 women and men in roles as diverse as helicopter crews, tank and artillery units, logistics and satellite communications.

He saw active service in Syria, Lebanon, Iraq, and Afghanistan. Gus now serves in executive and advisory roles in the defence

industry, private equity, cyber security, and information systems companies. I'm also pleased to introduce Colonel (rtd) Andrew Condon CSC, Industry Professor for veterans and their families at the Australian Catholic University where he has been for a year. Andrew will conduct a conversation with Gus after his presentation. Andrew's a former CEO of Legacy and chair of RSL LifeCare aged care. He currently serves on the federal government's Aged Care Advisory Board. Gus, welcome to the stage, and, Andrew, you'll follow to conduct the Inquisition and also to ask for questions from the audience. Welcome.

Gus McLachlan: Well, thank you very much for having me. I think it's a very important topic and I think in a well-informed democracy, we need to take the time to understand what's happening in places like Ukraine, which might seem a long way away, but with the sort of storm clouds of instability growing over the region, I think the more we understand about the way war is being shaped by technology, the better the decisions we will make.

1 This paper is derived from a presentation to the Royal Society, at the State Library of NSW, on 1 February 2023 (Ordinary General Meeting number 1310).

2 See <https://www.abc.net.au/news/programs/the-drum> [Ed.]

Past and future tank battles

Mark Twain famously said that history doesn't repeat, but it rhymes. And in the late summer of 1943, the largest tank battle in history took place on the plains of Eastern Europe, east of Kyiv, at a place called Kursk. The Soviet counter attack against the German invading force was ultimately successful. And to this day is regarded as the largest tank battle in history.

It's likely that this (northern) summer will echo with tank battles in the same area, and it's through this lens that we need to understand the imminent decisions that people like Olaf Scholz are making as the Chancellor of Germany about the trepidation he feels as a leader of a country, deeply scarred, by providing German tanks that rumble across the plains of Europe as he makes decisions about whether to contribute those tanks to the ultimate liberation of Ukraine. We're 12 months into a land war, and there are numerous things that we are learning about the impact of technology on the war, and, sadly, one of the things we're also learning is that a whole lot has not changed.

So, what are we seeing? It's important we talk a little about the impact of technology on the war, but I think it's also important we spend some time on the origin to the conflict. Andrew and I are very conscious of the experience and wisdom in this audience.

Origins of the war

Please allow me to go back over a little bit of time. Olaf Scholz said, soon after the Russian invasion, that the invasion ultimately ended 40 years of unipolar US leadership. I think it's important to understand this challenge to the Western system that we have benefited from so generously, with

things like global trade, uninterrupted supply chains and a relatively benign period of US leadership that are now appears to be over. The Russian foreign minister, Sergey Lavrov, went as far as to say "the US wants a unipolar world, not a global village, but a US village. We're not closing the door on the West, they're closing the door on us." And Putin himself, interestingly, 90 minutes late in his address to his nation as a result of "hactivism" — I'll talk a little bit more about that soon — said that "the US believe they represent God on earth. Everything else is a colony or a backyard."

The United Nations General Assembly has voted twice to discuss the issue of condemning the Russian aggression in Ukraine. And as recently as a speech in Canada, the US Secretary of Defense celebrated the fact that, of the 193 countries, 141 chose to condemn the Russian invasion and condemn Russian behaviour: only five countries supported Russia's behaviour. That included countries like North Korea. But 35 countries abstained, and in that 35 countries is 50% of the world's population — China, India, Pakistan, Vietnam, South Africa, for example — all chose to abstain on the question of the ultimate morality of the Russian invasion.

I think it's important for us all to understand that this view of the benefit of 40 years of unipolar US leadership is not universally perceived. So this period — the second period of globalization, as it's being called — looks like it's over. There is much industry analysis around the end of just-in-time supply chains, moving to "friendly-in-time," or to holding stocks. We'll leave that for another discussion. But, through my period of military professional education and development, we followed kind of two schools of thought.

Francis Fukuyama, the American academic posited that the demise of the Berlin Wall and the end of the Soviet Union represented the end of history.³ And that the liberal democratic world order supported by the mechanisms of capitalism meant that, in real terms, history was over: it was inevitable that those things would prevail. Sam Huntington, interestingly Fukuyama's professor, took a different view:⁴ he said that it is ultimately the case that civilizations will clash, and that the real conflict was still to come. Now, lots of people contest Huntington's division of the sort of cultural landscape. And I'm one that accepts that it was far from perfect.

But, really interestingly, the fault line down the eastern side of Ukraine, with the Orthodox Russian side on the East and the Catholic European view of Christianity on the West, has clearly played into Putin's understanding of what would happen when he invaded Ukraine. Putin clearly believed that that fault line would fracture, and that the Orthodox, predominantly Russian-speaking, people in the east of the country would welcome him and the invading force with garlands of flowers. And that's clearly not been the case. So again, let's just briefly explore some of the background by zooming out to the strategic level.

In one of my roles in the military I was seconded to the Pentagon in Washington to work on the first defence policy statement of the Obama administration. Only two countries asked to participate in that activity — the Brits and us — and this represents the very special relationship we have with

our main alliance partner. US presidents are obliged by law to release a policy statement in the first year of their administration, unlike in Australia, where governments can choose to release a defence white paper when circumstances change.

What's really significant in the Biden quadrennial defence review is that the Biden administration admitted for the first time that the US was incapable of winning two wars at once. US defence policy for decades had been that they, as the main global superpower, were capable of winning two wars at once, understanding that that might mean a war in Europe, and it might mean a war in the Asia-Pacific. Biden admitted what most of us professionals had known for some time; that that was impossible. In fact, most of us had known that perhaps the Americans could hold or support one area of conflict and arguably win in another. And it's into that new US uncertainty that Xi Jinping and Vladimir Putin, as two leaders who are interested in bifurcation of global systems and of ending this period of unipolar American leadership, have stepped in to exploit that challenge.

So, US policy is now largely designed — to the extent they can hold the situation in Europe — to enable a Ukrainian victory, whilst keeping their eyes on the far more difficult challenge of an emergent and increasingly confident and belligerent China.⁵ This bifurcation of global systems has a political and a philosophical bent, but it also has a technological bent. The Huawei efforts to dominate the rollout of the 5G networks and global internet systems are

3 In his article, Fukuyama (1989), and later his book.

4 In his article, Huntington (1993), and later book.

5 See White (2023). [Ed.]

a clear attempt for China to take the lead of those technical systems. We're seeing the SWIFT mechanisms of global internet payment systems under threat by alternate Chinese pathways, and Chinese challenges to the World Bank, and other things. So those leaders who challenge this US period of leadership are fundamentally seeking an alternate organization.

The war in Ukraine

Let's talk a little now about Ukraine. While Putin had ambitions (many of which were imperialist ambitions that dated back to the 12th century — Russian myth-making, perhaps), he chose to pick a fight with a genuine 21st-century leader. My argument is that we are seeing a war between a 20th-century leadership construct in Russia and a 21st-century leadership construct in Ukraine. Putin commenced what he called a special military operation without mobilisation. And, for people like Andrew and me, there were clear indications in that about Putin's understanding and ambition mobilised about 290,000 troops and positioning them in the snow at the borders of Ukraine.

It was pretty clear that he intended to invade. That was about 65% of the Russian standing army, meaning that it's a one-shot opportunity. There's no spare army with which to rotate those forces. There wasn't at the time — military planners do a basic set of what we call mathematical tactics, or force ratios. When I looked at something close to 200,000 troops on the border, we knew that the Ukrainians actually were capable of fielding an army of about 200,000 people. It was pretty clear to military professionals that, despite what we perceived as Russian technological and perhaps profes-

sional advantage, they didn't have the force to overrun all of Ukraine.

Putin's advisors might have been telling him that there was likely to be this social collapse, with garlands thrown in front of soldiers as they marched on Kyiv. But the reality of the force ratios and the mechanics of the war that he faced meant that it was unlikely that he would be successful. And I sadly said in forums like this, almost a year ago — while some commentators were saying the war would be over in three weeks — that we'll still be talking about this at Christmas, meaning Christmas 2022. Well, sadly, I'm now going to say to you tonight that I think we're still going to be talking about this at Christmas 2023. I think we're entering possibly the most dangerous phase of the war.

Three phases of the war so far

Broadly, there have been at least three phases of the war so far — first, what I'd call *the battle for Kyiv*, which, which was almost immediately unsuccessful. There was the Russian withdrawal, and reversion to a phase I call *fire and movement*: the Russians would bombard a thousand metres in front of their troops for 24 hours, and they would advance a kilometre, destroying infrastructure, homes, people and troops as they went. That was a dangerous and difficult period for the Ukrainians because, even though their soldiers were better trained, they lacked the ability to reach Russian artillery and Russian logistics. They were in a dire position. Fortunately for them, the West responded — and we'll talk a bit more about how the West responded — in terms of providing equipment and support.

The next phase of the war I call *the Ukrainian local counterattacks*. And we saw a very

significant counterattack in the summer that removed the Russians from probably 10 or 15% of the captured territory. In my opinion, that gave Zelensky time to pursue all-out defeat of the Russians, because, prior to that success, I think that it was likely that people like the French president Emmanuel Macron and the German chancellor Olaf Scholz were starting to manoeuvre towards negotiations with the Russians over a negotiated settlement. The barbarity of the Russian attacks became clear in this period. There were atrocities committed in villages before they withdrew. And there were very significant attacks on infrastructure, which continue.

The fourth phase is what we are building towards now. And that's what I'd call *the strategic counterattack*, where the Ukrainians are seeking to build up the capacity to actually evict the Russians from their country. Remember those force ratios that I talked about before — simple, broad military planning mathematics — a defender is expected to be able to stop probably three to five attackers.

Think about the defenders' advantage: they are on home ground. They've probably had a chance to prepare defences to dig in and get below ground. They have resupplies on what are called interior lines. So it's generally expected that a defender will be able to stop a greater number of attackers. That's what we saw with the professional performance of the Ukrainian army. Under considerable threat, they were able to force and ultimately cause the Russians to grind to a halt.

But the polarity of that force ratio now reverses, and we have a situation where, if

the Ukrainians are to evict the Russians from their country, they're going to need at least to be able to generate local advantage of three to five times the troops that are available on the Russian side, which is going to be very difficult. This, of course, leads to the discussion around systems like the provision of tanks and other things, which I'll get to in a moment.

A dangerous counterattack phase

I therefore anticipate a very dangerous and dramatic period where we'll see counterattacks from the Russians, now led by this Wagner group of mercenaries who are throwing conscripted young soldiers into a fight. 200,000 young Russians have been mobilised, with very little training. They are literally being forced into advances. And it's highly likely there are Wagner soldiers at the back of their formations, threatening to shoot them from behind if they turn around and run away. And they'll be telling the hapless recruits that "at least you've got some chance of living if you continue to attack." So a very brutal period.⁶

Volodymyr Zelensky, a 21st-century leader, is agile. He knows how to communicate. Everyone knows that he was a former comedian. Interestingly, he's more on "The Chaser" style of comedian, so politically aware, smart, sharp, savvy — he topped his law school at university. It's possible to argue that he wasn't being a particularly successful peacetime leader, since Ukraine is a difficult country to govern, with lots of endemic corruption. But cometh the hour, cometh the man. And what we've seen is a leader who is capable of a level of sophistication in modern communication that I don't

⁶ See Renwick (2023). [Ed.]

think we've seen before. I think we will look back on him as almost a Churchillian figure in terms of his ability to mobilise support for his country. His communications are on agile multi-platform multimedia, tailored to the audience, TikTok sound bites, short, sharp penetrating commentary, while his adversary is giving 90-minute rambling speeches on traditional platforms that nobody is listening to.

The cyber war

Zelensky knew he had to preserve the information networks of his country in order to get those messages out. They knew the Russian invasion was coming. Cyber defence was planned ahead. Data was offshored into global cloud capacity. Applications for running their government were offshored into global cloud capability. They mobilised the agencies of the West to help them prepare their cyber defences: the National Security Agency (NSA) in the US, GCHQ in the UK and, and the Australian Signals Directorate. You may recall Prime Minister Morrison at the time saying that we would provide cyber support. What he was talking about was this support to help keep alive this communications layer in Ukraine.

I'm an adjunct professor at Monash University. There's a wonderful institution at Monash, part of what is known as the Internet Observatory,⁷ which monitors internet performance for evidence of state-sponsored reduction. They tracked the Ukrainian internet performance throughout this period, and the lowest level of function of the Ukrainian internet and communications architecture was degraded to was about 85% of capacity,

which was a remarkable achievement, given the former superpower's capacity that was thrown at them. That fight is not over, by the way: we are seeing a significant rallying of Russian capacity, including trying to strike at those agencies and companies and countries that have supported Ukraine. So there's likely some attention for Australia in that process. But ultimately Zelensky's critical vulnerability is Western attention and Western engagement, which leads to material support for his army. Remarkably, he's been able to keep the West aligned with that process.

We have very current representations of the state of play on the ground. Interestingly, they're from an organization called the Institute for the Study of War,⁸ one of a number of organizations that are providing an outstanding level of analysis on what is happening in the war. They provide a platform for a fairly clear understanding for people like me to be able to follow the conflict in a way that is really quite remarkable. It is empowered by a new level of open-source intelligence that is unprecedented. I think I know more about what's happening on the ground in Ukraine than I did when I was a general on the ground in Afghanistan. Which was not that long ago. The level of pervasive, hand-based phone imagery coverage goes right down to the cheap Chinese tyres on the logistic convoys that are bursting in the snow and causing tailbacks of Russian convoys that can then be attacked.

We're seeing drone footage and disposition maps with a level of granularity that's really quite extraordinary. You'll hear the

⁷ See Ackerman et al. (2017) [Ed.]

⁸ <https://www.understandingwar.org> [Ed.]

term OS INT — open-source intelligence.⁹ We've got to be careful because it's not analysis, it's information, and it's being manipulated, in this case we think by the good guys. So Zelensky is being very careful to make sure there's free access to this sort of imagery, giving a positive depiction of what the Ukrainians are facing. Sadly, he necessarily has to restrict our understanding of how many casualties the Ukrainian forces are taking, which has been very, very significant. So, it is not really intelligence, but it is certainly unprecedented information. The UK head of GCHQ, the British Cyber Intelligence Agency, Jeremy Fleming, in a visit to Australia last year, said in his opinion the pace of declassification of the information provided by the intelligence agencies is unprecedented.¹⁰

And it's been picked up by organizations and promulgated in a way that all of us (and people like me) can consume. Fleming goes on to say — which I think is really significant — that intelligence is only worth collecting if it's used. And in this case, it's being used to pre-empt Russian action. So if we are reporting that it's likely the Russians are going to try and create a dirty bomb from the former Chernobyl nuclear facility, with credible intelligence, it provides a significant disincentive for the Ukrainians to do so. Another significant element of these layers of support.

We've talked about state-sponsored agencies, the cyber agencies of the Five Eyes countries, but we've also had this exciting emergence of a thing I call *Hactivism*. The "white hat" hackers of the world, many of whom work in banks for intrusion

detection, you know, testing code et cetera, have rallied behind this cause in a way that we haven't seen before. I described Putin's speech as being delayed for 90 minutes. It was not delayed by Western intelligence agencies, but by white-hat hackers, who wanted to make a mockery of Putin and the Russians' ability to defend his network.

We expected cyber attacks from the Russians. When we studied the Russian invasion of Georgia, we saw — prior to Russian troops going across the border — things like the telco networks being pulled down, traffic signals, power and distribution, even the functioning of hospitals all disabled in cyberspace before physical troops came across the border. But, as I said, in this case, there was significant anticipation of that by the Ukrainian government.

Industry cyber support and Starlink

The other piece I didn't talk about — we've talked about the state-based agencies, and we've talked about hacktivism — but we've also seen industry stepping up in a way that is quite remarkable, that is, picking sides. Microsoft, as an example, has done an extraordinary role, working with the Ukrainian government to preserve the functioning of their government. They set up a cyber operations centre that specifically watches Ukraine. They are seeing the attacks the Russians are making and rapidly deploying patches that remove those vulnerabilities in real time from the Ukrainian government agencies.

Now, when you're a country that's trying to deal with up to 4 million displaced civilians, tracking where your citizens are,

⁹ See <https://www.csoonline.com/article/3445357/what-is-osint-top-open-source-intelligence-tools.html> [Ed.]

¹⁰ Director GCHQ Sir Jeremy Fleming's full speech from the Australian National University (Thursday 31 March 2022) <https://www.gchq.gov.uk/speech/director-gchq-global-security-amid-russia-invasion-of-ukraine> [Ed.]

understanding the attacks to your infrastructure, you can imagine how critically important that support has been. Russia and China have proven to be quite adept at offensive cyber — that is, the ability to steal intellectual property to disrupt — but I don't think they anticipated the need to establish their own defences, and they've proven to be quite vulnerable to the offensive cyber activities that have followed them.

Starlink is a system of low-orbit Earth satellites, launched by Elon Musk.¹¹ I think there were probably 2,000 satellites in orbit, and it may grow to about 8,000 over time. Musk donated — or at least made available, I think the Ukrainians are probably paying for, or the American government is on behalf of the Ukrainian government — these terminals so that the functioning of the Ukrainian government could continue. And, while I'm going to talk about their military use, let's look at a non-military use. There were passport-issuing checkpoints at key railway stations. 4 million people displaced, leaving to go outside the country, to travel all over the world, many of whom had never left the country, and didn't have passports. Without internet connectivity through Starlink and the ability to process, this would simply have been a shambles. It's an interesting example of what Starlink was able to provide.

How significant has Starlink been militarily for Ukrainian forces? While 85% of the communications infrastructure of Ukraine has been maintained, out in the field, where the military are, there's very little infrastructure, and communications would've been incredibly difficult. In fact, the Russians

have been enormously challenged by the ranges that they've dealt with, which is why their generals have been taking out their mobile phones trying to resolve issues. The three-letter agencies in the United States, such as the NSA, provided the location of those mobile phones to rocket forces of Ukraine. And five or six Russian generals were killed quite quickly.

So taking your mobile phone out at the front line for Ukrainian forces was not the option. The provision of Starlink terminals down at the frontline, very close to the combat force, has been a specific example of where technology has enabled this 21st-century force. In the face of this brutal 20th-century adversary,¹² through Starlink they've been able to create a digital mesh, an internet of things, if you like. That's a useful forum for providing information in our military. We then put a layer of protected command-and-control systems in there, and we put all sorts of checks and balances and layers and approvals in that system.

Ukraine has a very technically savvy population and workforce. What else did they do with Starlink? Drone forces were out on the front line, to identify where a Russian artillery piece was bombarding through what I called the fire-and-manoevre phase. The Ukrainians would post the location of that artillery unit effectively on an Uber-like platform through Starlink. And say, literally, "we have seen artillery at the following location." Over on the other side there was the artillery fire from Ukraine effectively shopping from that menu of targets with immediacy, able to just select a target, with no approval and mechanisms. (In Australia

11 <https://www.starlink.com> [Ed.]

12 See Renwick (2023) [Ed.]

you would have five generals, about eight colonels, 28 captains, and, you know, 15 other people get in the way.) With no layers in between, those Ukrainian artillery units have responded to the target of opportunity.

What that means is, whenever a Russian artillery unit stops to shoot, between three and five minutes later counter fire was landing where they had been standing. That's unprecedented in warfare. So you create this moment where the Russians can shoot a few rounds, but then have to pack up their guns and go within three to five minutes. They call it "shoot and scoot." Well, the reason for having to do that is the amazing adaptation of Ukrainian forces utilizing the Starlink technology.

Putin has tried to disrupt the Starlink frequency. Ultimately it's a radio signal to space. But because it is relatively low-earth and because it is a direct line of sight, it's proving to be a very difficult thing to disrupt, whereas a broader-based command-and-control system that hops through a series of radios on the ground can ultimately be disrupted by electronic warfare capability.¹³

A drone war

My photo at the start was a trench, not unlike we saw in World War I, but I guess this image is 21st-century. There are soldiers, many of them militia, so many of them Ukrainian teachers, professors, engineers, bus drivers. Now in this force, hovering over them, is a commercially available drone — I think probably a DJI Chinese-made drone — and a Toyota Hilux. And their ability to infiltrate the frontline, use

that drone to spot Russian movement and then post that kind of information onto the command-and-control system is quite extraordinary. Sounds widely exciting and exotic, an incredibly dangerous operation. Again, the Russians are adapting. These drones can be heard. These forces are enormously vulnerable when the drone is in the air. And often the Russians will try to follow the drone back to where it lands, to be picked up as a Toyota Hilux races off into the distance.

This is at the bottom end of this drone war. At the top end of the drone war we've learned about the Turkish Bayraktar drone. Fascinating story in its own right again for us, with our Western focus. I confess I had not heard of this capability, but, around the world, it has been involved in more than 800 strikes in wars from North Africa to the Caucasus. It's very capable of destroying sophisticated systems like air defence, electronic warfare, radars and tanks. And in this case, the Ukrainians have bought these drones from this Turkish company. They're actually a much cheaper version of the Predator drone that Western forces used in wars in Iraq and Afghanistan. Selçuk Bayar runs a fascinating business. In Turkey they regard him as the Turkish Elon Musk, with 2 million Twitter followers, he is a celebrity in his own right. And, for that part of the global population who are not particularly enamoured by Western advanced technology and the ability to strike with impunity anywhere around the world, this fellow and his technology is regarded as something of a Robin Hood-like figure with his response

¹³ One day in October 2022, Ukrainian forces reported outages of some Starlink communication devices, apparently because Elon Musk was not happy that the technology was being used in warfare and there was an issue over payments. (Farrow, 2023) [Ed.]

ultimately to US Predator strikes.¹⁴ Fortunately for the Ukrainians, the Bayraktar TB2 has been in their inventory and not the other side's.

The Russians have similarly adopted an imported drone: the Iranian Shahed drone or the Marty drone. It's ultimately an attack or suicide drone, quite unsophisticated, with a small petrol motor. No camera but with GPS location programmed in it effectively flies itself onto a target, relatively accurately. In real terms it is a terror weapon, to suppress the Ukrainian population, and has been quite effective, unfortunately, at bringing down the Ukrainian power generation system, which is predominantly Soviet-era equipment, and therefore replacement parts, et cetera, are very difficult to obtain. So it's a strategic play that the Russians are about using their technology.

There are racing drones. If you're not aware of drone racing, it's the hottest sport for young people with incredible reflexes. Unlike me, they put a 3D visor on, and they literally fly as if they're on these drones through gates and round targets and under buildings. And they fly these bombs literally into the windows of vehicles and buildings. Those warheads are from a rocket-propelled grenade called the RPG-7, which is one of the most ubiquitous weapons on the planet.¹⁵ So instead of a soldier having to stand there and run at the tank and shoot their RPG-7, the 21st-century warrior straps it to a racing drone, and flies it in through the window.

Other weapons

There is predominantly American support, which significantly outweighs that of other countries. But Australia is, I think, in the top 10 countries providing support. Lloyd Austin, the US Secretary of Defense, has called it standing against the global politics of fear and coercion,¹⁶ meaning, if we allow "might is right" to return to the preeminent position of how human beings resolve their differences, then the global-based order that has led to a relatively peaceful planet since World War II will be completely undermined. And the Americans understand their amazing privilege of being able to fight the Russians through the population and the people of Ukraine. And it would be very interesting to see, under the new Congress, whether there are people unwise enough to start to withdraw American support, given this incredible privilege of fighting through the resolve and resilience of other people. All the Ukrainians want is the means to do so.

Then there is the Javelin. Javelin missiles have become part of the language of all of us now in the West. Technologically, this is an extraordinary missile.¹⁷ It has a seeker head that is ultimately AI- or machine-assistance-enabled. So the soldier whose knees are shaking as the Russian tanks are coming towards them just has to put the image on the tank. The seeker head then recognizes it as a tank. The soldier can fire the missiles — it's called fire and forget — and can

14 See Witt (2022). [Ed.]

15 See <https://en.wikipedia.org/wiki/RPG-7> [Ed.]

16 Words spoken by President Biden before the UN <https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/09/21/remarks-by-president-biden-before-the-77th-session-of-the-united-nations-general-assembly/> [Ed.]

17 <https://www.lockheedmartin.com/en-us/products/javelin.html>

then escape back into, you know, a hole in the ground or into a ravine behind. And the missile is on its way.

Now, tank designers have known about missiles for a while, so they put all the heavy armour in the front of the vehicle as it advances forward. Javelin says, “I know your tricks, thank you.” And it pops itself up, and then flies down through the thinly skinned roof of the vehicle. Quite an extraordinary system. Some 86% of missiles fired have hit their target, which, again, is an extraordinary level of success. But the reality for us in the Western Alliance is that about 40,000 of these missiles have been made, but production has stopped, and about half of global available stocks — those not fired in training — have been consumed in the war in Ukraine. And it’s interesting, there’s been a subtle shift of American support away from systems like the Javelin and into things like artillery. And that’s because they’re running out.

I mentioned the prospect of two conflicts that the Americans had to deal with. One might be in the Asia-Pacific. So we’ve seen a quiet shift away from the provision of the Javelin, a remarkable missile. Other systems? The Stinger¹⁸ is a similarly capable missile for firing at aircraft, which is the reason the Russians haven’t been able to achieve complete superiority over the Ukraine Air Force.

And we saw another system enter our language. Who knew that Australians would know what a HIMARS system was? This a high-mobility artillery rocket system.¹⁹ This is probably the game changer that allowed the shift that ended that period of fire-and-

movement in which we saw that barbaric crushing behaviour of the Russians, with former Soviet artillery and stock holdings.

The HIMARS system has been able to strike at Russian logistics and artillery systems, and we’ve seen a more than 50% drop-off in the amount of artillery that the Russians have been able to fire back in return. It is very significant that its range is 45 kilometres. And the Americans have made very clear to the Ukrainians that it is fired inside the borders of Ukraine only. This is all about the fear of escalation and potential nuclear retaliation. There is a longer-range version of this missile that will reach up to 500 kilometres. You can imagine how much the Ukrainians would like to get hold of that, which would allow them to strike deep into Russia when things like trains full of artillery ammunition or logistic resupply are moving forward. For now, the Americans have constrained the conflict within the country of Ukraine itself.

Tanks

I’ll finish on the Germans. If you’d listened to the narrative about a year ago, the tank was finished in the history of warfare. 3000-odd Russian tanks have been destroyed, a pretty damning indictment on the Western system, and it was probably reasonable to assume that its days in modern warfare were over. So why is it that the Ukrainians are so desperate to get hold of Western tanks? Of that 3000, we know about half were abandoned by poor conscripts who had no interest in dying in the face of a Javelin missile, so they parked up beside the road, popped out the hatch and took off. We saw

18 <https://www.raytheonmissilesanddefense.com/what-we-do/land-warfare/precision-weapons/stinger-missile>

19 <https://www.lockheedmartin.com/en-us/products/himars.html>

images of Ukrainians with their farm tractors stealing those vehicles. But about 1500 were destroyed by systems like the Javelin.

A tank employed poorly is a very vulnerable weapon system. But a tank such as the Challenger, the Leopard, or the Abrams employed within a well-trained army like the Ukrainians are, is absolutely critical to achieve that combat power-ratio advantage that I talked about. As they go into offence, if they can't achieve a three-to-one numerical advantage, well then you have to bring technology in the systems to bear to do so. So they're asking the West for any one of these three. Thank you, they're saying to the West, for the British Challenger,²⁰ the German Leopard 2,²¹ and my favourite, the Abrams tank,²² (because that's what we use).

But actually the most important tank is the German Leopard 2. Now, the Germans have only offered, I think, 14 of these to go to Ukraine. This relatively small number will make not much difference, but, most importantly, it has allowed other countries that use the German Leopard 2 to forward it into the conflict. In arms procurement, the seller has a significant say over where the weapon is used, because they won't supply spare parts or systems. The Germans, up until now, have been telling countries like Poland who operate the Leopard 2, "no, we won't agree to you forwarding it into Ukraine," again on the assumption that this would lead to a level of escalation that potentially would cause the Russians to retaliate. But I think at the heart of it is that echo of history: Olaf Schultz and the population of Germany do not want to see

masses of German tanks advancing across the plains of Europe again. And I can understand exactly why they would feel that way. In this case I think they've relented, but with some discomfort.

Those Western tanks have all sorts of embedded technology. They have a laminated layers of armour that are designed to more efficiently dissipate penetrating projectiles. They have very advanced night-fighting capabilities based on thermal images. They have advanced ballistic computers that allow them to shoot on the move with very high levels of accuracy. And, increasingly, they include countermeasures and systems that will stop an incoming missile by firing out a blast of molten metal. So they very significantly overmatch the Russian capability.

Conclusion

In conclusion, I think, sadly, this war has a long way to run. We're entering a very dangerous period. We in the West have to maintain our support, that the Ukrainian people, population and military have demonstrated their resilience and resolve. We need to maintain ours. This period of Russian mobilisation is yet to be tested. I think many thousands of young Russians are going to be killed in this next phase as they push these poorly trained conscripts in human-wave attacks. We've seen them dig trenches that look exactly like the trenches that were in Western Europe in World War II. And the danger for the people of Ukraine is not necessarily the Russians, it's us with our ongoing confidence and resolve. So

²⁰ https://en.wikipedia.org/wiki/Challenger_2

²¹ https://en.wikipedia.org/wiki/Leopard_2

²² https://en.wikipedia.org/wiki/M1_Abrams

with that, I think I'll leave some time for questions and discussion on many of those elements.

Commentary and discussion

Andrew Condon: My name is Andrew Condon. I'm an Industry Professor at ACU. Can I begin first by acknowledging the Royal Society of New South Wales for taking on this subject? As confronting as it is, it's important that we have this conversation and that we're informed, and that we inquire, and that, being informed and inquiring, speaks to the mantra of the Society itself. I'm just going to put a few more questions to Gus, just to draw out a few more points. He's covered a lot already. I think there are a couple of things we can come back to. And then I will open it up to questions from the floor.

In the spirit of full transparency. I have known Gus for a long time. We joined the Army on the same day. Our military paths crossed many times. In 2004 on the tarmac in Baghdad, as I arrived on a C130 Hercules to start a six-month tour, I was greeted by Gus. We said hello, he quickly shook my hand, and then got on the plane to leave after his six months.

I value Gus's contribution here and in other forums because he's a practitioner in this space, a space that is often occupied by what I broadly call the commentariat. And we often don't actually hear from the practitioner. We'll hear from people who come out of the journalist space, the academic space, industry space, political space. But very rarely do we hear such an articulate practitioner. So I think we've been quite privileged here in what we've heard. Gus has covered a lot in a very short time. I just

want to dwell quickly on why it's important that we cover this subject.

We live in a global world where we're part of the global village. We have a war in Europe, or certainly that's what the Europeans call it: it depends who you talk to over there, but they'll tell you Europe is at war. We need to really deal with that and what the implications are for us here as a member of the global village.

Gus, if I can go to you now. You talked early about how we're entering the fourth phase, the counter-offensive phase. And you said it was the most dangerous. Can you just take us through why you think it's the most dangerous, what the risks are, and perhaps some of the things that we should be keeping an eye out on?

Gus McLachlan: Yes, thanks, Andrew. The Russians have used the winter — and, interestingly, the Russians have a term, they call it General Winter. General Winter has saved them a number of times. General Winter stopped Napoleon's advance, stopped Hitler's advance, and the Russians feel that the winter is their friend. In this particular case, the Ukrainians are as adept at the winter as the Russians are, and in fact have been equipped with much better cold-weather equipment and technology. They've come through the winter better than their Russian adversaries. But the Russians have used that period to dig very highly developed trenches and defensive systems. Now, history shows that things like the Maginot Line, which have been very highly developed systems, are far from impervious. But they do make the calculus for the Ukrainians much harder.

So breaking through a trench system — you know, finding a way through that defensive work — and then penetrating deep to liberate more territory is much

harder than it would be if those trenches were not there. So significant defensive works. The other thing is the simple reality of 200,000 Russian conscripts that are refreshing. Over the course of the first year, it's highly likely the Russians have had over 45,000 casualties.

Just think about that. We had 41 young men killed in Afghanistan. As a leader I buried three of those boys, standing next to their mum and dad, and it was heart wrenching. 45,000 young Russians have been killed. Interestingly, Putin rejected the first Ukrainian offer to repatriate bodies. Why did he do that? He didn't want the Russian population to know how many of their young men had been killed. So there are 200,000 Russian recruits, and, whether we like it or not, mass matters. We're going to see them enter the fray.

And I am still concerned about the Western approach: giving the Ukrainians just enough to be more successful than the Russians. I understand why that is the case. There's a great fear of escalation to nuclear weapons. We haven't talked much about that tonight, so I understand that fear, but I think the reality is we need to enable them to be successful as quickly as we can if we want war to be over.

Andrew Condon: You said dangerous from the point of view that Ukrainians are going to have to be much bolder in terms of going on an offensive, because potentially time is running out, and there is a big difference between defence and offence. Tell us about the challenges around the offence, particularly when they've now collected, through the generosity of other nations, such a diverse group of offensive weapons.

Gus McLachlan: In a perfect world, you would never have three different countries'

tanks operating in your military, three different spare parts systems, three different training methodologies and supply chains. They are relatively similar, those systems, but it's far from ideal. I think the Ukrainians will identify a brigade that deals with nothing but American systems and technologies. They might have another brigade that deals exclusively with German technology. In the fullness of time as they professionalize in the years ahead, they will remove a lot of this equipment and pick one particular way to go ahead. And that's why I actually favour the Leopard from Germany. 3000 Leopards have been produced. It's the most widely used tank by European nations. That's the one that is ultimately most likely to be the system that they would adopt.

Offence is harder for a range of reasons. In defence, you can largely be stationary, controlling anything — kids, dogs, people: easy when they sit still. In offence, you have to move and you have to pick up and move. And generally your opposition's trying to do things to harm you. So coordinating an advancing army is much harder. Keeping logistics up to it.

Andrew was a logistics officer, and I was a tank officer. I broke them, and he fixed them, and that's much harder as you know — keeping the fuel up to an advancing army. So I think the Ukrainians are actually professionally capable of all that. Noting that you don't mention this: the Russians have performed very, very poorly. They're a third-rate army. You've just got to be better than third-rate. And the Ukrainians are significantly better than third-rate. So I'm optimistic, but it will be bloody difficult and grinding.

Andrew generously describe me as a practitioner. What I don't want to do is

have you all understand and live what it's been like sitting under an artillery barrage for 24 hours. I have not done that. These Ukrainian soldiers at the moment are sitting under a 24-hour barrage of Russian artillery fire. If they move or put their head above a parapet, huge chunks of metal are flying around the battlefield. And so picking yourself up, moving forward through all that is an incredibly demanding thing to ask soldiers to do. So for all those reasons I am very apprehensive about what's still to come.

Andrew Condon: So big, big risks there for the Ukrainians. Clearly leadership is going to play a big factor. And you talked a little bit about leadership. There are some big leaders in this game: Putin, who brought this whole thing on, Zelensky, who has been able to hold off the Russians by keeping the nation together. Then Joe Biden, the European leaders, and Xi Jinping. There are a lot of people playing in this space, even though the conflict is limited to Ukraine. The point I'm keen to get you to focus on is the real impact that Zelensky is having potentially at the true level. Can you take us through what we understand and know about the value of leadership and its effect on morale, as essentially as a force multiplier?

Gus McLachlan: Yes, great question. In military thinking, we say the morale is to the physical as three is to one.²³ So leadership and morale are three times as important as a new weapon system, or additional troops. And I think that's been clear: Zelensky's leadership, cascading through a very, very professional senior military leadership, has been significant. And if the soldiers believe their leaders are authentic, real, willing to share their risks and are very good at their

job, then they'll generally follow orders and keep doing what they need to do.

On the Russian side, the Russian soldiers know their leadership don't care about them. There are often troops behind them, willing to shoot them in the back if they don't advance. And so that morale is to physical plays opposite for them. My only hope for what might happen is that the Russian military morale might collapse as it did in 1917, when the Russian military ultimately rejected Czarist leadership and brought on the Russian Revolution. I don't anticipate that it'll be quite as dramatic as that, but it is entirely possible that whole battalions of Russian troops will simply refuse to fight. And that that might percolate quite quickly back to Russia. That's probably the only thing in my mind that could lead to them turning on Putin.

We haven't talked about the Ukrainian military leadership. It's been quite extraordinary. I'll give you one anecdote. You probably haven't followed it as closely as I have, but there was a period there where Zelensky was saying publicly in Ukraine and through all this media commentary that he does and all these meetings with foreign leaders, "I have told my troops that they are to focus on the south. The Russian troops that have crossed the Dnieper River must be removed at all costs. I have told my troops to do that." Now I remember thinking at the time, "It's a bit unusual that he's being that explicit because that gives the Russians an indication of his intent." And we actually saw Russian troops moving to reinforce that enclave. That was part of a strategic-level deception. The counterstrike occurred hundreds of kilometres away in the East.

²³ This is often attributed to Napoleon, in 1808. [Ed.]

So they have a level of cooperation between the things the president's saying and what the military leadership are asking him to help with around deception, that is incredibly heartening to see. And, again, we are just not seeing that, on the other side, Putin is just whipping them, telling them they can't withdraw — all of those things which Hitler did in World War II that made the ability for his generals to do their job incredibly difficult. So, again, I think we've got a 21st-century modern authentic leader willing to share the risks and be with his soldiers and be identified. And we've got another fellow who sits at a 30-metre-long table with people at the other end in case he gets a dose of COVID.

Andrew Condon: Let me take you to the subject of drones. You've spoken about that. I'm interested in what we are learning about drones and potentially what the crossover is into other domains. I'll pick agriculture as an example, but there is scope for many others as well, in terms of innovation, the whole learning cycle and adaptation cycle. What are the opportunities you're seeing particularly with drones, or anything else that we're seeing in Ukraine?

Gus McLachlan: Huge question. And I'm conscious that I'm in the presence of the chair of the Autonomous Systems CRC, who knows far more about this than me. First, I've used the drone examples shown. And in fact, one is a commercial drone with a 3D-printed release mechanism to drop a hand grenade down somebody's shorts while they're cleaning their teeth. But we also saw drones being used in the attack on the "Moskva," the Russian cruiser that was sunk in the Black Sea on April 14, 2022. Drones buzzed that vessel for two or three days, bringing the crew to a level of fatigue and

belief that these were just irritating. And then, in the screening effect provided by the drones, they flew some anti-ship missiles and sank a Russian cruiser — an extraordinary achievement.

We've also seen Russian surface combatants sunk by sea-based drones. These are large model boats, loaded with explosive, that can find their way through defensive works and ram themselves into the hull of a ship. And we are just as likely to see them emerge soon in the ground domain in terms of their ability to have sleeper vehicles that can pop up and drive themselves into the side of a tank. Horrific, scary stuff.

For a country like ours, we've got to decide what we can build strategically in this country. We've chosen to have a national ship-building endeavour, incredibly expensive and difficult. And, it appears we're going to make a go of that. I'm much more interested to hear how Mr. Marles describes our ability to make nuclear submarines in Adelaide.

But we can do things like drones. The fourth industrial revolution has allowed us to skip the hundred years of iron forges and welding that was needed for ships. But we can produce and we do produce some of the best autonomous systems in the world. Now what we've got to do is back those organizations, help them collaborate and put in private equity and buy enough from our military. We will then see crossover into other industries.

Andrew and I volunteered last year in the wheat harvest when the wheat farmers couldn't get labour. The two of us went out to help harvest. And we saw immediate things. These farmers are using amazing digital systems on their tractors that can do AI-based weed spraying, but they can't

always get connectivity with the web. A simple drone, such as the military takes for granted, circling overhead, could change the nature of the connectivity of our agricultural industry, for example. Dangerous, boring and dirty. You know, a drone can do many things better than humans. And we all know there are many applications like that. I think this is one of the things we can be globally competitive in relatively quickly.

Questions

Andrew Condon: I'll now go to the audience for any questions. The first question is around the use of mathematical modelling, to essentially understand the risks of nuclear war. Gus, have you got any thoughts on that?

Gus McLachlan: I thought I might defer to the former head of Army simulation and modelling, who's sitting on my right, and let Andrew comment. The answer is: yes, sophisticated models are used. Recently we've seen in my world a number of publications about models that have simulated the China-Taiwan scenario. I've got no doubt that those same models are being run by NATO. Effectively what they're doing is putting in as many of the variables as they can, and ultimately working out potential casualties, et cetera, in modern digital command-and-control systems.

We also, at a much less sophisticated level, try to build what we call a war game into that process. So there is some intellectual rigour around the analysis. Generally where technology's going more broadly: we match the tool to the experience and judgment. And together we think that's going to make better decisions. What'll be interesting in the future is we'll have the spies of respective countries with one of their objectives to get hold of the modelling tool that their

adversary is using, to understand the decision making. I think this is the world that we're entering. But, Andrew, you genuinely are an army expert.

I've studied military operations research, and, yes, the modelling and the sophistication of that is significant, but it's highly classified. So we common people are not likely to see that. But, clearly, decision makers would have access to what the current status of that is. The reason it's classified is specifications like the armour thickness and the accuracy levels of weapon systems. All that is built into the code. There are effectively game-based systems, which replicate some of that, but not to the level of granularity. So the answer to your question is, yes, they do use mathematical modelling. And the good news is they're often worst-case predictions, which I think is important. I'd much rather know the worst possible outcome and make my decision on that basis.

Andrew Condon: Gus mentioned we're at phase four, and the next question is: what are the subsequent phases and what is likely to be the end phase, or one of the possible end phases?

Gus McLachlan: This is the question that all of us are turning our minds to, and there's Zelensky's preferred end, and then there's the other end — I might call it the Macron end. I might be being unfair to the French president, but I'm just going to put him in two camps. Zelensky is working incredibly hard to maintain his narrative and the drumbeat that Ukraine can win and evict Russia from all of its territory. I don't necessarily disagree with him, I just wonder what the cost to his country and his people will be. But at the moment, it appears that the people of Ukraine are supporting his

determination in that regard. And in fact, he might be politically vulnerable if he took a different stance. So that's one possible outcome. Sadly, we're still talking about this at Christmas 2024, because that's a grind that is not over quickly.

I think there is another group of people who are trying to work out what we call an off-ramp. How do you give Putin and Zelensky a solution to this problem that allows some level of stepping down, maintaining face and not putting the Europeans at risk of subsequent Russian activity where they might be emboldened to continue in five or ten years' time? I think that group would probably say that it is unlikely the pre-2014 borders will be resumed, which means ceding the Crimea and a large chunk of the Donbas to an invading, neighbouring army. We can all feel the emotional discomfort with forcing that on the Ukrainian people. Had the Ukrainians not been so successful with the counterattack that that recently occurred, I think would be further down that discussion than perhaps we are. If we were in the grinding, attritional fire-and-movement phase still, and we hadn't seen the Ukrainian success that we saw late in their summer, then I think we would be further down this discussion.

So Zelensky and his army have bought themselves further time and opportunity for an all-out victory. I'm not going to put weight on which I think is more likely, but I think for now particularly the Americans are still backing Zelensky and the Ukrainians' opportunity to have a total victory. I think perhaps the president of France and the chancellor of Germany might have a slightly different view.

Andrew Condon: The other factor is the Putin leadership. It's yet to be confirmed, but the Twitter world is talking today that the *Wall Street Journal* is reporting that Putin's terminally ill with cancer.²⁴ If he was no longer the leader, we don't know where that would go, whether we'd get someone more moderate or worse.

Gus McLachlan: 75% of the Russian population still supports the war, although information is controlled and I don't think the Russians know all the things that are occurring. So unless Putin does fall over, I don't see a palace putsch to get rid him. I think it's unfortunately going to have to be done the hard way.

Andrew Condon: The next question is: given that Russia is a nuclear power, could it ever be satisfied to lose a war on its doorstep? The second part of the question was on Russian because they can still mobilise so many more people. How does that factor play into this calculation?

Gus McLachlan: I'll take the second part first. I think full mobilisation appears to be one of Putin's Achilles heels: otherwise he would've done it by now. This partial mobilisation, I think, came at some cost. I think the reality for him is that popular support would evaporate. But full mobilisation is a tool available to him still and would be a significant game changer. That's the simple reality. The Russians still have acres and acres of old equipment — some are very old T34 tanks from World War II — that if Putin fielded a brutal attrition army with a mobilised force, and he put enough of that into the field, it would have an effect. And, again, this comes partly to my fear for that

²⁴ At the Aspen Security Conference in July 2022, the director of the CIA, William Burns, publicly announced that there's no evidence that Putin is sick [Ed.]

Russia under Putin is still a very dangerous country to fight, but I do think there's something that he understands about his own population that may be a step too far.

The nuclear question is a huge question. There are whole theories around deterrence and its value. And there are certainly many Russian commentators who are potentially on the right of Putin — scary thought — who are saying, “well, we're a nuclear capable nation. Why wouldn't we use it rather than be defeated?” I know those voices are out there because we are seeing some of it replayed back to us from their media and other commentators. I'm doing some work with Joe Hockey, our former treasurer. Joe's publicly said he and some of the Washington elites are thinking that there's still a 30% chance that nuclear weapons will be used in Ukraine.

I disagree with him. I think it's probably closer to 5%, but even the thought of a 5% chance of nuclear war on the continent of Europe is still an extraordinary risk. And that really explains the very careful measured American response, particularly about just how much support they're giving the Ukrainians. Joe Biden was asked, why are they not getting F16s? The Americans are trying to be just inside that threshold of nuclear retaliation, in my view. I think they're doing some other things. They've put masses of aircraft into a bunch of European bases. And I think the message to Putin is: “we won't retaliate with nuclear weapons, but we'll retaliate with enormous conventional force.” Things like sinking the Baltic Sea fleet, et cetera. So they're trying to increase the stakes against Putin using nuclear weapons. A kind of a layer removed from giving the F16s straight to the Ukrainians. But there's a whole theory of deterrence

research that is going into this. And, God forbid, even the optimist in me says we're only 5% likely to see a nuclear exchange on the continent of Europe.

Andrew Condon: I can't resist the comment as a logistician in terms of the mobilisation question. That is a massive logistic challenge. And so far the Russians haven't really demonstrated world's best practice in that space. I suspect that's one of the other hurdles that Putin has now realized: that actually it's a really tough gig to mobilise, given what appears to have been the endemic corruption and lack of systems that have been functioning, for them to be able to do that. So even when he wants to do it, it's going to be really hard for them.

Gus McLachlan: Yes, in the “special military operation” phase: you know most of those conscripts came from ethnic minorities, socially disadvantaged groups, and so are largely invisible from the Russian elite. I think full mobilisation brings that, you know, into the families of Moscow — a whole different kettle of fish.

Andrew Condon: So I think got time for one last question.

Roy MacLeod: Thank you. Something old and something new. I speak as a historian: Australia has a lot of bearing on this. It was the younger WL Bragg who developed the sound-ranging techniques that took out the German artillery that permitted the advance in the Hindenburg line that helped contribute to the end of the First World War. He anticipated a lot of the current technology in sound-ranging and flash-spotting. Secondly, I wanted you to ask you quickly, in relation to the choices, the alternatives that are going to be part of the defence review next month. What do you

see as the particular lessons coming to our Defence Department, our defence establishment, from Ukraine? And, related to that, what would be your choices, rising above the Army to some extent, not dealing with submarines or with F35s or B21s? Where do you see the priorities?

Gus McLachlan: Well, we're going to need to book the facility for another talk, because it's a huge question. It is important. And I can tell you if you want to read some fantastic material, Chatham House²⁵ and *Russi* have published a very good analysis of the lessons learned from the first year of the conflict, and some outstanding technical analysis of the different capabilities of the Western versus the Russian systems. One of the things they observed: they were shocked at how many Western chips were in the Russian technology. Quite shocked at how reliant on Western chips they were. So for some reading separately, I can shoot this to the Society so we can put it in the *Journal*. We definitely need to be studying the lessons from this for our military.

We've got a defence strategic review that the new government has commissioned.²⁶ I think Mr. Marles already has the results of that review on his desk and they're working through it. What does it mean? Do we modernize our armoured vehicles in the Army with this in mind? Or are they now a liability and we need more long-range missiles, drones and potentially nuclear submarines — although I think I'll be long retired from this discussion before we see any of those. So a huge topic. The other associated question, into Andrew's area of logistics: what should our national pri-

orities be? At the moment, Mr. Marles has announced that we are contributing some artillery ammunition: we will provide the explosive propellant that will be shipped to France to be packed into a projectile to given to the Ukraine.

We can't make a complete artillery projectile in this country. We can't make a missile, et cetera, et cetera. So the days of being able to outsource to this global supply chain, if we wanted more Javelins tomorrow — by the way, they are firing Australia's entire stock holding of Javelins every two days in the war — we can put our orders in all we like, but we won't see a missile cross our ports for two to five years. So, these are all questions that we've got to be asking, and that's why Andrew and I are grateful for the opportunity to talk about this because I've spent my military career looking to preserve Australian democracy. Democracy works if people are informed and we are making the right decisions and asking our politicians the right questions. These are all the right questions to ask them.

Christina Slade: I've got a very daunting task of thanking our two speakers tonight. Towards the second half of last year, we in the program committee were thinking about what the issues for 2023 were going to be. Even then we knew power might be one, but the one that we thought about and I started to worry about was technology and what we are learning from the war in Ukraine. that was a big question. We knew that there were these issues, but we didn't know who we could get to talk about it. It's very difficult to find the right person to talk.

²⁵ <https://www.chathamhouse.org/regions/russia-and- Eurasia/ukraine>

²⁶ <https://www.defence.gov.au/about/reviews-inquiries/defence-strategic-review>

As it happened, I'd been introduced to Major General (rtd) Gus McLachlan, in early 2021, or maybe 2020. And I managed to persuade him last year to become a Fellow of the Royal Society. So we are extremely lucky, and I think he's probably absolutely unique among Fellows of the Royal Society in being a highly decorated, combat-hardened senior officer. So we had the perfect person. Looking back over what Gus had done, there were a series of articles quoting him, where he was leading exercises, Exercise Chong Yu, where he was quoted saying this included a static display of the LAND 400 P2 Boxer CRV, the Eurocopter Tiger armed reconnaissance helicopter, protected mobility, light Hawkei vehicle, and unmanned aerial systems. He really knows this work and he's led it all the time.

He, in fact, agreed to become the chair of an advisory group for a new centre focussed on cybersecurity and artificial intelligence at Charles Sturt University. And, as we were setting that up and recruiting a really excellent head, I learnt that Gus was able to draw on a really wide range of people from very different areas: people from the federal police, from the start-up communities, and find something, and managed to get an answer and think it through. That was really, really impressive for me. I think what you said, Andrew, was really interesting: that we've chosen a practitioner and, I think, incredibly luckily, we've got someone who, as it turns out, is not just a practitioner: he's a journalist — there he is on "The Drum" tonight — but obviously also a commentator and a thinker and an academic around these areas. And I must say

that my own feeling after tonight was that if our military is at this level of expertise, but also has the ability to think through the strategic historical context and also to bring that very sharp ethical view to bear, then we are pretty lucky. So I do want to thank you both very much indeed. I think we're very excited. We hope that we'll get something in the *Journal* to be based on that and look at us on YouTube.

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The Russia/Ukraine conflict — developments in war crimes

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Introduction

The rather dry title of this paper should not obscure the fact we are discussing legal issues arising in an armed conflict which is an existential one for Ukraine. As Australian Chief of the Defence Force General Angus Campbell AO DSC recently said in a quote I will return to: “If Russia ceases to fight the war ends. If Ukraine ceases to fight Ukraine ends ...”. So when I say, as lawyers tend to, that a legal question is *interesting*, *difficult* or *fascinating*, I am not intending to downplay the terrible seriousness of the conflict in which the questions arise.

Thus, Prime Minister Albanese has described as “incalculable” the “costs of Russia’s aggression,”² and they can be measured in different ways. Out of Ukraine’s population of 36 million people: 8 million have fled the country and a further 6–8 million are displaced; hundreds of thousands³ of civilians and combatants have been killed or wounded in the conflict, and the shock-

ing damage to all aspects of life and the economy in Ukraine continues.

Given I had the privilege of assisting the IGADF Special Forces Inquiry,⁴ it will not surprise you that I have chosen to express some personal legal views on the topic of war crimes arising out of the current armed conflict in Ukraine: in particular the recent indictment of Russian President Putin for war crimes and the possible revival of the war crime of aggression, last successfully prosecuted in the Nuremberg and Tokyo trials.

The current armed conflict in Ukraine has been described as Europe’s greatest crisis since 1945. I suggest that, arising from the conflict in Ukraine, we are witnessing a recasting of law and practice relating to war crimes as it affects the “top table” of leaders.

Finally, I note that many other legal topics could have been chosen. And, beyond the law, one could ask whether the conflict has revolutionised modern warfare, revitalised NATO, allowed the United States to

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2 “This is a most sombre occasion for the people of Ukraine. One year on from Russia’s unprovoked, unjustified and unlawful full-scale invasion, the costs of Russia’s aggression are incalculable.”

3 US and UK estimates are for Ukraine 40,000 civilian and over 100,000 military; for Russia about 200,000 military casualties of which about 50,000 have died.

4 The Inspector-General of the ADF (IGADF) Afghanistan Inquiry — (the “Brereton Report”) see <https://www.defence.gov.au/about/reviews-inquiries/afghanistan-inquiry>

more fully pivot to our region, and given our adversaries pause for thought in relation to their stated aims in our region. Those are topics for another day, although we should not forget any of them.

Outlawing wars of aggression

The United Nations Charter which was drafted during World War 2, and adopted at its conclusion, begins with the stirring preamble, that:

We, the peoples of the United Nations, determined to save succeeding generations from the scourge of war, which twice in our lifetime has brought untold sorrow ... to unite our strength, to maintain international peace and security, and to ensure, by the acceptance of principles and the institution of methods, that armed force shall not be used, save in the common interest.

The Charter then states in Article 2(4) that, save in the cases of self-defence in Article 51,⁵ and action authorised by the Security Council:⁶

All Members shall refrain in their international relations from the threat or use

of force against the territorial integrity or political independence of any state.

Despite the claims by Mr Putin, it is clear that the Russian armed invasion of Ukraine, which *re*-commenced a year ago, is in breach of the United Nations Charter. The contrary is frankly unarguable.

To return to the quote I began with, on 3 March 2023 at the Raisina Dialogue, the Chief of the ADF said this:

If Russia ceases to fight, the war ends. If Ukraine ceases to fight, Ukraine ends ... War is a clash of wills: everything else is, and emerges, from that. What I see is a Ukrainian nation unified under extraordinary leadership, and with a will determined to resist. Equally I don't see any change yet in the intent to prosecute at whatever cost to his own forces, his own country, and the people of Ukraine, being shown by President Putin ... This is an illegal, unjust violation of the integrity of a sovereign nation ... My assessment is that this war will continue.⁷

War crimes

Before I come to the decision to indict President Putin, let me set the scene for a

⁵ Article 51: "Nothing in the present Charter shall impair the inherent right of individual or collective self-defence if an armed attack occurs against a Member of the United Nations, until the Security Council has taken measures necessary to maintain international peace and security. Measures taken by Members in the exercise of this right of self-defence shall be immediately reported to the Security Council and shall not in any way affect the authority and responsibility of the Security Council under the present Charter to take at any time such action as it deems necessary in order to maintain or restore international peace and security."

⁶ See: Article 41: "The Security Council may decide what measures not involving the use of armed force are to be employed to give effect to its decisions, and it may call upon the Members of the United Nations to apply such measures. These may include complete or partial interruption of economic relations and of rail, sea, air, postal, telegraphic, radio, and other means of communication, and the severance of diplomatic relations."

Article 42: "Should the Security Council consider that measures provided for in Article 41 would be inadequate or have proved to be inadequate, it may take such action by air, sea, or land forces as may be necessary to maintain or restore international peace and security. Such action may include demonstrations, blockade, and other operations by air, sea, or land forces of Members of the United Nations."

⁷ General Angus Campbell AO DSC, CDF, Raisina Dialogue, 3 March 2023.

moment. Ukrainian President Zelensky has recently said that more than 70,000 Russian war crimes have been recorded over the past year since Russia's full-scale invasion began last February. He also said:

it is clear how serious these crimes are. What the scale of the criminal manifestations of Russia's aggression is ... We remember everything.⁸

Following the 18 February 2023 announcement by US Vice President Harris in Munich that the United States had "formally determined" that Russia had committed crimes against humanity,⁹ President Biden made this unambiguous statement:

... this has been an extraordinary year in every sense. Extraordinary brutality from Russian forces and mercenaries. They have committed depravities, crimes against humanity, without shame or compunction. They've targeted civilians with death and destruction. Used rape as a weapon of war. Stolen Ukrainian children in an attempt to ... steal Ukraine's future. Bombed train stations, maternity hospitals, schools, and orphanages ... We'll hold accountable those who are responsible for this war. And we will seek justice for the war crimes and crimes against humanity continuing to be committed by the Russians.¹⁰

In his 2022 book, *Veiled Valour*,¹¹ Professor Tom Frame AM wrote this:

[war] crimes are odious because they usually point to a collapse of discipline and failure of leadership. They are collectively referred to as "atrocities" insinuating they are born of cowardice and cruelty.

But while that second sentence about *atrocities* is no doubt true of all war crimes, the first about *failure of leadership* may not be, in so far as the Russian perpetrators of war crimes on the battlefield appear to be carrying out their orders rather than defying them. In those circumstances, as in World War 2, our attention is naturally drawn to how to call to account the "top table" of leaders.

Plainly enough, crimes against humanity and war crimes as defined by the Rome Statute of the International Criminal Court (ICC) — but excluding aggression — fall within the current jurisdiction of that court, despite neither Ukraine nor Russia being State parties to the Rome Statute. That follows because Ukraine has made an indefinite declaration that it accepts the ICC's jurisdiction from 2014 (under Article 12 (3)) and must therefore fully cooperate with the court in its investigation and prosecution of crimes (under Part 9 of that Statute).¹²

8 <https://www.yahoo.com/news/zelensky-says-more-70-000-144701330.html>

9 <https://www.whitehouse.gov/briefing-room/speeches-remarks/2023/02/18/remarks-by-vice-president-harris-at-the-munich-security-conference-2/>

10 <https://www.whitehouse.gov/briefing-room/speeches-remarks/2023/02/21/remarks-by-president-biden-ahead-of-the-one-year-anniversary-of-russias-brutal-and-unprovoked-invasion-of-ukraine/>. Further: PM Albanese said <https://www.pm.gov.au/media/australia-stands-ukraine-additional-military-support-and-sanctions>: "This is a most sombre occasion for the people of Ukraine. One year on from Russia's unprovoked, unjustified and unlawful full-scale invasion, the costs of Russia's aggression are incalculable."

11 Frame, T. (2022) *Veiled Valour: Australian Special Forces in Afghanistan and War Crimes Allegations*, Sydney, UNSW Press.

12 And a year ago a group of 39 States including Australia supported a State Party referral to the ICC Prosecutor who then opened a formal investigation, which continues.

The recent indictment

On 17 March 2023, ICC Pre-Trial Chamber II issued warrants of arrest for President Putin and Maria Lvova-Belova, Commissioner for Children’s Rights in the Office of the President of the Russian Federation. This was based on the applications by the ICC Prosecutor, Kareem Khan KC, on 22 February 2023. The Pre-Trial Chamber concluded that there are reasonable grounds to believe that each bears responsibility for the war crime of unlawful deportation of population (children) and that of unlawful transfer of population (children) from occupied areas of Ukraine to the Russian Federation, to the prejudice of Ukrainian children.

The relevant Statute of Rome Provisions are in Article 8(2)(a):

(vii) Conscripting or enlisting children under the age of fifteen years into armed forces or groups or using them to participate actively in hostilities;

(viii) Ordering the displacement of the civilian population for reasons related to the conflict, unless the security of the civilians involved or imperative military reasons so demand;

The allegations are summarised by Mr Khan KC as follows:¹³

Incidents identified by my Office include the deportation of at least hundreds of children taken from orphanages and children’s care homes. Many of these children, we allege, have since been given for adop-

tion in the Russian Federation. The law was changed in the Russian Federation, through Presidential decrees issued by President Putin, to expedite the conferral of Russian citizenship, making it easier for them to be adopted by Russian families.

My Office alleges that these acts, amongst others, demonstrate an intention to permanently remove these children from their own country. At the time of these deportations, the Ukrainian children were protected persons under the Fourth Geneva Convention.

What happens next? Russia has denounced the indictments and arrest warrants, and would of course thwart any Security Council resolutions to enforce the indictments.¹⁴ What does the ICC Statute say?

By Article 27, the ICC has jurisdiction even over heads of State. Thus:

1. *This Statute shall apply equally to all persons without any distinction based on official capacity. In particular, official capacity as a Head of State or Government, a member of a Government or parliament, an elected representative or a government official shall in no case exempt a person from criminal responsibility under this Statute, nor shall it, in and of itself, constitute a ground for reduction of sentence.*

2. Immunities or special procedural rules which may attach to the official capacity of a person, whether under national or international law, shall not bar the Court

¹³ <https://www.icc-cpi.int/news/statement-prosecutor-karim-khan-kc-issuance-arrest-warrants-against-president-vladimir-putin>

¹⁴ Russian spokesman Dmitry Peskov said found the very questions raised by the ICC “outrageous and unacceptable,” but noted that Russia, like many other countries, did not recognise the jurisdiction of the ICC. “And accordingly, any decisions of this kind are null and void for the Russian Federation from the point of view of law.” Asked if Putin now feared travelling to countries that recognised the ICC and might therefore try to arrest him, Peskov told reporters: “I have nothing to add on this subject. That’s all we want to say.”

from exercising its jurisdiction over such a person.

By Article 59 it is provided that:

A State Party which has received a request for provisional arrest or for arrest and surrender shall immediately take steps to arrest the person in question in accordance with its laws and the provisions of Part 9.

By Article 89 it is provided that:

The Court may transmit a request for the arrest and surrender of a person, together with the material supporting the request ... to any State on the territory of which that person may be found and shall request the cooperation of that State in the arrest and surrender of such a person. *States Parties shall, in accordance with the*

provisions of this Part and the procedure under their national law, comply with requests for arrest and surrender.

While those provisions seem clear enough, the single ICC-era example is not encouraging. In 2015, South Africa declined to enforce an ICC warrant for the arrest of Sudanese head of state Omar al-Bashir¹⁵ during a visit. Pretoria argued that it saw “no duty under international law nor the Rome statute to arrest a serving head of state of a [ICC] non-state-party such as Omar al-Bashir,” and several other countries that he visited also declined to arrest him.

The ICC attempted to escalate this by referring these countries to the General Assembly of the UN, but the result was inconclusive.¹⁶

¹⁵ <https://asp.icc-cpi.int/non-cooperation>

¹⁶ Fatou Bensouda, Chief Prosecutor of the ICC, presented her latest report on the situation in Darfur, noting that the pre-trial chambers have issued multiple arrest warrants following their independent assessment of relevant evidence. Today, warrants remain outstanding for five people, all of whom occupied positions of responsibility as officials of the Government of Sudan at the time of their alleged crimes. Naming Omer al-Bashir, Ahmed Harun, Abdel Hussein, militia leader Ali Kugayb and rebel leader Abdallah Banda, she pointed out that several of those individuals continue to hold senior positions within the Government. Their arrest warrants contain more than 60 counts of war crimes and 50 counts of crimes against humanity, including extermination, murder, rape, forcible transfer and torture, she said. She went on to outline the significant progress made by the Court during the reporting period, saying that its investigators remain dedicated to their mission despite facing many challenges. “The body of evidence is increasing and my prosecution team continued to prepare in anticipation of the future arrest and surrender of any of the Darfur suspects,” she affirmed.

Over the period under review, she continued, levels of violence against civilians in Darfur decreased, but impunity — as well as the commission of serious crimes — regrettably persists. She cited attacks against personnel of the African Union-United Nations Hybrid Operation in Darfur (UNAMID); the ongoing conflict in the Jebel Marra area between Government forces and the Sudan Liberation Army (led by Abdul Wahid); the destruction of villages; the killing, injury and displacement of civilians; and reports of sexual and gender-based violence against women and girls. Recalling the Council’s concern — expressed in resolution 2429 (2018) — that UNAMID is unable to access areas from which it has withdrawn, she called upon the Government to respond affirmatively to its request for the Operation’s unfettered access throughout Darfur. She pledged to continue to monitor the situation and collect evidence — including by making use of reports from reliable entities and sources operating in Darfur — while pointing out that the Government continues its policy of antagonism and non-cooperation with the Office of the Prosecutor, in contravention of resolution 1593 (2005) and effectively obstructing its ability to conduct on-the-ground investigations.

Describing multiple impediments, she recalled the failure by the Government of Jordan to arrest Mr. Bashir when he visited that country in March 2017. Pre-trial Chamber II found that Jordan failed to comply with its obligations under the Rome Statute and decided to refer the country to the Assembly of States Parties and the Security Council. Noting that Jordan decided to appeal that decision, she said that the Court’s Appeals Chamber

Croatia, Austria and Germany have all just announced they would arrest Putin if he entered their respective territory. We shall have to see what happens next, but it nevertheless seems true to say, as a CNN headline put it on 19 March 2023: “Putin’s world just got a lot smaller with the ICC’s arrest warrant.”

Possible revival of the crime of aggression

There has also been much discussion whether the crime of aggression, prosecuted in the post-World War 2 Nuremberg and Tokyo War Crimes Trials, should be revived. Let me remind you briefly of what occurred then.

In 1942, the Allies started considering the possibility of war crimes trials. There was considerable debate about this: some Allied leaders simply wanted summary justice — execution without trials. But the argument which won the day was that a trial ensured there would be evidence of what had happened from living memory thus recorded in human history.

According to Neave (1978)¹⁷ (by then Major Airey Neave) who, having escaped from Colditz, was employed by the International Military Tribunal to serve the indictments on the Nuremberg defendants and then observe the trials:

At first there were two camps. The plan was made by the United States Secretary of the Treasury Henry Morgenthau Jr, who proposed that major war criminals should be identified and shot as allied soldiers advanced into Germany. Winston Churchill and Lord Simon, the Lord Chancellor, also advocated summary execution. Stalin and Roosevelt favoured a trial. Stalin, because he feared that he, Roosevelt, and Churchill would be accused of killing Hitler and the Nazi leaders out of personal revenge. In America, the Morgenthau plan was dropped. Although the question of summary execution was never finally decided by the cabinet, the British were opposed to a trial until 3 May 1945, but Anthony Eden, the foreign secretary,

heard a five-day hearing on the matter in September. Multiple legal submissions were made — including by Jordan, the African Union, the League of Arab States, professors of international law and the Office of the Prosecutor — and the parties are currently awaiting a final determination. However, Mr. Bashir continued to travel internationally, including to Djibouti and Uganda, she noted, recalling that both States were previously referred to the Assembly of States Parties and to the Council for their failure to arrest and surrender Mr. Bashir. The Council took no action in relation to those or any other referrals, she said.

“It is therefore not surprising that States parties to the Rome Statute ... continue to host [ICC] suspects on their territory, in blatant violation of Court findings,” she emphasized, citing the lack of any meaningful consequences for that inaction. Many Member States taking part in a related Arria-formula meeting in July also voiced concern over the Council’s failure to act, she continued. The session offered an opportunity for an exchange of views and several participants proposed concrete, workable measures to enhance cooperation between the Court and the Council. “I remain hopeful that the constructive dialogue and proposals at that meeting will provide further momentum, resulting in concrete action taken by the Council on this issue,” she said. Listing other instances of non-compliance by the Government of Sudan, she said that if the latter is in possession of evidence, it should come forward and share it with the Office of the Prosecutor. Pledging full respect for the due process rights of all suspects — including the right to a fair, independent and impartial trial — she reiterated her call for the Government to “open a new chapter of cooperation” with the Court and demonstrate its commitment to combating impunity. “Justice delayed is justice denied; the judgement of victims and the critical eyes of history are upon us,” she stressed.

17 Neave, A. (1978) *Nuremberg: A Personal Record of the Trial of the Major Nazi War Criminals in 1945–6*, London, Hodder and Stoughton.

capitulated at the San Francisco conference in the face of Soviet and American pressure. It was some time before they could look upon plans for a major war crimes trial with any enthusiasm ...

[Later, in London] after several weeks of tense negotiation, the Charter of the International Military Tribunal was signed by the United Kingdom, America, France and the Soviet Union on 8 August 1945. The charter laid down the crimes which the tribunal were to try under the heading: “crimes against peace,” “war crimes” and “crimes against humanity.” Three of those who formulated these laws in London later became members of the tribunal. This was a slightly indelicate position and, from the outset of trial, the judges found it necessary in various ways to make clear their independence of the prosecution. The International Military Tribunal was also set up in August 1945 and held its opening session in Berlin in October which, as a result of Russian insistence, became its seat. With the destruction of the city, there was no prison suitable to hold prominent war criminals in single cells. After much argument, Nuremberg, where the prison was intact, was chosen for the place of trial. Hitler was dead. Goebbels and Himmler too. Goering and Ribbentrop and many other prominent Nazis were in Allied hands. Further discussion produced a list of twenty-four defendants who were named in a lengthy indictment signed on 6 October by the chief prosecutors of the four Allied powers. What did the victorious Allies hope to gain by these proceedings? The Russians, with 20 million dead, undoubtedly wanted revenge. They wanted to see the Nazi ringleaders hanged, for their

losses were more terrible than any other country’s. The French, deeply embittered by the events of 1940, had suffered greatly from Nazi occupation. On the sidelines, urging vengeance, were the Dutch, the Belgians, the Norwegians, the Poles, the Yugoslavs, and smaller nations, ravaged by occupation. The Americans and British had not experienced the horrors of Nazi occupation. They often misunderstood the depth of feeling in liberated countries. At the heart of the Anglo-American case was a sincere but naïve attempt to apply the rule of law to those who had perpetrated untold acts of brutality against ordinary human beings. For many the trial presaged a new era of international law against tyranny and unprovoked aggression. Nuremberg sought to establish an ordered system of justice between nations. If that attempt has not yet succeeded, it was not the fault of the trial or the principles on which it was based. Those who seek to excuse or ignore Nazism as something best forgotten should look at the record. Nuremberg revealed to the world the terrible crimes committed by the followers of Hitler, unexampled in the history of the world ... [as he later concluded in this book] Without Nuremberg, we should have had no complete record of the concentration camps and of the Final Solution. Without the trial, the scene of horror would have taken years to reproduce in all its dreadful detail.

The Charter of the International Military Tribunal (Nuremberg) stated in Article 6:

The following acts, or any of them, are crimes coming within the jurisdiction of the Tribunal for which there shall be individual responsibility:

Crimes Against Peace: namely, planning, preparation, initiation or waging of a war of aggression ...

Common count 2 of the Indictment alleged:

All the defendants with divers other persons, during a period of years preceding 8th May, 1945, participated in the planning, preparation, initiation and waging of wars of aggression ... [being those declared against the allies.]

In dealing with the argument that the crime of aggression, never previously prosecuted, was unknown to the law, the Final judgment concerning the Nazi leaders at Nuremberg said this:¹⁸

To initiate a war of aggression ... is not only an international crime; it is the supreme international crime differing only from other war crimes in that it contains within itself the accumulated evil of the whole.

...

The war against Poland did not come suddenly out of an otherwise clear sky; the evidence has made it plain that this war of aggression, as well as the seizure of Austria and Czechoslovakia, was pre-meditated and carefully prepared, and was not undertaken until the moment was thought opportune for it to be carried through as a definite part of the pre-ordained scheme and plan. For the aggressive designs of the Nazi Government were not accidents arising out of the immediate political situation in Europe and the world; they were a deliberate and essential part of Nazi foreign policy.

...

The Tribunal is fully satisfied by the evidence that the war initiated by Germany against Poland on the 1st September, 1939, was most plainly an aggressive war, which was to develop in due course into a war which embraced almost the whole world, and resulted in the commission of countless crimes, both against the laws and customs of war, and against humanity.

...

The Charter makes the planning or waging of a war of aggression or a war in violation of international treaties a crime, and it is therefore not strictly necessary to consider whether and to what extent aggressive war was a crime before the execution of the London Agreement. But in view of the great importance of the questions of law involved, the Tribunal has heard full argument from the Prosecution and the Defence, and will express its view on the matter.

It was urged on behalf of the defendants that a fundamental principle of all law — international and domestic — is that there can be no punishment of crime without a pre-existing law. *Nullum crimen sine lege, nulla poena sine lege*. It was submitted that *ex post facto* punishment is abhorrent to the law of all civilised nations, that no sovereign power had made aggressive war a crime at the time the alleged criminal acts were committed, that no statute had defined aggressive war, that no penalty had been fixed for its commission, and no court had been created to try and punish offenders.

¹⁸ See Annex A below.

In the first place, it is to be observed that the maxim *nullum crimen sine lege* is not a limitation of sovereignty, but is in general a principle of justice. To assert that it is unjust to punish those who in defiance of treaties and assurances have attacked neighbouring states without warning is obviously untrue, for in such circumstances the attacker must know that he is doing wrong, and so far from it being unjust to punish him, it would be unjust if his wrong were allowed to go unpunished. Occupying the positions they did in the government of Germany, the defendants, or at least some of them, must have known of the treaties signed by Germany, outlawing recourse to war for the settlement of international disputes; they must have known that they were acting in defiance of all international law when in complete deliberation they carried out the designs of invasion and aggression. On this view of the case alone, it would appear that the maxim has no application to the present facts.

This view is strongly reinforced by a consideration of the state of international law in 1939, so far as aggressive war is concerned. The General Treaty for the Renunciation of War of 27th August, 1928, more generally known as the Pact of Paris or the Kellogg-Briand Pact, was binding on sixty-three nations, including Germany, Italy and Japan at the outbreak of war in 1939 ...

The first two Articles are as follows:

Article I: The High Contracting Parties solemnly declare in the names of their respective peoples that they condemn recourse to war for the solution of international controversies and renounce it as

an instrument of national policy in their relations to one another.

Article II: The High Contracting Parties agree that the settlement or solution of all disputes or conflicts of whatever nature or of whatever origin they may be, which may arise among them, shall never be sought except by pacific means.

The question is, what was the legal effect of this Pact? ... In the opinion of the Tribunal, the solemn renunciation of war as an instrument of national policy necessarily involves the proposition that such a war is illegal in international law; and that those who plan and wage such a war, with its inevitable and terrible consequences, are committing a crime in so doing.

In the result, 16 of the accused senior Nazi leadership were found guilty of this crime.

The crime has not been successfully prosecuted since the Nuremberg and Tokyo trials.

Looking beyond the constant charge of “victors’ justice,” what makes the crime of aggression so intriguing is that it really straddles the line between the *jus ad bellum*, the international law on resort to force, and the *jus in bello*, or international humanitarian law, as war crimes are usually independent of questions concerning the justification or reasons for an armed conflict.

Disputes about both the content and appropriateness of such a crime meant it was not included in the ICC’s original jurisdiction. The Working Group on the Crime of Aggression in the framework of the Assembly of States Parties and at a conference in Kampala, came up with the “Kampala Compromise” which has the result in relation to Russia set out in Article 15 (bis) (5) namely: “In respect of a State that is not a party to this Statute, the Court shall

not exercise its jurisdiction over the crime of aggression when committed by that State's nationals or on its territory." Expanding the ICC's jurisdiction insofar as that required the consent of the UN Security Council, would be vetoed by Russia.

In the ICC statute the crime of aggression is defined as:

the planning, preparation, initiation or execution, by a person in a position effectively to exercise control over or to direct the political or military action of a State, of an act of aggression which, by its character, gravity and scale, constitutes a manifest violation of the Charter of the United Nations. (Article 8 bis(1))¹⁹

It may be that the current indictment against Putin will take the focus away from the idea of a new court or tribunal trying him for the crime of aggression, although it remains an absorbing possibility.

Conclusion

One of the hardest tasks for observers of or participants in significant contemporary events — lacking as they do the hindsight advantage of historians — is for them to discern whether events such as the Ukraine conflict presage a genuinely new way of thinking and acting.

To return to where I began, we know that the "untold sorrow" of the first two World Wars led to a UN Charter which sought to outlaw the "scourge" of aggressive war. Still such wars continue.

If, as here, they involve a Permanent Member of the UN Security Council (a majority of whom are not State Parties to the ICC), that avenue of action for resolving the conflict is blocked.

Perhaps we are witnessing a tipping point. The dissolution of the former Yugoslavia and the current conflict in Ukraine are the most significant land wars in Europe since World War 2 ended. That conflict in the Balkans recast notions of external intervention in international law and relations. The two

¹⁹ For the purpose of paragraph 1, "act of aggression" means the use of armed force by a State against the sovereignty, territorial integrity or political independence of another State, or in any other manner inconsistent with the Charter of the United Nations. Any of the following acts, regardless of a declaration of war, shall, in accordance with United Nations General Assembly resolution 3314 (XXIX) of 14 December 1974, qualify as an act of aggression:

(a) The invasion or attack by the armed forces of a State of the territory of another State, or any military occupation, however temporary, resulting from such invasion or attack, or any annexation by the use of force of the territory of another State or part thereof;

(b) Bombardment by the armed forces of a State against the territory of another State or the use of any weapons by a State against the territory of another State;

(c) The blockade of the ports or coasts of a State by the armed forces of another State;

(d) An attack by the armed forces of a State on the land, sea or air forces, or marine and air fleets of another State;

(e) The use of armed forces of one State which are within the territory of another State with the agreement of the receiving State, in contravention of the conditions provided for in the agreement or any extension of their presence in such territory beyond the termination of the agreement;

(f) The action of a State in allowing its territory, which it has placed at the disposal of another State, to be used by that other State for perpetrating an act of aggression against a third State;

(g) The sending by or on behalf of a State of armed bands, groups, irregulars or mercenaries, which carry out acts of armed force against another State of such gravity as to amount to the acts listed above, or its substantial involvement therein.

examples I have mentioned — one being utilised and one actively discussed — involve a genuinely new approach in prosecuting a head of State and “the top table” for war crimes from a P5 country.

While we will have to wait and see if it will succeed, I suggest these are worthy topics for further study, publication and debate by the many countries which support Ukraine.

Annex A

To initiate a war of aggression ... is not only an international crime; it is the supreme international crime differing only from other war crimes in that it contains within itself the accumulated evil of the whole. The first acts of aggression referred to in the Indictment are the seizure of Austria and Czechoslovakia and the first war of aggression charged in the Indictment is the war against Poland begun on the 1st September, 1939.

...

The war against Poland did not come suddenly out of an otherwise clear sky; the evidence has made it plain that this war of aggression, as well as the seizure of Austria and Czechoslovakia, was pre-meditated and carefully prepared, and was not undertaken until the moment was thought opportune for it to be carried through as a definite part of the pre-ordained scheme and plan. For the aggressive designs of the Nazi Government were not accidents arising out of the immediate political situation in Europe and the world; they were a deliberate and essential part of Nazi foreign policy. From the beginning, the National Socialist movement claimed that its object was to unite the German people in the consciousness of their mission and destiny, based on inherent

qualities of race, and under the guidance of the Führer.

For its achievement, two things were deemed to be essential: the disruption of the European order as it had existed since the Treaty of Versailles, and the creation of a Greater Germany beyond the frontiers of 1914. This necessarily involved the seizure of foreign territories. War was seen to be inevitable, or at the very least, highly probable, if these purposes were to be accomplished. The German people, therefore, with all their resources were to be organised as a great political-military army, schooled to obey without question any policy decreed by the State.

...

In the opinion of the Tribunal, the events of the days immediately preceding the 1st September, 1939, demonstrate the determination of Hitler and his associates to carry out the declared intention of invading Poland at all costs, despite appeals from every quarter. With the ever increasing evidence before him that this intention would lead to war with Great Britain and France as well, Hitler was resolved not to depart from the course he had set for himself. The Tribunal is fully satisfied by the evidence that the war initiated by Germany against Poland on the 1st September, 1939, was most plainly an aggressive war, which was to develop in due course into a war which embraced almost the whole world, and resulted in the commission of countless crimes, both against the laws and customs of war, and against humanity.

...

The jurisdiction of the Tribunal is defined in the Agreement and Charter, and the crimes coming within the jurisdiction of the Tribunal, for which there shall be individual

responsibility, are set out in Article 6. The law of the Charter is decisive, and binding upon the Tribunal.

The making of the Charter was the exercise of the sovereign legislative power by the countries to which the German Reich unconditionally surrendered; and the undoubted right of these countries to legislate for the occupied territories has been recognised by the civilised world. The Charter is not an arbitrary exercise of power on the part of the victorious nations, but in the view of the Tribunal, as will be shown, it is the expression of international law existing at the time of its creation; and to that extent is itself a contribution to international law.

The Signatory Powers created this Tribunal, defined the law it was to administer, and made regulations for the proper conduct of the Trial. In doing so, they have done together what any one of them might have done singly; for it is not to be doubted that any nation has the right thus to set up special courts to administer law. With regard to the constitution of the court, all that the defendants are entitled to ask is to receive a fair trial on the facts and law.

The Charter makes the planning or waging of a war of aggression or a war in violation of international treaties a crime, and it is therefore not strictly necessary to consider whether and to what extent aggressive war was a crime before the execution of the London Agreement. But in view of the great importance of the questions of law involved, the Tribunal has heard full argument from the Prosecution and the Defence, and will express its view on the matter.

It was urged on behalf of the defendants that a fundamental principle of all law — international and domestic — is that there can be no punishment of crime without a pre-existing law. *Nullum crimen sine lege, nulla poena sine lege*. It was submitted that *ex post facto* punishment is abhorrent to the law of all civilised nations, that no sovereign power had made aggressive war a crime at the time the alleged criminal acts were committed, that no statute had defined aggressive war, that no penalty had been fixed for its commission, and no court had been created to try and punish offenders.

In the first place, it is to be observed that the maxim *nullum crimen sine lege* is not a limitation of sovereignty, but is in general a principle of justice. To assert that it is unjust to punish those who in defiance of treaties and assurances have attacked neighbouring states without warning is obviously untrue, for in such circumstances the attacker must know that he is doing wrong, and, so far from it being unjust to punish him, it would be unjust if his wrong were allowed to go unpunished. Occupying the positions they did in the government of Germany, the defendants, or at least some of them, must have known of the treaties signed by Germany, outlawing recourse to war for the settlement of international disputes; they must have known that they were acting in defiance of all international law when in complete deliberation they carried out the designs of invasion and aggression. On this view of the case alone, it would appear that the maxim has no application to the present facts.

This view is strongly reinforced by a consideration of the state of international law in 1939, so far as aggressive war is concerned.

The General Treaty for the Renunciation of War of 27th August, 1928, more generally known as the Pact of Paris or the Kellogg-Briand Pact, was binding on sixty-three nations, including Germany, Italy and Japan at the outbreak of war in 1939. In the preamble, the signatories declared that they were:

Deeply sensible of their solemn duty to promote the welfare of mankind; persuaded that the time has come when a frank renunciation of war as an instrument of national policy should be made to the end that the peaceful and friendly relations now existing between their peoples should be perpetuated ... all changes in their relations with one another should be sought only by pacific means ... thus uniting civilised nations of the world in a common renunciation of war as an instrument of their national policy ...

The first two Articles are as follows:

Article I: The High Contracting Parties solemnly declare in the names of their respective peoples that they condemn recourse to war for the solution of international controversies and renounce it as an instrument of national policy in their relations to one another.

Article II: The High Contracting Parties agree that the settlement or solution of all disputes or conflicts of whatever nature or of whatever origin they may be, which may arise among them, shall never be sought except by pacific means.

The question is, what was the legal effect of this Pact? The nations who signed the Pact or adhered to it unconditionally condemned recourse to war for the future as an instrument of policy, and expressly renounced it. After the signing of the Pact,

any nation resorting to war as an instrument of national policy breaks the Pact.

In the opinion of the Tribunal, the solemn renunciation of war as an instrument of national policy necessarily involves the proposition that such a war is illegal in international law; and that those who plan and wage such a war, with its inevitable and terrible consequences, are committing a crime in so doing. War for the solution of international controversies undertaken as an instrument of national policy certainly includes a war of aggression, and such a war is therefore outlawed by the Pact. As Mr. Henry L. Stimson, then Secretary of State of the United States, said in 1932:

War between nations was renounced by the signatories of the Kellogg-Briand Treaty. This means that it has become throughout practically the entire world ... an illegal thing. Hereafter, when nations engage in armed conflict, either one or both of them must be termed violators of this general treaty law ... We denounce them as law breakers.

But it is argued that the Pact does not expressly enact that such wars are crimes, or set up courts to try those who make such wars. To that extent the same is true with regard to the laws of war contained in the Hague Convention. The Hague Convention of 1907 prohibited resort to certain methods of waging war. These included the inhumane treatment of prisoners, the employment of poisoned weapons, the improper use of flags of truce, and similar matters. Many of these prohibitions had been enforced long before the date of the Convention; but since 1907 they have certainly been crimes, punishable as offences against the laws of war; yet the Hague Convention nowhere designates such practices as criminal, nor is any sentence

prescribed, nor any mention made of a court to try and punish offenders. For many years past, however, military tribunals have tried and punished individuals guilty of violating the rules of land warfare laid down by this Convention. In the opinion of the Tribunal, those who wage aggressive war are doing that which is equally illegal, and of much greater moment than a breach of one of the rules of the Hague Convention. In interpreting the words of the Pact, it must be remembered that international law is not the product of an international legislature, and that such international agreements as the Pact have to deal with general principles of law, and not with administrative matters of procedure. The law of war is to be found not only in treaties, but in the customs and practices of states which gradually obtained universal recognition, and from the general principles of justice applied by jurists and practiced by military courts. This law is not static, but by continual adaptation follows the needs of a changing world. Indeed, in many cases treaties do no more than express and define for more accurate reference the principles of law already existing.

The view which the Tribunal takes of the true interpretation of the Pact is supported by the international history which preceded it. In the year 1923 the draft of a Treaty of Mutual Assistance was sponsored by the League of Nations. In Article I the Treaty declared “that aggressive war is an international crime,” and that the parties would “undertake that no one of them will be guilty of its commission.” The draft treaty was submitted to twenty-nine States, about half of whom were in favour of accepting the text. The principal objection appeared to be in the difficulty of defining the acts which would constitute “aggression,” rather than

any doubt as to the criminality of aggressive war. The preamble to the League of Nations 1924 Protocol for the Pacific Settlement of International Disputes (“Geneva Protocol”), after “recognising the solidarity of the members of the international community,” declared that “a war of aggression constitutes a violation of this solidarity and is an international crime.” It went on to declare that the contracting parties were “desirous of facilitating the complete application of the system provided in the Covenant of the League of Nations for the pacific settlement of disputes between the states and of ensuring the repression of international crimes.” The Protocol was recommended to the members of the League of Nations by a unanimous resolution in the Assembly of the forty-eight members of the League. These members included Italy and Japan, but Germany was not then a member of the League.

Although the Protocol was never ratified, it was signed by the leading statesmen of the world, representing the vast majority of the civilised states and peoples, and may be regarded as strong evidence of the intention to brand aggressive war as an international crime.

At the meeting of the Assembly of the League of Nations on the 24th September, 1927, all the delegations then present (including the German, the Italian and the Japanese), unanimously adopted a declaration concerning wars of aggression. The preamble to the declaration stated:

The Assembly:

Recognising the solidity which unites the community of nations; Being inspired by a firm desire for the maintenance of general peace;

Being convinced that a war of aggression can never serve as a means of settling international disputes, and is in consequence an international crime ...

The unanimous resolution of the 18th February, 1928, of twenty-one American Republics of the Sixth (Havana) Pan-American Conference, declared that “war of aggression constitutes an international crime against the human species.”

All these expressions of opinion, and others that could be cited, so solemnly made, reinforce the construction which the Tribunal placed upon the Pact of Paris, that resort to a war of aggression is not merely illegal, but is criminal. The prohibition of aggressive war demanded by the conscience of the world, finds its expression in the series of pacts and treaties to which the Tribunal has just referred.

It is also important to remember that Article 227 of the Treaty of Versailles provided for the constitution of a special Tribunal, composed of representatives of five of the Allied and Associated Powers which had been belligerents in the First World War opposed to Germany, to try the former German Emperor “for a supreme offence against international morality and the sanctity of treaties.” The purpose of this trial was expressed to be “to vindicate the solemn obligations of international undertakings, and the validity of international morality.” In Article 228 of the Treaty, the German Government expressly recognised the right of the Allied Powers “to bring before military tribunals persons accused of having committed acts in violation of the laws and customs of war.”

It was submitted that international law is concerned with the action of sovereign States, and provides no punishment for

individuals; and further, that, where the act in question is an act of state, those who carry it out are not personally responsible, but are protected by the doctrine of the sovereignty of the State. In the opinion of the Tribunal, both these submissions must be rejected. That international law imposes duties and liabilities upon individuals as well as upon States has long been recognised. In the recent case of *Ex Parte Quirin* (1942 317 US 1), before the Supreme Court of the United States, persons were charged during the war with landing in the United States for purposes of spying and sabotage. The late Justice Stone, speaking for the Court, said:

From the very beginning of its history this Court has applied the law of war as including that part of the law of nations which prescribes for the conduct of war the status, rights and duties of enemy nations as well as enemy individuals.

He went on to give a list of cases tried by the Courts, where individual offenders were charged with offences against the laws of nations, and particularly the laws of war. Many other authorities could be quoted, but enough has been said to show that individuals can be punished for violations of international law. Crimes against international law are committed by men, not by abstract entities, and only by punishing individuals who commit such crimes can the provisions of international law be enforced.

The provisions of Article 228 of the Treaty of Versailles already referred to illustrate and enforce this view of individual responsibility.

The principle of international law, which under certain circumstances, protects the representatives of a state, cannot be applied to acts which are condemned as criminal by international law. The authors of these

facts cannot shelter themselves behind their official position in order to be freed from punishment in appropriate proceedings. Article 7 of the Charter expressly declares:

The official position of defendants, whether as Heads of State, or responsible officials in government departments, shall not be considered as freeing them from responsibility, or mitigating punishment.

On the other hand the very essence of the Charter is that individuals have international duties which transcend the national obligations of obedience imposed by the individual State. He who violates the laws of war cannot obtain immunity while acting in pursuance of the authority of the State if the State in authorising action moves outside its competence under international law.

It was also submitted on behalf of most of these defendants that in doing what they did they were acting under the orders of Hitler, and therefore cannot be held responsible for the acts committed by them in carrying out these orders. The Charter specially provides in Article 8:

The fact that the defendant acted pursuant to order of his Government or of a superior shall not free him from responsibility, but may be considered in mitigation of punishment.

The provisions of this Article are in conformity with the law of all nations. That a soldier was ordered to kill or torture in violation of the international law of war this never been recognised as a defence to such acts of brutality, though, as the Charter here provides, the order may be urged in mitigation of the punishment. The true test, which is found in varying degrees in the criminal law of most nations, is not

the existence of the order, but whether moral choice was in fact possible.

...

Judge PARKER:

General

The evidence relating to war crimes has been overwhelming, in its volume and its detail. It is impossible for this Judgment adequately to review it, or to record the mass of documentary and oral evidence that has been presented. The truth remains that war crimes were committed on a vast scale, never before seen in the history of war. They were perpetrated in all the countries occupied by Germany, and on the High Seas, and were attended by every conceivable circumstance of cruelty and horror. There can be no doubt that the majority of them arose from the Nazi conception of "total war," with which the aggressive wars were waged. For in this conception of "total war," the moral ideas underlying the conventions which seek to make war more humane are no longer regarded as having force or validity. Everything is made subordinate to the overmastering dictates of war. Rules, regulations, assurances and treaties all alike are of no moment, and so, freed from the restraining influence of international law, the aggressive war is conducted by the Nazi leaders in the most barbaric way. Accordingly, war crimes were committed when and wherever the Führer and his close associates thought them to be advantageous. They were for the most part the result of cold and criminal calculation.

On some occasions, war crimes were deliberately planned long in advance. In the case of the Soviet Union, the plunder of the territories to be occupied, and the ill-treatment of the civilian population, were settled in minute detail before the attack

was begun. As early as the Autumn of 1940, the invasion of the territories of the Soviet Union was being considered. From that date onwards, the methods to be employed in destroying all possible opposition were continuously under discussion.

Similarly, when planning to exploit the inhabitants of the occupied countries for slave labour on the very greatest scale, the German Government conceived it as an integral part of the war economy, and planned and organised this particular war crime down to the last elaborate detail.

Other war crimes, such as the murder of prisoners of war who had escaped and been recaptured, or the murder of Commandos or captured airmen, or the destruction of the Soviet Commissars, were the result of direct orders circulated through the highest official channels.

The Tribunal proposes, therefore, to deal quite generally with the question of war crimes, and to refer to them later when

examining the responsibility of the individual defendants in relation to them. Prisoners of war were ill-treated and tortured and murdered, not only in defiance of the well-established rules of international law, but in complete disregard of the elementary dictates of humanity. Civilian populations in occupied territories suffered the same fate. Whole populations were deported to Germany for the purposes of slave labour upon defence works, armament production and similar tasks connected with the war effort. Hostages were taken in very large numbers from the civilian populations in all the occupied countries, and were shot as suited the German purposes. Public and private property was systematically plundered and pillaged in order to enlarge the resources of Germany at the expense of the rest of Europe. Cities and towns and villages were wantonly destroyed without military justification or necessity.



A simple past — a complex future: thoughts from the Heron Island symposium “Complexity, Criticality and Computation”

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Abstract

The big questions, once the sole province of philosophers and theologians, are coming under increasing scrutiny by scientists. In January 2023 a group of such scientists — a deliberate mix of the older generation and young future leaders — met on Australia’s Heron Island to delve into such questions as the fundamental relationship between physical and biological sciences, the emergence and principles of consciousness and its relation to artificial intelligence, the rise and fall of civilizations, and even the future of man itself. It rapidly became obvious that we are at the beginning of a journey with regard to such questions. Here I report on the first few faltering steps, and how they may hopefully help lead future scientists to a path that will steer us away from potential global catastrophes.

Introduction

An old scientists’ joke describes the reaction of a physicist when asked for a mathematical description of a cow. “Let us begin,” says the physicist “by assuming that the cow is spherical.”¹

The joke encapsulates an essential truth — that science has largely been at a loss when it comes to describing complex

systems that are more than just the sum of their parts. Our main weapon for understanding such systems, and natural laws in general, has been reductionism: a process where a complex system (from an atom to a galaxy) is simplified, often by breaking it down literally or metaphorically into its component parts, whose individual properties or interactions in pair-wise fashion are then studied and used to predict the behaviour of the system as a whole.

The reductionist and other simplifying approaches have been hugely successful over the past few centuries in helping us to understand how nature operates. But it has always been apparent that most complex systems are more than just the sum of their parts. Complexity arises from internal feedback loops and multi-component, multi-scale interactions within and between systems that range from atoms to galaxies, from amoebæ to elephants, from natural ecosystems to human societies and human institutions at all scales. In all of these cases, the outcome of complexity is *emergent behaviour* that cannot be predicted from the properties and pair-wise interactions of the component parts alone, whether these parts be subatomic particles or biological organisms.

¹ My Bristol University colleague Sir Michael Berry has, however, performed a contour integration over a real horse (Berry 2010).

But, during the last half-century or so, increasingly powerful computational approaches and fresh insights into the mathematics of networks have made it possible to study complex systems as an integrated whole. So a new field of “complexity science” has emerged,² with a host of applications that include town planning, ecosystem management, communication technologies, and the behaviour of human societies.

The new science is particularly important when it comes to understanding and coping with interconnected global threats such as pandemics, climate change loss of biodiversity, and food security. It has also encouraged a re-examination of some of the biggest questions in science, including the nature of science itself.

A group of scientists at Sydney University, led by Professor Mikhail Prokopenko FRSN, are in the vanguard of research into modelling and understanding complex systems. Mikhail, Ian Wilkinson and the Centre for Complex Systems organized a meeting on Australia’s Heron Island to examine where science has got to and where it is going.³

The Meeting

Heron Island is situated at the southern tip of Australia’s Great Barrier Reef, and is so small that it could fit comfortably into Sydney’s Farm Cove and not protrude beyond the Opera House. It is home to one of the world’s most complex ecosystems — a system that scientists from the University of

Queensland have been studying for decades in an effort to understand how it all fits together. The research institute on the island was thus a particularly apt choice of venue for a meeting devoted to understanding progress on how complex systems of all types fit together and function as integrated entities.

The island itself was formed through a complex process where sediment drawn from a reef was swept by shallow waves to a focal point determined by interactions between the waves and the contours of the reef flat. The resulting coral cay, perched on a corner of the reef, is reached from the coastal town of Gladstone by a two-and-a-half hour ferry journey, crossing a channel that was traversed by Captain Cook in 1770. A helicopter journey is now also possible, and sometimes preferred for a return to the mainland by those who have suffered from the waves on the way over.

On arrival, the sandy path from the jetty divides after just a few metres. The fork on the left takes arriving passengers to an expensive resort, dream world for honeymooners and the holidaying older generation. The fork on the right leads through a dense tangle of *Pisonia grandis* (the Giant Pisonia, or Bird-Killer Tree) to the more functional University of Queensland research station, which was home for the week to dreams of a very different sort — nothing less than the role of complexity in determining the past, present and future of human society, mankind and the universe.

2 The late Lord Robert May DistFRSN, a pioneer in the field with his seminal papers “Will a large complex system be stable?” (1972) and “Simple mathematical models with very complex dynamics” (1976), expressed a doubt that there is such a thing as “the science of complexity.” (Rear cover comment on Len Fisher *The Perfect Swarm* (2009).) But the common principles that scientists are continuing to discover across a range of disciplines, as exemplified by the talks on Heron Island, now more than justify the term.

3 See the web site <https://www.sydney.edu.au/science/our-research/research-centres/centre-for-complex-systems/c3-symposia.html>

The group of scientists that met at the research station was also more than the sum of its parts. Chosen by invitation to represent present leaders in the field and the up-and-coming younger generation, the idea was to mix the two in a friendly and stimulating environment where interaction and feedback within and between the generations was not only encouraged, but almost inevitable.

This was not the first time that such a group had been brought together at this venue. The first such complexity conference, brainchild of Ian Wilkinson, Louise Young, and Fabian Held, and based on a course devised by Terry Bossomaier of Charles Sturt University, had been held there eleven years previously under the umbrella Sydney University's Complex System Institute, and had proved to be a great success. A series of biennial "Complexity, Criticality and Computation" conferences, driven by the enthusiasm and dedication of Mikhail, followed at various venues. Now it was time to return to Heron Island, and to an eclectic mix of subjects that included pandemics, the nervous system, consciousness, the changing nature of science, and the origins and future of life, human societies, and the universe itself.

Mikhail's goal was to build the meeting around three big questions:

1. Is biology beyond physics: are there universal principles across both physical and biological phenomena?
2. What are the principles underlying the emergence of consciousness, language and intelligence, and can these principles be applied to develop powerful AI?
3. Are there fundamental physical constraints guiding the rise and fall of civilisations?

These questions to be considered in the context of a set of practical issues:

- Critical phenomena, singularities & entropy
- Brain and mind
- Survival of the fittest
- Pandemic/crisis modelling
- Why do civilisations fall?

An eclectic mix indeed. To the accompaniment of some 30,000 mutton birds (*Puffinus tenuirostris*), screeching day and night in their burrows, the participants set forth on an exhilarating ride of new, and sometimes revolutionary ideas. Here I share the ride, and outline some of the main ideas that emerged across a range of fields too broad for most minds to encompass, but providing cross-disciplinary fertilization upon which the new and rapidly emerging science of complexity — possibly the most important scientific discipline of the century — will be built.

The Ideas

Let me begin with two caveats. The first is that it is impossible in a short article to cover all of the topics that were presented. What I offer here is a personal selection of those that I believe readers of the *Journal & Proceedings* will find most interesting and/or will feel to be among the most important.

The second caveat is that, even with this selection, it is still impossible to go into much depth and detail about the chosen ideas. Many of them have deep roots that require equally deep consideration, and some require specialist knowledge of the field concerned. What I have thus attempted to do is to offer a taster of what the ideas are *about*, with major references for those who wish to follow them up. The ideas are often

a stimulus, rather than a final solution. Be prepared for the ride of your life, and make sure that your seat belts are fastened.

I have divided the ideas into four broad categories: *Beginnings and Endings*; *The Brain*; *Change*; and *Practicalities*.

Beginnings and Endings

Author, broadcaster and all-round scientific savant, Paul Davies, launched proceedings with a dizzying array of fundamental questions (Davies 2004; Lineweaver *et al.* 2013) that went back to the very beginning of the universe and took us through to its end. What are the laws of physics and where do they come from? Is Newtonian dualism (of force and matter, implicit in the equation $\text{force} = \text{mass} \times \text{acceleration}$) correct? Have the laws of physics always been the same, or may they have been different in the past and may they change in the future? Is there an arrow of time, and does complexity increase along it? How does this relate to the Second Law of Thermodynamics and the postulated increase in *disorder* with time, leading ultimately (as Lord Kelvin suggested in 1852) to the “heat death” of the universe?

Founding member of the Santa Fe Institute, Stuart Kauffman, offered potential answers to these questions in a fascinating talk based on a trilogy of staggeringly original, very recent papers (Cortès *et al.* 2022; Kauffman 2022, 2023) (the most recent had not even appeared in print at the time of the Heron Island symposium, where arguments were presented to a scientific audience for the very first time). In these three papers, Kauffman argued that:

- In a universe that contains life, physical laws do not and cannot provide a complete explanation for everything that occurs. As Stuart claims “We cannot explain the

evolution of the biosphere using physicals alone. No law entails that ever-creative evolution.”

- A Fourth Law of Thermodynamics is thus required whereby, at constant energy input, the biosphere will construct itself into an ever more localized sub-region of its ever-expanding phase space
- We are facing a third major transition in science beyond the Pythagorean dream that “All is number” and beyond the subsequent number-based Newtonian physics, to a phase where the emergent creativity of an evolving biosphere is also taken into account.

Central to these arguments is the notion that the ergodic hypothesis (which postulates that all accessible microstates of a system have an equal probability of being occupied over a long period of time) fails for biological systems, where the vast majority of potential biological states (organisms) are never realized. Since the Second Law of Thermodynamics relies on the truth of the ergodic hypothesis, it may therefore be open to challenge once biological systems enter the picture.

The ergodic hypothesis may equivalently be stated in terms of a physical concept called *phase space*, where each possible combination of defining variables (e.g. position and momentum) for all the components corresponds to one unique point. The ergodic hypothesis means that the system spends equal amounts of time in equal volumes of phase space.

Phase space entered the picture in a different way when Geraint Lewis pointed out (Barnes & Lewis 2021) that the beginnings of the universe must have been at a single very rare point in phase space. If things had

been just slightly different, he argued, the periodic table would now consist of just two elements — iron and nickel. “But,” says Lewis, “we won the multiverse lottery, with selection over a myriad of universes that has allowed us to live in a complex universe that has made complexity from order, and filled the periodic table with elements.”

Archaeologist Roland Fletcher brought us back to earth with a thump when he pointed out that the rise and fall of civilizations most likely depended on issues of complexity. It’s not a new idea. As I have mentioned in an earlier article for the *Journal & Proceedings* (Fisher 2018), the historian Joseph Tainter has proposed the fall of the Roman Empire was due to “the fact that the empire had reached a level of complexity that rendered it susceptible to small perturbations.” But Fletcher, an expert in the evolution of the Angkor and Khmer civilization, has made the argument a lot more concrete, and has identified three great transformations in human civilization over the centuries:

- Agriculture and sedentism
- Managed human labour and agrarian urbanism
- Machine production and industrial urbanism.

Fletcher’s original observation has been that each of these transitions occurred at successive order-of-magnitude increases in the number and density of people aggregated within centres of population (Fletcher 2020). On this model, he argues, we may expect the next transition (away from the age of metals and metal-based products) some time within the next two centuries.

The Brain

The big ideas involving ergodicity and phase space were brought down to earth by **Valentina Baccetti** with her talk on changes of state in the human brain. Baccetti described recent studies which showed that the statistics of ergodicity could be used to accurately model these transitions in a neuromorphic system (e.g. the brain) close to its critical point. Put in less abstract terms (Caravelli *et al.* 2021), a circuit containing simple elements and based on memristors can give rise to intricate emergent behaviours that mimic the behaviour of real networks such as the neural network of the brain.

The brain very likely operates near criticality (i.e. in a state where a small fluctuation can drive a major change) according to Sydney University modeller, **Mac Shine**, who is studying the complex topological organization of the brain. It appears that the emergent dynamics of the inherent circuitry of the brain might shape complex, adaptive behaviours (John *et al.* 2022), which require robustness, flexibility and unity. These three signatures are well-aligned with the structural and functional interactions between the thalamocortical system and the cerebellum, basal ganglia and superior colliculus, respectively.

One of the most exciting big ideas was to bring to actuality the concept of using *reservoir computing* to model and mimic the behaviour of the human brain. The basic, very abstract idea⁴ “lies in leveraging a fixed non-linear system, of higher dimension than the input, onto which an input signal is mapped. After this, it is only necessary to use a simple readout layer to harvest the state of the reservoir and to train it to the desired output.”

4 See <https://martinuzzifrancesco.github.io/posts/a-brief-introduction-to-reservoir-computing/>

This very abstract idea was brought into concrete reality by Caravelli & Kuncic, who constructed a working reservoir computer from a stack of short lengths of silver wire, each coated with a very thin layer of insulting polymer (not unlike conducting neurons coated with myelin sheaths). On the application of an electrical signal, the wires produced dendritic growths that penetrated the polymer coating and eventually made electrical contact with neighbouring wires, first through quantum tunnelling, and eventually through direct contact. This reversible process permits the assembly to “learn” in response to feedback (Hochstetter *et al.* 2021). Michael Small offered a rigorous analysis of this process, and introduced a key idea of the shortest description length being the computationally most efficient (Thorne *et al.* 2022).

What about the efficiency of the brain itself? Daniel Polani argues that its evolution may be driven significantly by the conflicting needs to process information efficiently while maintaining effectiveness in the use of that information. In this “perception-action loop,” information that is extracted from the environment comes in many cases with extraneous information that is not need for the task in hand. An efficient organism will use this “piggyback information” to help with other tasks where it may be relevant.

Polani argues that “the effectiveness of the action-perception channel is a proxy for the organism sitting in a good sensorimotor niche, and when it doesn’t, driving it to move there. This can provide a good direction for behaviour whenever no obvious overriding drives control the behaviour” — a process that he calls “empowerment” (Volpi & Polani 2020).

Change

The Santa Fe Institute’s Michael Lachmann argues that evolutionary theory has much broader application than just biology, offering nuclear decay, the growth of snowflakes and the evolution of planets as examples. “Since the explanatory power of evolutionary theory lies in explaining the formation of function/functionality/purpose,” he argues “this means that these are generated in many other areas. Thus in thermodynamics/statistical mechanics there is a process of conversion of free energy into functional information, related to the conversion of order into complexity that Paul Davies discussed.”

But Michael argues that we can go further. “If we give up considering evolution as happening just at the level of individuals, and instead [focus on] on lineages of information, it will apply much better to how biology works, [and] will also apply much better to other systems, such as the free market, culture, etc. These lineages of information can also be information about how to be a good group, so it includes the regular view of levels of selection” (Sharma *et al.* 2022).

I cannot here go into the ramifications of the many informal discussions about consciousness and the nature of mind, but must make mention of Michael Harré’s work in marrying game theory and artificial intelligence into the beginnings of a new theory of mind (Harré 2022). An important step.

Practicalities

The improvement in our understanding of complex systems has come largely from increasingly powerful computational methods and the use of big data.

Progress in computation has largely consisted, not just in speed, but in finding really novel, efficient ways to understand and predict the behaviour of complex systems using computational methods. This has often involved the analysis of big data sets, although this is not without its dangers. Seeking for patterns in data is the basis of Baconian science, and it is perilously easy to forget that correlation does not imply causation. My ecologist daughter once pointed this out when she “demonstrated” that sheep farmers were migrating from New South Wales to Victoria and turning into letter-boxes. According to Government reports, the two numbers were identical.

Fortunately, our theoretical understanding of complex systems is progressing, and it thus becomes possible to use the correlations from big data as a basis for hypothesis, rather than jumping the gun and taking them as the direct basis for conclusions. Eduardo Altmann made a related point with regard to some well known statistically-based “laws,” such as Zipf’s law for word frequencies, or even the frequency of scale-free networks. Many such “laws” (of which there is now a plethora) are in fact influenced by unexpected correlations in the observations, and need careful statistical testing and understanding (Altmann & Gerlach 2015).

Metaphorical thinking can be quite useful if handled carefully, as Mikhail showed with his overview of thermodynamic models of complex systems and the efficiency of self-organization, with examples ranging from the thermodynamics of collective motion near criticality (Nigmatullin & Prokopenko 2012) to the growth of Greater Sydney (Croato *et al.* 2018). The main point of Mikhail’s talk was to suggest that *self-organization* is

ubiquitous because it brings “thermodynamic efficiency,” providing a gain in predictability per amount of additional work at some sweet spot (e.g. the critical behaviours of swarms, etc.), as opposed to the lower efficiency demonstrated by extremes of *randomness* (low predictability gain and low additional work) or *perfect order* (high predictability gain but high additional work).

Big data can also be used to understand and handle details of pandemic spreading (and in fact spreading and chains of many types) as Carl Suster and Rebecca Rockett (Rockett *et al.* 2020) showed with their work on genomic surveillance and the role of genomic differences in the occurrence and severity of COVID-19, Sheryl Chang through her work on population heterogeneity and interdependencies in pandemic spreading (Chang *et al.* 2022), and Sara del Valle’s highlighting of the importance of social interactions in supply chains, also in the context of pandemic models (Beesley *et al.* 2023). In a different context, Arunima Malik showed how climate change is already affecting food supply chains in a differential manner across the various sectors in a world already full of socio-demographic inequalities (Malik *et al.* 2022).

The pandemic, with all of its negatives, at least offered a chance to test, and to demonstrate the success of, agent-based computer models, which simulate the behaviour and interactions of multiple individuals. Tim Germann, a pioneer in the use of such models during the influenza pandemic of 2006 (Germann *et al.* 2006), emphasized their successful application (unfortunately often disregarded by politicians) during the COVID pandemic.

One aspect of science that non-scientists have become aware of during the COVID-19 pandemic has been the effective replication (R) number.⁵ A very important insight from Joel Miller was the importance of individual action when this number is close to one (Althouse *et al.* 2020).

The biggest question of all: does man have a future?

Most readers of this article will be aware of the Fermi paradox. Proposed by Enrico Fermi during a lunch-time conversation at the Los Alamos laboratories sometime shortly after WWII (Jones 1985), it asks of extraterrestrial life forms “Where are they?” As argued in detail by Michael Hart in 1975, interstellar travel should be feasible for a technologically advanced civilization, and the resultant migration should fill a galaxy within a few million years — a very short time compared with the known age of the Milky Way. Given that the conditions for the formation of life seem to be relatively common among the increasingly discovered number of planets, why have we had no contact with any of these civilizations?

A terrifying potential answer, proposed by Robin Hanson in 1998, is *The Great Filter*. Put simply, a civilization must undergo a series of steps/transformations in order to reach a stage where interstellar travel and colonization of distant planets become possible. Since such colonization seems not to have happened, at least one of those steps must be very improbable, so that civilizations become locked down, or even exterminated, prior to that stage. Hanson

suggests that pessimistic scenarios like nuclear war, ecological disasters or (prescient for 1998) the takeover of machine intelligence may form part of this process. (I would add personally that overcoming the constraints to cooperation exposed by game theory may be the biggest problem of all⁶ (Fisher 2008).)

Perhaps, as argued by astronomy writer Doug Adler (2020) “the Great Filter might be a consequence of technology itself. Perhaps advanced civilizations usually eradicate themselves via some sort of technology run amok... Humanity is already more than capable of destroying itself via global thermonuclear war. And sadly, it’s possible that such extinction is virtually inevitable throughout the cosmos” — a scenario that was neatly encapsulated by Isaac Asimov in his remarkable 1958 short story “Silly Asses.”

The Great Filter and The Nature of Consciousness were two of the biggest questions that preoccupied our after-dinner discussions on Heron Island. Many of the talks that I have listed under “practicalities” may in fact be reinterpreted as modelling Great Filter events (thanks to Mikhail Prokopenko for this suggestion), and attempting to understand such events and their consequences better. If the Great Filter hypothesis is anywhere near correct, as it certainly threatens to be on the only planet where we know for certain that life exists, the big ideas that Mikhail proposed at the beginning — Is biology beyond physics?; Consciousness and the emergence of AI. How do civilizations rise and fall? — assume an even greater importance. The answers are

⁵ The effective reproductive number (R) is the average number of secondary cases per infectious case in a population made up of both susceptible and non-susceptible hosts. [Ed.]

⁶ See Diamond (2011) for his explanation of the disappearance of trees on Easter Island and the disappearance of European settlers on Greenland. [Ed.]

crucial to our future, and perhaps to our very survival. A major objective of the Heron Island meeting was to help pass the torch for illuminating these answers on to the next generation of researchers. We can only hope that, as with the last generation that has laid the foundations, the next generation will build a structure that keeps us safe in the face of such problems as climate fragility, future pandemics, the threat of nuclear war, and the conglomeration of social problems driven by the relentless pursuit of individual self-interest at the expense of cooperation and integrated action. The omens may not be promising but, on the evidence of Heron Island, the talent is certainly there (see also a perspective by PhD student Christina Jamerlin⁷).

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Critical hydrologic impacts from climate change: Addressing an urgent global need

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Abstract

A consensus statement from the Regional Action on Climate Change Symposium (RACC-15) held on September 30, 2023: An adjunct session of the Science, Technology and Society Forum (Kyoto).²

An accelerating climate crisis

This year the developing climate crisis has accelerated and worsened with further warming of both oceans and land. The overall threat continues to be driven by accumulating greenhouse gases in the atmosphere. This outcome has long been predicted by the climate science community (IPCC 2021). But preparation for its impacts by policy makers and governments has been severely lacking.

Previously RACC warned: “Earth’s climate, ecological and human systems could converge into a comprehensive crisis” worsened “by factors such as inequality, inadequate health infrastructure and food insecurity,” (Falk et al. 2021) as well as regional conflicts. Evidence of such convergence, sometimes now described as a “polycrisis,” (Lähde 2023) is now increasingly visible.

Whilst efforts to mitigate emissions remain crucial, we must now focus with equal commitment on supporting adaptation to these changes, especially for those most vulnerable.

A transforming hydrologic cycle

Shifts in the hydrologic cycle are creating many of the most urgent needs for adaptation. Driven by climate change, these shifts threaten the availability of freshwater, impoverishment of biodiversity, reduced food production, and direct and indirect impacts on human health.

Traditional approaches to managing hydrologic variability are failing. Infrastructure, built for a climate system that no longer exists, is being overwhelmed by increasingly frequent and severe extreme events. Institutional systems (such as insurance, fire fighting, disaster response, and organisations supporting displaced people) are increasingly unable to cope.

Governments find themselves unable to sufficiently reduce water withdrawals from stressed rivers (such as the Nile and the Colorado River) and over-tapped aquifers. Hydrologic variability is putting millions of people at risk. For example, in the Vietnamese Mekong Delta, increased variability is undermining hydropower and water infrastructure, whilst increasing

¹ See a list of the 30 co-authors with their affiliations, below.

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farming costs and threatening livelihoods in both flooding and salinity zones. Globally, rising temperatures, changing circulation patterns, and acidification of the oceans, combined with pollution and over-fishing, are disrupting the ocean's yield of marine foods with enormous potential impact for human populations.

Of particular concern are the impacts of hydrologic variability on those living in the drylands, and particularly those dependent on water supplies from the Himalayan regions where temperatures are rising fast and ice and snow are disappearing. This includes the 240 million people who live in the Hindu-Kush Himalaya mountains³ (Wester et al. 2019) — “the water tower for Asia” — which is the source of ten major river basins and the 1.9 billion people who live in them.

Fresh responses are needed. For example, more young leaders could be welcomed into training capacity. In the context of Future Design, where impacts on future generations are explicitly taken into account (Saijo 2020), young leaders could play a much stronger role. Current road blocks to global agreement may be overcome by utilising experimental governance, where policy innovation and potential solutions are first tried at smaller scales with successful outcomes building support for more comprehensive changes (Sabel and Victor 2022).

Global commons, such as the oceans, need much greater research attention and protection through enhanced governance. The coastal regions, on which the food and livelihood of millions depend, are connected to one another by ocean currents, fish migration and floating pollutants.

Equitable, globally shared responsibility in ocean governance, utilising best science for protecting all communities, is essential for averting the most serious impacts. Whilst the Special Report of the IPCC (2019) summarised current research, together with the maritime biodiversity treaty adopted this year (United Nations 2023), are both good steps forward, much more globally coordinated work monitoring the ocean system and regional impacts is necessary.

More immediately, energetic multi-disciplinary development of adaptation strategies, able to address converging risks, should be supported. As a matter of priority these should be directed at building resilience of those who are most at risk.

Priority actions

From the local to global, actions are required now to prepare and protect the most vulnerable, especially in the drylands where some 80% of the Earth's poorest people live. Priority actions should be framed in the light of all SDG targets, including these interlinked approaches:

To monitor and predict threats and develop solutions for the most vulnerable

- Deploy early-warning systems on the regional and local level
- Develop technical approaches that can provide advance warning of major changes to the local climate system and their impacts
- Focus on identifying and protecting human populations and ecosystems where climate impacts will be felt first and most intensely, including especially impacts on biodiversity and human health

³ Including the Krakoram mountains.

- Scale up the multiple benefits of research and development of nature-based solutions combined with agricultural, water, and food sufficiency measures that support SDG targets
- Assist decision-making in the face of deep uncertainty using machine learning, behavioural science, non-market economics, and other methodologies
- Devise and put in place updated infrastructure and institutions that address the converging impacts of extreme events
- Support the enhancement of human coping and adaptive capacity in the most vulnerable ecosystems and societies.
- Coordinate, support, and make visible at global scale, regional goals and efforts to protect and restore ocean sustainability as a global public good, and ensure research into ocean health is at a commensurate scale
- Enhance efforts to adapt to shifting timing for drought, floods, and extreme weather conditions, and optimise regional and international cooperation to address risks in countries facing rapid hydrologic changes
- Encourage collaboration between policy makers, researchers, practitioners, and communities supported by knowledge-action networks, to discover and implement strategies for tackling the most serious risks in each place
- Build global collaboration and capacity for disaster assistance sensitive to local needs and capabilities.

To increase regional capacity

- Expand regional awareness of the threats of climate change and support access to action options
- Research, publicise, and respond to the medical and mental health impacts of climate change
- Improve private sector understanding and action on climate risks, especially in the insurance industry
- Identify and publicise best practices in improving governance using multi-stakeholder engagement with local communities to enhance adaptation to climate risks.

To focus greater attention at all scales on a transforming hydrologic cycle

- Protect the hydrologic cycle as a “Global Public Common Good” with new economic policies and approaches that create greater value and incentive for more sustainable use of fresh water

To focus and invest in science to transform agriculture

- Develop greater water-use efficiency in agriculture (which represents some 70–80% of water withdrawals), including water re-use with cheap and effective methods to remove diverse contaminants from reclaimed water (for example, by utilising zero-valent sand filtration) (Seongyun et al. 2021)
- Support local food security by restoring currently declining soil health in many parts of the world using ecosystem and science-based approaches to return and retain carbon in soils, including financially rewarding carbon farming
- Mobilise the biotechnology revolution to provide poor farmers with affordable drought- and salt-tolerant seeds suit-

able to local agro-ecology under climate change. Continue development of genetic resources as a tool for adaption to dynamic increases of temperature

- Support biodiversity in particular by bringing all UN systems dealing with biodiversity together and, with the CGIAR (Consultative Group for International Agricultural Research), coordinate and make the data openly available to vulnerable countries.

And, in particular:

- To build on the decision at COP-27 to redress loss and damage, by creating sufficient global funds and other supports including vulnerability indicators to identify, initiate, and finance urgent actions to ensure inter-generational equity and protect and support vulnerable populations as they face the converging threats of climate change.

In summary

Rapid and wide-ranging efforts need to be launched to support and improve community resilience to now-unavoidable climate changes at all regional scales.

Efforts at mitigating greenhouse gases must accelerate in all sectors, including agriculture, land use, and land-use change and forestry, with restoration and conservation of ecosystems key to restoring the hydrologic cycle and water resources. But adaptation is no longer a secondary option. Governments at all levels need to anticipate converging threats and invest in economic, scientific, and policy responses. In particular, much greater and more urgent attention needs

to be applied to the severe and escalating hydrologic impacts being driven by climate change, especially for the most vulnerable communities.

Needed actions include expanding access to local information about climate impacts, new financial investments and tools for local adaptation, education around both risks and adaptation strategies, global support to de-risk initiatives that invest in resilience where it is most needed, and provision of the resources to implement on-the-ground actions consistent with justice.

Current efforts are inadequate at all scales given the rapid rate of changes now occurring and the extensive and widespread risks. In particular, beginning at COP-28, it is vital that national leaders pledge to protect, resource, and support actions to help the most vulnerable populations, notably in the drylands, to build resilience to the mounting challenges of climate change.

Thirty co-authors

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More details of the RACC and its International Advisory Committee are set out at <https://www.stsforum.org/racc2023/iac/>

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The Search for Truth: History and Future of Universities

Review of Maxwell Bennett (2022)

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I

In 1988 the Commonwealth *Higher Education Funding Act*, piloted through Federal Parliament by John Dawkins, Minister of Education, Employment and Training, inaugurated a new regime for Australian universities.¹ The Minister's announced intention was beneficial change, or rather "reform," of the existing highly diversified post-school educational landscape, in order to create a more efficient and equitable national university system. Critics then and now have been less certain of the overall benefits and desirability of the proposed changes, and of subsequent variations on the same theme by Dawkins's numerous successors. Most but not all criticism has come from academics. University administrators or managers (as they soon came to be known), were generally content to comply with and implement the new order. It may not be unduly cynical to suggest that their initial co-operation owed something to a Faustian bargain, which saw the removal of both the former Australian Universities Commission and its powers to regulate the remuneration of vice-chancellors and

other senior university officers. Yet in a wide-ranging recent compilation on the state of Australian public universities, the former vice-chancellor of the University of Melbourne, who now heads Australia's Public Service, raises a number of pointed questions about the consequences of the developments set in train by Dawkins.²

Another new title from the same publisher takes a very different approach to the same issue, placing it within a much wider chronological, geographical and philosophical context.³ It is generally not a good idea to review books written by one's friends. My excuse for embarking on this present hazardous venture is that while Max Bennett and I were student contemporaries at Melbourne University, we have subsequently followed very different intellectual and personal trajectories. I altogether lost contact with Max for nearly half a century after leaving Melbourne in 1962. Our reconnection followed circulation of a memoir by Ken McNaughton, a former member of what Bennett himself here recalls as "a group of like-minded undergraduate students from different disciplines to which we gave the

1 Note: this essay incorporates much of a review recently submitted to and published by the journal *Minerva*: <https://link.springer.com/article/10.1007/s11024-022-09483-8>

2 Glyn Davis (2022), Why are Australian universities so large? in *Australian Universities: A Conversation about Public Good*, ed. Julia Horne and Mathew A. M. Thomas (Sydney University Press, 2022), 41–53; see also idem, *The Idea of an Australian University* (Melbourne University Publishing, 2017).

3 Maxwell Bennett (2022), *The Search for Truth: History and Future of Universities* (Sydney University Press, 2022).

pretentious name ‘the Athenian Society’” (p. xix). Brought together in 1959 by the slightly older and somewhat charismatic Max, after he had published in the student newspaper *Farrago* an article entitled “The Search for Truth,” our small cadre of earnest young men met weekly for hours of intense if naive amateur philosophising.

I did not then know anything of Max’s family background and upbringing, which go some way towards explaining his life-long dedication to what Charles Darwin once termed “an instinct for the truth.” His mixed parentage (Jewish father of Russian-Rumanian extraction, Catholic-Irish mother), consequent early acquaintance with both the Torah and the New Testament, and Catholic schooling evidently focused this young enquiring mind on some basic epistemological questions. Max’s personal dedication to this mode of enquiry was quite unique among our group. Even after I had dropped out during or following that first year, it was — and indeed still is — difficult not to feel in some awe of the intellectual span of a former electrical engineering student who, after having been forced by paternal mandate to abandon school for a technical apprenticeship at age 14, chose to spend his spare time reading classic texts ancient and modern — from Plato and Descartes to Whitehead, Russell and Wittgenstein — and now in his early eighties, garlanded with honours, has only just retired as professor emeritus of neuroscience at the University of Sydney.

This latest book is characteristically wide-ranging in its coverage of centuries, cultures, languages and topics, from twelfth-century French nominalists and realists through the German enlightenment, languages and linguists, to twentieth-century nuclear

physics, corona viruses, artificial intelligence, post-modernism and neo-liberalism, to mention only a fraction of the polymathic whole. But despite its subtitle, the author maintains that his concern is not simply to add another volume to the already extensive bibliography on the history of universities. It is rather to highlight “the greatest events in the evolution of the university that established the faculty, the department, and the administrative structure, which together optimised the means of maintaining and prospering the university” (p. 5).

The four parts into which his book is divided consider first the search for “Divine Truth” in the nascent university of Paris during the twelfth and thirteenth centuries, with chapters on Peter Abelard’s logic, Thomas Aquinas’s reconciliation of Christian theology and Aristotelian philosophy, and the emergence of scholasticism as the distinctive pedagogical methodology of the new educational institution on the Left Bank of the Seine. We then move to “Empirical Truth and the University of Berlin,” with Immanuel Kant’s rejection of humanism in favour of scientific education and Wilhelm von Humboldt’s revolutionary establishment of the University of Berlin in 1810 as “the mother of all modern universities” (p. 138). Moving into the twentieth century, the third part deals with “Scientific Truth and the University of California,” the new era of big science inaugurated by Robert Oppenheimer and Ernest Lawrence, together with Clerk Kerr’s masterful reorganisation of Californian public higher education institutions, which preserved and enhanced the multi-campus University of California, while enabling state and community colleges to offer all secondary-school graduates a merit-based pathway to higher education.

Finally, Bennett turns to “The University and Contemporary Challenges,” identifying three existential threats to the future of humanity: first, artificial intelligence, notably the risks posed by machines which may soon become not only more intelligent than their mortal makers, but capable of still further intellectual self-improvement; second, the continuing proliferation of nuclear weapons, and pandemics. (Third, the dangers of climate change are perhaps already too obvious and well-recognised to merit further discussion here.) Universities and academics have an obvious role to play in meeting and mitigating these challenges to the continued presence of *Homo sapiens* on this planet. But the extent to which they can be expected to do so is another question.

His concluding chapter examines the various current “forces arrayed against the core values of universities.” These include the Hayekian/Reaganite/neo-liberal reaction to the growth of government spending on education and social services generally following World War II, the somewhat paradoxical tendency for governments to seek ever more control over the operation of universities even as the proportion of university income attributable to direct contributions from the state declines, the rise of interdisciplinary research centres which erode the former dominance of discipline-based departments, the growing influence of variously dubious national and international university rankings on the allocation of scarce resources, especially research funding, and the increased power of university administrators and managers *vis-à-vis* career academic researchers and teachers.

In this chapter much of Bennett’s analysis is derived from his own experience as a

senior and successful Australian academic, and is particularly applicable to the plight of Australia’s public universities, most of which have chosen (or been forced) to replace significant shortfalls in government funding with much increased dependence upon fee income derived from international student enrolments. But the difficulties which now face Australian universities are scarcely unique to this country, even if the magnitude of the emoluments received by their vice-chancellors (and presidents — as these leaders now dub themselves, following American fashion in this as other respects) may be unparalleled elsewhere.

II

Bennett has given us an historically based apologia and manifesto for his vision of what a university is, or should be: not so much a work of history *per se*. This is not to criticise the quality of his research and exposition. Even if much of the historical content is unavoidably reliant on secondary sources, considerable effort has been made to seek appropriate expert advice, and the subject bibliographies appended to the first three parts cover an impressive range of both original printed material and recent scholarly literature. The argument is presented in a clear, unaffected, and largely jargon-free prose; unfamiliar technical detail and vocabulary rarely get in the way of the theme being developed, and a multitude of visual aids — diagrams, graphs, illustrations, tables — supplement the text. I personally find the prolific use of numbered section headings to divide up each chapter slightly distracting in terms of following the main argument and would prefer to read my way through pages unadorned by such analytical signposts; but no doubt they will bother few

readers from other disciplines where this practice is entirely routine and expected. A reprint or second edition will provide the opportunity to address the very occasional typo, as well as to correct the unfortunate anachronism which has Wilhelm von Humboldt's work influencing "the idea of the university in the late 17th and early 18th century" (p. 128).

So much for form, what of content? The historical development of universities plainly involves a good deal more than the search for truth. After enthusiastic references to the "thousands" (p. 2) or "hundreds if not thousands" (p. 21) of students attracted to Abelard's lectures, relatively little attention is paid to the individuals who comprised the undergraduate body attending medieval, early modern, and modern universities, or the motives which impelled them to seek admission, and their families, friends and benefactors to support their studies. While the search for truth doubtless played a part in individual cases, it seems likely that the quest for employment, preferment and social status was at least an equal and often a higher priority. Universities and their members have also always exercised significant economic and political roles, as employers and consumers, as well as sources of expertise, influence and patronage, alongside their primary educational and intellectual functions.

Nor did even medieval universities enjoy a monopoly on the search for truth. In the early modern period (c. 1400–1750), learned academies, salons, artisans' workshops and learned societies all provided venues for such activity, which continues today in a wide variety of both public and private research centres and institutions. That having been said, the search for truth was and is a very

important and sometimes overlooked part of the history of universities, even if other bodies might claim at least some of the same *raison d'être*.

At some points, especially in the discussion of German philosophical and educational thought during the eighteenth and early nineteenth centuries, more consideration of the particular circumstances of time and place, the social and political context in which thinkers and universities were operating, and how these environments may have affected the outlook of individuals and institutions, would have been desirable. Exclusive focus on the history of ideas too easily gives the impression that thought moves entirely of its own volition, by a process of more or less logical internal development. While this may be true to some extent, it is rarely the whole truth. Another danger, which Bennett does not altogether escape, is that tracing a pattern of evolution from past to present can support a teleological narrative of progressive change, imparting unquestioned legitimacy to the current state of things, as though all previous change has somehow been directed towards the situation in which we now find ourselves — or did, before recent unfortunate tendencies disturbed its optimal equilibrium.

Although written in Australia by an eminent senior Australian academic, this book says little about the development of Australian universities before the late twentieth century. That may well be because in terms of culture, curriculum, governance and structure, Australian universities were heavily derivative of English, or British, universities until at least the 1970s, and as Bennett points out, the English "resisted the Humboldtian model for a long time" (p. 139).

German universities did have their influential admirers in nineteenth-century Britain, including the poet and public intellectual Matthew Arnold, who nevertheless sought to defend the traditional classical and literary learning of Oxford and Cambridge against those who, like Mark Pattison and T. H. Huxley, believed that higher education should henceforth be dominated by more exact and utilitarian studies, a view which gained increasing institutional weight in the newly-established provincial colleges and “redbrick” universities. Bennett’s claim that the “autonomous college system” of Oxford and Cambridge enabled those elite institutions “to ignore all changes and directions from the state” (p. 139) is also a bit sweeping, given the royal commissions into Oxford and Cambridge of 1852–54 and 1873, together with the reform acts of 1854, 1856, and 1871 which largely secularised both ancient universities, removed the requirement that college fellows abandon their teaching posts upon marriage, and established new faculty structures.

Nevertheless the German model was certainly more successful in the United States, beginning with its implementation by Daniel Coit Gilman at Johns Hopkins University from 1876. Yet even in the USA remnants of an earlier Oxbridge influence persisted in the Ivy League and liberal arts colleges. Indeed it is conceivable that the eventual triumph of what became the German-American model of the modern university throughout the Anglosphere owed at least as much to the collapse of the

British empire and the rise of American global dominance after World War II as it did to the intrinsic virtues of Humboldt’s educational vision. Nor did that triumph come without cost. What worried the Victorian opponents of German professors was not just the rebarbative pedantry of Dr Casaubon and his like, but the likely deleterious impact of a research-dominated academic culture on the quality of teaching provided to undergraduate students. Of course, those students were largely selected from a relatively small socio-economic segment of the population at large. But it would be difficult to demonstrate that the modern era of mass higher education and considerably worse staff:student ratios is capable of providing a much-expanded and in some respects more socially inclusive student body with an educational experience of equal depth and all-round quality to that enjoyed by their counterparts even half a century ago. That graduates from the University of Melbourne, long Australia’s top-placed university in international rankings based largely on research metrics, were of all Australian university students surveyed in 2021 the least satisfied with their undergraduate experience, is one among many straws pointing in the opposite direction.⁴

III

But whatever one’s doubts or misgivings about Bennett’s historiography, it would be entirely misleading to end on a negative note. The second half of his book is particu-

⁴ 2021 Student Experience Survey, at [https://www.qilt.edu.au/surveys/student-experience-survey-\(ses\)#report](https://www.qilt.edu.au/surveys/student-experience-survey-(ses)#report). The interpretation of such survey results is plainly fraught with difficulty. Was it just that Melbourne’s highly-selected student body arrived on campus with more unrealistic expectations than those of their counterparts at less exalted institutions? Alternatively, did their already finely-honed critical faculties become even more acute in response to the excellent quality of the teaching they received? On balance, a long history of student complaints about Melbourne’s overcrowded “tutorials” makes the former seem more likely.

larly compelling, perhaps in part because it deals with more recent and contemporary history. The accounts of twentieth-century physics and Clerk Kerr's multiversity are real highlights and the sobering dissection of threats to humanity's very survival gains added force from the consideration that the nuclear-rattling Russian autocrat's Ukranian adventure evidently post-dated its composition. The final chapter is almost equally depressing, not least because it is hard to see how either the present state of universities or the economic, political and social contexts in which they exist are likely to change markedly for the better in the short to medium term. On the other hand, as Bennett himself points out, universities have been around for a very long time,

while experiencing numerous transformative changes over the course of that *longue durée*. So it clearly would be premature to abandon all hope, or to assume that the present less than ideal condition of the modern university will prove any more durable — let alone terminal — than those of its numerous predecessors. The key question is whether and when the pendulum which since the 1980s has swung so hard against the ideal of universities as collegial scholarly communities primarily dedicated to the search for truth will assume a reverse trajectory. Perhaps it has already begun to do so.

Wilfrid Prest
21 January 2023



Thesis abstract

Archaeobotanical applications of microCT imaging

Aleese Barron

Abstract of a thesis for a Doctor of Philosophy, submitted to the Australian National University

This thesis explores the ways in which the three-dimensional and non-destructive imaging technique of microCT can be applied to archaeobotanical materials to extract additional information previously inaccessible using traditional two-dimensional techniques. Across a series of eight publications, two microCT imaging protocols focusing on the imaging and analysis of two distinct types of archaeobotanical remains are presented along with archaeological case studies to which they have been successfully applied. Both protocols seek to utilise the relatively new imaging technique of microCT in order to explore the histories of some of the world's most important, yet in some cases understudied food crops including rice (*Oryza sativa*) in island Southeast Asia, sorghum (*Sorghum bicolor*) and pearl millet (*Pennisetum glaucum*) in Africa, and taro (*Colocasia esculenta*), sweet potato (*Ipomoea batatas*), and yams (Dioscoreaceae) in Southeast Asia and the Pacific.

The first protocol outlines how organic cereal tempers can be virtually extracted from inside pottery sherds through the use of microCT scanning and 3D digital segmentation techniques. These extracted digital remains can then be taxonomically identified and their domesticated status assessed using the morphological information only accessible with the penetrative X-rays of microCT. This protocol has been successfully applied to extract new rice and

sorghum assemblages from previously excavated pottery sherds and their analysis has expanded our knowledge of the dispersal and early cultivation histories of these staple food crops.

The second protocol uses microCT to build the first virtual reference collection of a greatly understudied type of archaeobotanical evidence, archaeological parenchyma. This protocol was developed by imaging samples of important root crops in the Southeast Asia and Pacific region from Jon Hather's parenchyma reference collection and applying his taxonomic identification method developed in the 1980s and '90s. Here his method is updated and adapted to include the added three-dimensional contextual information provided by microCT scanning as well as the greater range of anatomical variation captured both within and between species. The microCT datasets of these reference samples will form part of the first publicly accessible, online and virtual, archaeological parenchyma reference collection, which will hopefully encourage wider adoption and application of the technique.

Both archaeobotanical microCT protocols presented here demonstrate the enormous potential of the technique to expand on our current sources of archaeobotanical evidence. The digital nature of the datasets presents the possibility of increasing analytical efficiency in the future with the

development of automated archaeobotanical analyses.

This thesis was awarded the JG Crawford Prize for HASS at ANU.

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Thesis abstract

Experiences of statelessness and refugee protection: Exploring the “Rohingya Life” in Sydney, Australia

Zoe Louise Bell

A thesis in fulfilment of the requirement for the degree of Doctor of Philosophy, School of Social Sciences, Faculty of Arts, Design and Architecture, UNSW Sydney

The Australian government has two systems for refugee arrivals. One is the official refugee resettlement system, a coordinated approach between Australia and the United Nations High Commission for Refugees (UNHCR), and the other is the government’s response to informal or irregular arrivals of people seeking asylum, particularly those arriving by boat. Over the past 20 years, people who arrive informally have been placed in immigration detention, deported, or given temporary forms of refugee protection. Within this system some people are stateless, with no country to return to and no citizenship or nationality to protect them. Within the existing body of knowledge relating to statelessness, there is limited literature relating to the lived experience of statelessness and the experience of the stateless refugee in democratic countries that adhere to international human rights norms. Furthermore, there is only limited research on the Rohingya, a well-known stateless refugee community, in contexts outside of Myanmar and Bangladesh. To address these knowledge gaps, the research described in this thesis draws on the lived experiences of the stateless Rohingya refugees in Sydney, Australia, to explore the intersection of statelessness and temporary forms of refugee protection. More specifically, this thesis focuses on four areas of

research: 1) Developing an understanding of statelessness from the perspective of the Rohingya, how statelessness changes in different contexts, and how statelessness affects individuals, families, and groups; 2) Investigating the ways in which temporary forms of refugee protection create barriers to building a new life in accordance with a human-rights approach. Comparison is made between temporary and permanent settlement experiences; 3) Examining the intersection of statelessness and prolonged temporariness and analysing their impact on the Rohingya; 4) Exploring the ways in which notions of belonging and community are created within the context of prolonged temporariness and persistent statelessness.

Methodologies described in this thesis include phenomenology and anti-oppressive social work methodologies combined with participatory action research methods. Using this combined approach, members of the Rohingya community in Sydney engaged with this research in discussion through a collaborative partnership. Representatives from the Rohingya community were involved in developing the focus and design of the research project, as well as coordinating and co-facilitating of the fieldwork. A total of 63 participants from the Rohingya community shared aspects of their lived experiences through in-depth inter-

views and focus groups meetings between November 2020 and December 2021.

The key finding of this research is that statelessness dominates and dictates all aspects of life and inevitably permeates a person's sense of identity and self-worth, their choices, and perspectives. From a human-rights perspective, statelessness manifests as a form of internalised oppression, described by research participants as "Rohingya Life." This research also found that prolonged temporariness places people in a transitional or "liminal" state, which, combined with structural barriers, affects their interaction with time and mental health and challenges their sense of belonging. A key contribution of this research is the development of a new conceptual model that provides a structural analysis of statelessness and prolonged temporariness at the micro (personal), meso (community) and macro (structural) levels of society. The proposed model contributes to a better understanding of how statelessness intersects with Australia's temporary refugee protection system and enhances understanding of the lived experience of statelessness.

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Thesis abstract

Embodiment, affect, and relational practice in the emergence of leadership

Lindie Clark

Abstract of a thesis for a Doctor of Philosophy, submitted to Macquarie University

Adopting a feminist posthumanist practice perspective, this thesis explores how an affective form of leadership emerges from a situated practice, focusing on the everyday embodied knowledge work through which it is affected. It builds from two bodies of scholarship, the first frames leadership as an irreducibly processual and relational practice of producing direction for organising processes through collaborative agency, rather than the property of an individual “leader.” The second mobilises feminist Deleuzian readings of Spinozan embodied ethics to consider the power effects of its practice: what such emergent leadership does and how it feels to those affected by and affecting it. The research explores these concerns through an empirical case study of a situated practice anchored within a large work-integrated learning program at an Australian university from which, I argue, leadership emerges in a good and beautiful way. The leadership that emerges from this practice not only gets good work done but does so in ways that promote the mutually empowering flourishing-in-relation of all those entangled in its relational web. With the goal of contributing to the scholarship and more emancipatory practice of leadership in organisations, this thesis

explores the nitty-gritty details of the everyday intra-actions or embodied “habits of relating” through which this affective form of leadership is enacted, and the ethics and politics it affects. The three focus areas of the study are: the significance of embodiment and embodied knowledge in emergent leadership; the affective interplay between bodies and ideas entangled in this practice and the power relations, culture, and atmospheres they affect; and the embodied ethics or affective logic of this practice — the standards of excellence to which its practitioners hold themselves accountable, and the politics of relationality their practice affects. In concluding, the thesis reflects on the implications of the research for scholarship and practice, advancing collaborative reflective practice as a methodology of learning about leading.

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Thesis abstract

Substrate-induced activation of the rate-limiting cholesterol synthesis enzyme squalene monooxygenase

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (Biochemistry and Molecular Genetics), School of Biotechnology and Biomolecular Sciences Faculty of Science, UNSW Sydney, Australia

Cholesterol is vital for membrane function, yet toxic in excess and associated with cardiovascular disease and cancer. Squalene monooxygenase (SM, also known as squalene epoxidase or SQLE) catalyses the rate-limiting and first oxygen-dependent step of the committed cholesterol synthesis pathway, and past research has shown that cholesterol modulates its protein levels to ensure that pathway flux is coupled with supply and demand. This is mediated by the N-terminal regulatory domain of SM (SM-N100), which senses high cholesterol levels and accelerates entry into the endoplasmic reticulum-associated degradation (ERAD) pathway. A mechanistic understanding of how SM is regulated by such stimuli is critical, as aberrant SM activity is oncogenic in a broad range of cancers. Thus, this thesis sought to identify additional metabolic factors controlling SM degradation. Using a chemical genetics screen and SM-N100 reporter constructs, we found SM is protected from degradation by the accumulation of its substrate, squalene. This feedforward regulation involves allosteric binding of squalene to the SM-N100 domain, which prevents its recognition by ERAD effectors. We next studied a lower molecular-weight form of SM routinely detected by immu-

noblotting, and through SM mutagenesis and targeting of the ERAD pathway found it arises through the rare phenomenon of partial proteasomal degradation. This disrupts the cholesterol-sensing SM-N100 domain but not the catalytic domain, rendering truncated SM constitutively active. Truncated SM, but not full-length SM, is also capable of localising to lipid droplets. Finally, we identified hypoxia as a physiological trigger for truncation through a combination of accelerated entry into ERAD and the accumulation of squalene, which prevents complete degradation of SM by the proteasome. Analysis of endometrial cancer tissues revealed a marked upregulation of SM truncation that was well-correlated with a hypoxic marker protein, suggesting hypoxia-induced truncation occurs *in vivo* and contributes to the oncogenic properties of SM. In summary, this thesis identifies dual mechanisms of substrate-induced SM regulation that impair its proteasomal degradation and preserve catalytic capacity. Beyond these fundamental insights into the control of cholesterol synthesis, our data highlight the significance of SM feedforward regulation under both homeostatic and pathophysiological conditions.

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Thesis abstract

Regulatory responses to addressing and preventing sexual assault and harassment in Australian university settings

Allison Henry

A thesis in fulfilment of the requirements for the degree of Doctor of Philosophy, School of Global and Public Law, Faculty of Law & Justice, UNSW Sydney

Over the past decade, the Australian university sector and regulatory bodies have implemented a range of actions to improve the management and prevention of sexual assault and sexual harassment in Australian university settings. Despite these concerted efforts, little progress has been made in reducing campus sexual violence or in achieving institutional accountability.

To date, research on campus sexual violence in Australia has focused on the experiences of students and staff (such as prevalence surveys and the impact of sexual violence on educational outcomes) or institutional responses (such as policy frameworks, reporting mechanisms and support services). This dissertation offers a new perspective by taking a system-wide structural approach to consider the entire regulatory community. Through the lens of theories of responsive and smart regulation, this thesis critically examines the regulatory initiatives adopted by various actors during the period 2011–2021. Addressing a gap in the literature, I offer an analysis of how regulatory theory does not adequately explain the vital role of civil society activists in creating momentum and initiating reform in this area.

Drawing on legislative reviews, analysis of primary documents and 24 interviews with representatives drawn from across the regulatory community, the dissertation

reveals how a lack of political will and the absence of even a latent threat of genuine enforceable institutional accountability — a “benign big gun” in responsive regulatory theory — has undermined regulatory efforts across the whole sector. This dissertation also identifies the role that regulatory ritualism has played in stymying systemic change to respond to and prevent sexual violence in the Australian university sector, extending the existing literature by proposing two new applications of regulatory ritualism, language ritualism and announcement ritualism, and providing examples of where this has occurred.

This dissertation argues that substantive progress in tackling sexual assault and sexual harassment in Australian university settings has stalled due to an over-reliance on the self-regulating university sector to lead the reform effort, the failure of enforced self-regulation models led by regulatory agencies, the indifference of governments and sector-wide regulatory ritualism which has seen institutions adopt tokenistic rather than substantive responses. To address these factors and improve institutional accountability, I argue that genuine systemic reform will require political leadership, more robust application of existing legislative and regulatory tools towards effective enforcement,

JOURNAL & PROCEEDINGS OF THE ROYAL SOCIETY OF NEW SOUTH WALES
Henry — PhD thesis abstract

and innovative exploration of other legal
and regulatory approaches.

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Thesis abstract

Advanced trapping of light in resonant dielectric metastructures for nonlinear optics

Kirill Koshelev

Abstract of a thesis for a Doctor of Philosophy, submitted to the Australian National University

In the past two decades new frontiers emerged in the rapidly expanding field of nanophotonics that have revolutionised the conventional approaches to the manipulation of electromagnetic radiation at the nanoscale. The remarkable progress in the engineering of efficient nanostructured devices for functional flat optics and nonlinear photonics was achieved by using resonant dielectric metastructures operating through the excitation of Mie resonances and their collective configurations. Further progress in the subwavelength localisation of light in Mie-resonant nanostructures and enhancement of their optical nonlinearities remained hampered by the leaky nature of optical modes. The last decade marked the series of intense studies of optical resonances with a giant quality factor, bound states in the continuum (BICs), aimed to resolve this issue. The unique electromagnetic properties of BICs were examined as a versatile tool to tailor the optical response of photonic nanostructures, yet their physical nature and the feasibility of realisation in the form of high-quality quasi-BIC resonances in planar and compact metadevices remain largely unexplored. Moreover, it remains unknown in many aspects how BICs can be utilised for the engineering of resonant nonlinear metasurfaces and nanoantennas for efficient frequency conversion and the observation of strong nonlinearities.

In this thesis, we are focused on the comprehensive analysis of fundamental physical properties of optical quasi-BICs in resonant dielectric metastructures and exploration of their practical feasibility for strong light confinement and nonlinear applications. We outline the general framework for design and optimisation of nanostructured devices supporting quasi-BICs in the visible and infrared range for the maximisation of the local fields and associated enhancement of optical nonlinearities. More specifically, we focus on planar metasurfaces with broken-symmetry meta-atoms, and individual subwavelength resonators with a compact footprint, for which we test the utility of the developed concepts. Ultimately, we target the challenge of engineering of nonlinear dielectric metastructures with outstanding nonlinear performances, which may lead to new breakthroughs in the realisation of efficient nonlinear frequency converters, low-threshold nanolasers, and compact quantum sources.

In Chapter 1, we overview the recent developments in the fields of nanophotonics, dielectric meta-optics, and optical BICs. We outline the motivation and structure of the thesis.

In Chapter 2, we propose the concept of light localisation in dielectric metasurfaces composed of meta-atoms with a broken in-plane inversion symmetry by using quasi-

BIC resonances. We show that the optical response of broken-symmetry metasurfaces can be tailored precisely by changing the asymmetry of the unit cell that induces the controllable change of the quasi-BIC quality factor. With this unified concept we explain the results of numerous earlier studies reporting on sharp Fano resonances, dark modes, metamaterial-induced electromagnetic transparency, trapped resonances in asymmetric plasmonic and dielectric metasurfaces observed in various spectral ranges, from the visible to radio frequencies. We further explore the importance of parasitic losses originating due to fabrication imperfections in metasurfaces on the value of the field enhancement. We outline the criteria for the maximisation of the local fields in realistic metasurfaces with imperfections by adjusting the structure geometry to satisfy the optimal coupling regime. Using these findings, we propose a universal framework for designing dielectric metasurfaces supporting sharp resonances with a specific operating wavelength and linewidth on demand.

Chapter 3 is focused on the analysis and experimental demonstration of nonlinear optical effects in broken-symmetry dielectric metasurfaces supporting quasi-BICs in the near-IR and mid-IR wavelength range. We generalise the optimal coupling criteria for the nonlinear regime for maximisation of harmonic generation efficiency for low pump intensities. We design Si metasurfaces for third- and high-harmonic generation and prove experimentally that in the optimal coupling regime the conversion efficiency is maximised. Using the developed optimal coupling model, we demonstrate the enhancement of optical nonlinearities of two-dimensional Van der Waals materials

integrated with Si metasurfaces supporting quasi-BICs. For strong field excitation, we demonstrate that Si metasurfaces tuned to the quasi-BIC resonance generate high-harmonic signal with the harmonic order up to the eleventh. We demonstrate pronounced self-action effects for ultrashort sub-picosecond pulse excitation of quasi-BICs in the near- and mid-IR and explain them in the model of resonantly enhanced photoionisation of Si.

In Chapter 4, we propose the new mechanism of light trapping in isolated subwavelength dielectric resonators by the formation of quasi-BICs due to the destructive interference of several Mie modes in the far field. For a dielectric disk with a variable aspect ratio, we demonstrate that quasi-BICs are manifested as high-Q resonances formed at an avoided resonance crossing of Mie mode dispersion branches. We study the near- and far-field properties of quasi-BICs and show that the cancellation of radiative losses is related to the suppression of the dominant multipolar component of the field. We explore the manifestation of quasi-BICs in the scattering spectra and outline the connection between the maximisation of the mode Q factor and the peculiarities of the scattering features. We show that the quasi-BICs can be realised in subwavelength dielectric resonators with refractive index more than 2 in various spectral ranges from the visible to microwaves. The findings are verified in proof-of-principle experiments in the near-IR and radiofrequency range.

In Chapter 5, we examine the efficiency of harmonic generation from individual dielectric nanoresonators supporting quasi-BICs and outline the criteria for the maximisation of conversion efficiency by optimising the mode structure, pump spatial

and temporal profile, and the environment design. We propose the theoretical model of second-harmonic generation for nanostructures resonant at the pump and harmonic frequency beyond the phase matching and derive an analytical closed-form expression for the emitted harmonic power. We verify the developed model experimentally and show a record-high measured conversion efficiency of the optimized nonlinear nano-antenna. Chapter 6 summarises the results and concludes the thesis.

This thesis was awarded the JG Crawford Prize for STEM.

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Thesis abstract

Introgression, sperm and mitonuclear interactions in the long-tailed finch (*Poephila acuticauda*)

Callum Scott McDiarmid

Abstract for a thesis submitted to Macquarie University

Modern genomic sequencing has revealed that hybridisation and the resulting gene flow between biological lineages is widespread across taxonomic groups. This gene flow, known as introgression, varies across the genome, with some genomic regions introgressing readily between lineages and others not. Naturally hybridising organisms offer an opportunity to observe introgression, but to test the mechanisms underpinning the observed heterogeneity ultimately requires experimental approaches, which has rarely been possible with naturally hybridising organisms. In this thesis I investigate the processes underpinning introgression and reproductive isolation by exploiting the well-established and tractable system of the naturally hybridising long-tailed finch subspecies, *Poephila acuticauda acuticauda* and *P. a. hecki*. This system exhibits various degrees of introgression: bill colour has introgressed 350 km east of the genomic hybrid zone; the mitochondrial DNA hybrid cline centre has introgressed 55 km west across the nuclear hybrid cline centre; and an inversion on the Z-chromosome appears resistant to introgression between the subspecies. In this thesis I use behaviour trials to reveal that the bill colour introgression is not driven by a universal female preference for yellow bills; instead, females display an assortative mating prefer-

ence that, combined with dominance patterns in the genes underlying bill colour, may be driving this bill colour introgression. I reveal that, when the mitochondrial and nuclear genomes of the two subspecies are mixed in hybrids, they interact and compromise cellular aerobic respiration. This is the first evidence of a mitonuclear interaction in a bird and it may be driving the westward introgression of mitochondrial genome across the nuclear hybrid zone. Next, I confirm that sperm morphology is divergent between the long-tailed finch subspecies, but find no evidence that the sperm of admixed individuals, or those with mitonuclear mismatch, is different from that of the parental subspecies, and so find no new evidence that sperm morphology is contributing to reproductive isolation in this system. Finally, I opportunistically investigate the genetic basis of sperm morphology in the long-tailed finch, and identify a rare sex-linked inversion that acts as an allele of large effect on sperm morphology, where carrier males have significantly shorter sperm midpiece, flagellum and total sperm lengths. Together, this research provides new insights into the mechanisms underlying introgression and reproductive isolation in a recently diverged, naturally hybridising avian system.

JOURNAL & PROCEEDINGS OF THE ROYAL SOCIETY OF NEW SOUTH WALES
McDiarmid — PhD thesis abstract

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Thesis abstract

Prioritising Blak voices: representing Indigenous perspectives in NSW English classrooms

Tamika Worrell

Abstract for a thesis submitted to Macquarie University

This thesis explores how English teachers in New South Wales represent Aboriginal and Torres Strait Islander peoples to their students through the texts they select in Year 7–10 classrooms, and how they approach the teaching of these texts. This investigation is urgent due to the ways in which both the Australian Curriculum and New South Wales Syllabus documents attempt to promote Indigenous perspectives, histories, and cultures across all key learning areas. It is important that all students learn about Indigenous peoples, histories, and cultures through the prioritisation of Indigenous voices. Furthermore, it is a necessity that Indigenous students can see themselves mirrored in the texts they are taught in the English classroom. Non-Indigenous students must also experience texts that enable them to “see” into Indigenous worlds and develop an understanding of Indigenous worlds.

The study utilises a foundational conceptualisation of Sims-Bishop’s “Mirrors and Windows” to build a new conceptual framework to understand Indigenous representation through texts. Through the consideration of texts as mirrors and windows, Indigenous-authored texts have the power to mirror identities for Indigenous students and provide a window for non-Indigenous students to see into a world different from their own. It is also crucial to understand

the ways texts are utilised in the classroom to represent Indigenous peoples to all students. This two-part research methodology prioritises Indigenous research paradigms, including Indigenous Standpoint and the Cultural Interface. This methodology includes a mixed-method questionnaire (Phase 1) and two-part conversations with a range of English teachers (Phase 2). These yarning conversations are crafted into individual Profiles of Practice as a way to reframe the understanding of participants as cases, thus humanising their role in the research process. It also prioritises the role of stories and storying as a relational and cultural practice that can be embedded within research contexts.

It is important to understand this educational landscape of representational practice as it is non-Indigenous teachers who are largely responsible for representing Indigenous voices to their students. This thesis addresses the professional concerns of authenticity, positionality, and fear that educators experience when embedding Indigenous perspectives. This ultimately leaves us with the theoretical challenge of speaking on behalf of others, and therefore, we are able to interrogate the pervasiveness of the settler colonial project that permeates education. Through this, educational stakeholders can be supported to influence and develop their practice by prioritising

Blak voices. Ultimately, this research investigation offers a set of recommendations and a framework to guide teachers and educational stakeholders to understand the act of representation for their educational practice.

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Thesis abstract

The application of photomediated RAFT polymerisation in 3D printing

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy,
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Vat photopolymerisation (VP) is a promising additive manufacturing technology which enables the construction of complex 3D objects via versatile photochemistries. VP techniques have demonstrated superior advantages in imparting spatiotemporal control and providing high build rates and high printing resolution. However, current photocuring methods are based on non-living free radical or cationic polymerisation which offer limited control over chain growth, network formation, and thus the final properties of 3D printed materials. Moreover, inert polymer chains produced during the polymerisation are incapable of being reactivated for post-functionalisation of pre-formed polymers. To fabricate materials with controlled properties and post-modifiable networks, photomediated Reversible Addition-Fragmentation chain Transfer (RAFT) polymerisation techniques were employed in VP. The addition of RAFT agents in photoresins provided control over polymer chain growth and network formation. Also, the retention of thiocarbonylthio polymer chain-ends in the network imparted living characteristics to 3D printed materials, which were easily post-modified with diverse functions and properties.

This work firstly explored photoinduced electron/energy transfer-reversible addition-

fragmentation chain transfer (PET-RAFT) polymerisation in 3D printing under visible light irradiation in the open air. The use of an organic dye in conjunction with a tertiary amine as co-catalyst allowed fast printing speeds. The inclusion of RAFT agents in photoresins provided control over the mechanical properties of 3D printed materials. The presence of latent RAFT agents in the resin allowed post-functionalisation of these materials. Based on this study, photoresins containing RAFT agents with different activating Z groups and leaving R groups were investigated for their application in 3D printing. Also, the impact of the concentration of trithiocarbonates on mechanical properties of 3D printed materials was demonstrated. In addition, the 3D printed materials containing RAFT agents were easily post-modified via one-pot in situ aminolysis and thiol-Michael additions. Finally, the inclusion of RAFT agents in 3D printed thermoset materials conferred self-healing functionality. Materials containing trithiocarbonate units that were 3D printed under visible light can perform rapid self-repair via a secondary polymerisation mechanism under UV light irradiation under open-air conditions and at room temperature. This study promisingly paves the way for the fabrication of novel 3D printed thermosets with self-healing properties.

JOURNAL & PROCEEDINGS OF THE ROYAL SOCIETY OF NEW SOUTH WALES
Zhang — PhD thesis abstract

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Adrian Lee AC FRSN FASM (1941–2023)

Robert Marks, Editor¹



Adrian Lee AC FRSN BSc PhD FASM was an academic at the University of New South Wales for thirty-eight years, first as a lecturer teaching medical and science students, to Professor of Medical Microbiology and Head of the School of Microbiology and Immunology for nine years.

His progression through the academic ranks was a reflection not only of his outstanding commitment to learning and teaching, but also his stellar research in the field of gut microbiology. During his career, Adrian built a large research team working in different aspects of this broad field,

most notably the gut bacterium, *Helicobacter pylori*.²

Adrian started his research with René Dubos, the so-called father of the gut microbiome, at Rochester University in 1967. His early research was focussed on curved and spiral-shaped members of the “normal microflora,” now referred to as the “microbiota.” This was a poorly understood area of microbiology, but, forty years later, has become a particularly hot area of the discipline and importance in all aspects of physical and mental well-being. Adrian’s work on the largely uncharacterised gut bacteria drew the interest of future Nobel Laureate, Barry Marshall, who sought Adrian’s guidance regarding curved bacilli that he and Robin Warren had observed in gastric biopsies of patients with gastritis and peptic ulcers. Adrian’s contribution to the research was to culture and grow the *Helicobacter pylori* organisms for Marshall and Warren — this was no mean feat. Many years later, Barry Marshall invited Adrian to the Nobel award ceremony in Sweden in 2005 and included him as an author in his book, *Helicobacter Pioneers: First-hand Accounts from the Scientists who Discovered Helicobacters 1892–1982*. (Wiley-Blackwell).

Adrian’s persistence and success in the challenging area of gut microbiology was recognised by the awarding of nationally competitive research grants from the

¹ The Editor acknowledges the obituary of Mitchell et al. (2023) for its information about Adrian Lee’s career.

² See his paper: Adrian Lee. Adventures with spiral bugs and *Helicobacter*. *Journal & Proceedings of the Royal Society of New South Wales* 154: 34–43. <https://royalsoc.org.au/images/pdf/journal/154-1-Lee.pdf>

National Health and Medical Research Council for over 30 years (1972–2003) — a truly remarkable record. He published over 250 research articles and had a significant impact on the *H. pylori* field. His major contributions include an understanding of how gastric acid contributes to pathology, the development of small-animal models to study *H. pylori* disease, and pioneering preclinical studies proving the feasibility of *H. pylori* vaccines.

In addition to being an exceptional researcher, Adrian was also an outstanding educator, inspiring and teaching thousands of future doctors and microbiologists. This was recognised by numerous awards, including the Vice-Chancellor's Award for Teaching Excellence at the University of New South Wales and the inaugural Distinguished Teaching Award of the Australian Society for Microbiology. During this time, he acted as a consultant for the World Health Organization in Medical Education, running workshops around the world in learning and teaching for health professionals. He extended this passion for education to support his colleagues to develop their teaching practice in his role as Pro Vice-Chancellor (Education and Quality Improvement) at UNSW. In 2008, he was awarded a Career Achievement Award

by the Australian Learning and Teaching Council for outstanding contribution to learning and teaching recognised across the higher education sector.

In his retirement, as a Professor Emeritus, he was Chair of the Academic Board of the Think Education Group and Torrens University and undertook various consultancies in Higher Education, all related to strategies to improve the student learning experience. He was an active Fellow of the Royal Society of NSW, president of the Lane Cove community choir, La Voce, and active in the Botany Bay Bourbon & Beefsteak Club. Adrian was an inspirational and passionate leader in microbiology research and education who left an indelible influence on those who had the privilege to work with him. He is survived by his wife Nerissa, children Andrew and Amanda, and the wider family.

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Stephen Wallace Gaukroger FRSN FRHistS FRSA FAHA 9 July 1950–3 September 2023

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Stephen Gaukroger was born in Oldham, Lancashire, on 9th July 1950. He died in Sydney on 3rd of September 2023, having been diagnosed with a brain tumour while in London earlier in the year. He was educated at Cardinal Langley Grammar School, Manchester, before going up to London University (Birkbeck College), where he took a First in philosophy. He studied for his PhD at Cambridge (Darwin College), before being elected to a Junior Research Fellowship at Clare Hall, Cambridge. In 1978 he was awarded a research fellowship at Melbourne University and in 1981 came to Sydney University as a lecturer in philosophy. Despite a good deal of travelling, there he stayed, becoming a Professor of

Philosophy and finally Emeritus Professor of the History and Philosophy of Science.

He published extensively in the history of early modern science and philosophy, with books on explanation in physics (1978), Cartesian conceptions of inference (1989) and on the conceptions of truth advanced by the philosopher Antoine Arnauld (1612–94) (1990). These prepared the ground for his much-acclaimed intellectual biography of Descartes (1995). Together these works, plus several edited volumes and papers, gained him an exceptional international reputation. Much of his attention remained centred on Cartesian mathematics and physics — including, with John Sutton and John Schuster, the world’s largest collection of essays on Descartes’ *œuvre* (2000). Yet in the following year he also produced a short but seminal study, *Francis Bacon and the Transformation of Early-Modern Philosophy*. In this he explored Bacon’s distinctive understanding of what being a philosopher entailed, in order to cast fresh light on early modern philosophy as a whole. It is a book important to a wider shift of perspective in the study of the history of philosophy.

His last years were taken up with an ambitious exploration of this whole field, a multi-volume and magisterial account of early modern science and its centrality to what we recognise as modernity, published by Oxford University Press, (2006, 2010, 2016, 2020). His last sole-authored book was a more general essay reflecting on the

whole history of western philosophy by exploring the importance and sometimes beneficial consequences of philosophical failure (2020), but collaboration continued with a co-edited anthology of essays on the problem of knowledge in post-Renaissance philosophy, and a complete English translation, with full editorial apparatus (2022), of Charles Bonnet's curious psychological excursus *Essai Analytique Sur Les Facultés De L'âme* (1760).

He has been a book series editor, sat on the boards of *The Australasian Journal of Philosophy* and *The British Journal for the History of Philosophy*, was an editor of *Intellectual History Review* and President of the International Society for Intellectual History.

Stephen's work was not only marked by an extraordinary depth and range of knowledge of philosophy — especially epistemology, science and mathematics — but also by a capacity to see further implications from the linkages he established between them. His written style was pellucid and uncluttered, and his treatment of the materials and the views of other scholars was fastidiously balanced.

The honours he received give some idea of his achievements as an historian of science and philosophy from the post-Renaissance world, and the respect which his work deserved: Fellowship of the Academy of the Humanities (1992); of this Society (2016); recipient of the Australian Centenary Medal (2003). He was a corresponding member of the *Académie Internationale d'Histoire des Sciences* (2007). He was awarded The Royal Society of New South Wales Medal in the History and Philosophy of Science in 2022. His works have been translated into in Arabic, Chinese, French, German, Italian, Portuguese, and Russian.

But those who worked with him have a much fuller appreciation of his professional and personal qualities. Convivial, generous, efficient and kind, he was a man of much good humour who enjoyed company, fine food and who occasionally played the viola — not at the same time. Despite his intellectual energy, he wore his abilities lightly and turned fruitful collaboration into lasting friendship: working with him was a joy and an education. He will be sorely missed. He leaves his wife, Professor Helen Irving, also a Fellow of the Royal Society of New South Wales, a daughter, a son, and a truly remarkable legacy.

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- The Blackwell Guide to Descartes' Meditations*. Blackwell, 2006.
- The Collapse of Mechanism and the Rise of Sensibility: Science and the Shaping of Modernity, 1680–1760*. O.U.P., 2010.

Objectivity: A Very Short Introduction. O.U.P., 2012.

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Royal Society of New South Wales 2023

Awards Winners 2023

The Awards for 2023 were announced at the 1318th Ordinary General Meeting of the Society, held on Wednesday, 29 November 2023. There has been a revision of the Awards this year, as is described below.

Four Career Excellence Awards

James Cook Medal

Scientia Professor Helen Cristensen AO FASSA FAHMS

Edgeworth David Medal

Professor Qilin Wang FRSN

Aboriginal and/or Torres Strait Islander Scholars Medal

Aunty Francis Bodkin

Ida Browne Early Career Medal

Dr Brendon Neuen

Five Discipline Awards and Lectureships

Clarke Medal and Lecture in Earth Sciences

Professor Moninya Roughan FRSN

Walter Burfitt Award in Medical and Veterinary Sciences and Technology

Professor Maria Kavallaris AM FRSN FAHMS

Award in the Social and Behavioural Sciences

Scientia Professor Kaarin Anstey FRSN FASSA FAHMS

Award in the History and Philosophy of Science

Professor Hans Pols FRSN FAHA FASSA

Jak Kelly Award

Mr Jamie Andres Alvarado-Montes

Two Bicentennial Postgraduate Scholarships

Ms Sasha Bailey, Mr Jayden McKinnon

Three Bicentennial Early Research Career Scholarships

Dr Jacinta Martin, Dr Abhimanu Pandey, Dr Shoujin Wang

Two Royal Society Service Awards

Royal Society of NSW Medal

Judith Wheeldon AM FRSN

Royal Society of NSW Citation

Mr Jason Antony MRSN

The Awards

James Cook Medal

Scientia Professor Helen Cristensen AO FASSA FAHMS

The James Cook Medal is awarded for the most meritorious lifetime contributions to knowledge and society in Australia or its territories made by an individual and conducted mainly in New South Wales. The recipient may be resident in Australia or elsewhere. The James Cook Medal was established by the Council in 1943 following a donation made by Henry Ferdinand Halloran to celebrate his 50 years as a member of the Society and it has been awarded periodically since 1947. In 2023, the Council determined to award it annually.

Helen Christensen, from the Black Dog Institute, UNSW Sydney, is a highly innovative scientist who has achieved an unparalleled level of impact on internet-mediated mental health both in Australia and worldwide. She is internationally recognised as founding the use of digital and online technology to deliver evidence-based prevention and intervention therapy for common mental illnesses. Her ground-breaking contributions have spawned a vast international research effort that incorporates academia, business, clinics and community, not only leading the research field internationally but also greatly improving the lives of many, many Australians living with mental illness.

Seven Awards for Research Excellence

Edgeworth David Medal

Professor Qilin Wang FRSN

The Edgeworth David Medal is awarded for the most meritorious contributions to knowledge and society in Australia or its territories, conducted mainly in New South Wales by an individual who is from 5–15 years post-PhD or equivalent on 1 January of the year of the award. The recipient may be resident in Australia or elsewhere. The Edgeworth David Medal was established by Council in 1943 in honour of Sir T. W. Edgeworth David FRS, who compiled

the first comprehensive record of the geology of Australia, following a donation made by Henry Ferdinand Halloran to celebrate his 50 years as a member of the Society. It has been periodically awarded since 1948; in 2023, the Council determined to award it annually.

Qilin Wang, from the University of Technology Sydney, has achieved international recognition for his contributions to sustainable wastewater treatment and wastewater-based epidemiology. His patented technology can convert wastewater treatment plants into carbon-neutral energy generators by ingeniously harnessing a waste by-product on-site. In addition to this energy innovation, Professor Wang's technology significantly reduces the environmental impact of wastewater treatment by effectively preventing pollution — including antibiotic resistance genes, pathogens, nitrogen, microplastics, and “forever chemicals” — from entering the environment while minimising waste production and land usage.

Furthermore, Professor Wang has pioneered the development of an accurate prediction tool that can forecast hospital admissions due to COVID-19 up to four weeks in advance, relying on wastewater-based epidemiology. His outstanding contributions have been recognised through numerous research and industry awards, including Eureka Prize for Outstanding Early Career Researcher, Eureka Prize for Applied Environment Research, Australian Research Leader in Water Supply & Treatment, NSW Young Tall Poppy, Prime Minister's Prize Finalist, MIT *Technology Review* Innovator, and Australia's Most Innovative Engineer. He secured a tenured full professorship only seven years after PhD completion, a German Humboldt Fellowship for Experienced Researcher, an ARC DECRA Fellowship only six months after PhD completion, and an ARC Future Fellowship — Level 2, only five years after PhD completion.

Aboriginal and/or Torres Strait Islander Scholars Medal

Aunty Francis Bodkin

The Aboriginal and/or Torres Strait Islander Scholars Medal is awarded for the most meritorious contributions to knowledge and society made by scholars identifying as Australian Aboriginal or Torres Strait Islander and conducted mainly in New South Wales. Recipients may be resident in Australia or elsewhere. The Aboriginal and/or Torres Strait Islander Scholars Medal was established by the Council in 2023 to reflect the full scope of the Society's values.

Francis Bodkin, of Western Sydney University, has made significant contributions to Aboriginal knowledge across multiple disciplines, including Medicine, Linguistics, the Environment and Psychology. Since her first publication in 1986 on native and exotic plants in Australia, Aunty Fran has contributed to 36 different works spanning fields of knowledge such as native flora and fauna, environmental sustainability, Dreamtime and Ancestral knowledge, climate, D'harawal Language, medicine, and psychology. Her D'harawal Pharmacopeia consists of 1,885 pages of native plants prevalent to D'harawal Country (the Sydney region), their medical uses and associations with other native plants. Aunty Fran has dedicated herself to teaching others in higher education, schools, community organisations, and to documenting her knowledge in literature for future generations. Without the contributions of Aunty Fran, undoubtedly a significant amount of Indigenous cultural knowledge would have been lost.

Ida Browne Early Career Medal

Dr Brendon Neuen

The Ida Browne Early Career Award recognises the most meritorious contributions to knowledge and society in Australia or its territories by an individual from 0–5 years post-PhD or equivalent on 1 January of the year of the award and conducted mainly in New South Wales. The recipient may be resident in Australia or elsewhere. The Ida Browne Medal was established by the Council in 2023 in honour of Ida Browne DSc, a palaeontologist and the first woman President of the Royal Society of NSW, serving from 1953–1954.

Brendon Neuen is a Nephrologist and Director of the Kidney Trials Unit at Royal North Shore Hospital, and Senior Research Fellow at The George Institute for Global Health, UNSW Sydney. He is widely recognised for his expertise in cardio-renal-metabolic medicine. Dr Neuen established the SGLT2 Meta-Analysis Cardio-Renal Trialists' Consortium, bringing together data on more than 90,000 patients to better understand the effects of this class of medicines in different types of patients. His work has directly informed more than 25 major international and national guidelines, position papers and scientific statements which optimal care for people with type 2 diabetes and kidney disease.

Discipline Awards and Lectureships

Clarke Medal and Lecture in Earth Sciences

Professor Moninya Roughan FRSN

The Clarke Medal and Lecture is awarded for distinguished research in any area of the sciences affecting the planet, excluding Medicine and Veterinary Science, and Agricultural and Environmental Science, and conducted mainly in New South Wales. Recipients may be resident in Australia or elsewhere. The Medal honours the Rev. William Branwhite Clarke, a geologist, and a significant figure in the history of the Royal Society of NSW, who served for a decade as a highly influential Senior Vice-President of the Society (noting that in the early years, the Governor of NSW was the President of the Society).

Moninya Roughan, from UNSW Sydney, is an outstanding oceanographer and authority on the dynamics of the East Australian Current (EAC), ocean observing and prediction systems and their application to understanding western boundary currents and continental shelf processes. She currently leads the Coastal and Regional Oceanography Lab at UNSW, where she has made important, far-reaching contributions to our understanding of continental-shelf processes and western boundary current warming through the use of new technologies. An internationally acknowledged leader in her field, she is also dedicated to the training of the next generation of scientific leaders.

Walter Burfitt Award in Medical and Veterinary Sciences and Technology

Professor Maria Kavallaris AM FRSN FAHMS

The Walter Burfitt Award recognises distinguished research in any area of the Medical and Veterinary Sciences and Technologies, conducted mainly in New South Wales. Recipients may be resident in Australia or elsewhere. The Walter Burfitt Award honours the life and

work of Walter F. Burfitt BA MB ChM BSc, an eminent Sydney surgeon in the 1950s. It was established as a prize with generous support from Dr Burfitt and his wife, and was first awarded in 1929.

Maria Kavallaris, from the Children’s Cancer Institute, UNSW Sydney, is an exceptional cancer research leader, innovator, mentor and role model who has made seminal discoveries on mechanisms of clinical drug resistance and tumour aggressiveness in childhood and adult cancers. Recognised as a world leader in cancer and microtubules, her discoveries have led to both patents and industry partnerships for the development of cancer therapeutics. Crucially, in complement to her exceptional research record, Professor Kavallaris has made outstanding contributions to NSW and Australia via highly influential medical research advocacy and mentoring the next generation of Australian cancer research leaders.

Award in the Social and Behavioural Sciences

Scientia Professor Kaarin Anstey FRSN FASSA FAHMS

This award recognises distinguished research in any area of the Social and Behavioural Sciences, including Psychology, Economics, Management, and related disciplines, conducted mainly in New South Wales. Recipients may be resident in Australia or elsewhere. This Award was established by the RSNWS Council in 2023 to reflect the full scope of the Society’s founding values.

Kaarin Anstey, from Neuroscience Research Australia, UNSW Sydney, is a world leader in cognitive ageing and dementia risk reduction. Her program of research has contributed greatly to the evidence base on dementia prevention through the identification and quantification of risk factors for dementia, the development of risk assessment tools and the implementation of interventions. Moreover, her work has directly informed public policy and guidelines, both within Australia and globally, particularly in her collaboration with the World Health Organization. As a consequence, she has made an important, sustained, positive impact on the lives of tens of thousands of people in Australia and around the world.

Award in the History and Philosophy of Science

Professor Hans Pols FRSN FAHA FASSA

This Award recognises distinguished research in the History and Philosophy of Science conducted mainly in New South Wales. Recipients may be resident in Australia or elsewhere. The Royal Society of NSW History and Philosophy of Science Award was established by the Council in 2013 to reflect the founding values of the Society and was first awarded in 2014.

Hans Pols, from the University of Sydney, is the preeminent historian of science and medicine in Indonesia and Southeast Asia and a leading international scholar of the development of the global neurosciences. His principal work, *Nurturing Indonesia: Medicine and Decolonisation in the Dutch East Indies*, transforms our understanding of the connections of scientific research with nationalism and decolonization, at the same time as it makes key contributions to the global history of science. His ground-breaking studies in the history of twentieth-century psychiatry are exemplars of science historiography, illuminating contemporary predicaments and showing how scientific insight is shaped by and shapes national projects and global concerns.

Jak Kelly Award

Mr Jamie Andres Alvarado-Montes

The RSNSW Jak Kelly Award recognises excellence in postgraduate research in physics annually. The winner is selected from presenters at each year's Australian Institute of Physics NSW Branch Postgraduate Awards, as advised to the Awards Committee of the Royal Society of NSW. This Award honours the life of Jak Kelly (1928–2012), Professor and Head of Physics at the University of NSW (1985–1989), Honorary Professor at the University of Sydney (2004), and President of the Royal Society of NSW (2005–2006). It was first awarded in 2010.

Jamie Andres Alvarado-Montes, originally from Colombia, is a PhD candidate in the School of Mathematical and Physical Sciences at Macquarie University. His research focusses on the planetary sciences, with an emphasis on extrasolar planets, moons, rings, asteroids, and comets. His award-winning presentation at the 2023 Australian Institute of Physics NSW Postgraduate Awards was titled “Tidal Evolution and Detectability of Close-in Extrasolar Systems.” In this talk, he discussed how close-in planetary systems, composed of giant bodies, can help us test tidal models and work as a probe to constrain the interior structure of stars and planets and showed how tidal interactions affect the evolution of planetary systems. He concluded by noting that despite the plethora of exoplanets discovered to date, none of them have the same characteristics as those of our unique solar system and that research, such as his, can provide a better understanding of how features of our solar system, yet to be discovered around other stars, may eventually be detected through improved models of planetary tidal evolution.

Bicentennial Postgraduate Scholarships

The RSNSW Bicentennial Postgraduate Scholarships are awarded each year to recognise outstanding achievements by young researchers in any academic field. Applicants must have completed an undergraduate degree within NSW or the ACT and must on 1 January of the year of nomination be enrolled as research students in the first or second year of their first higher degree at a university or other research institution in NSW or the ACT.

For 2023, two RSNSW Scholarships have been awarded:

- Ms **Sasha Bailey** — PhD Candidate, University of Sydney
- Mr **Jayden McKinnon** — PhD Candidate, University of Wollongong

Sasha Bailey is a second-year PhD and research assistant in the Matilda Centre for Research in Mental Health and Substance Use at the University of Sydney, having previously completed a BA in Philosophy and a Master of Public Health, also at the University of Sydney. Since commencing her PhD in March 2022, she has received 19 awards/prizes and has published two journal articles as a first author with a further 12 first-author publications under review. In addition to her research program, Sasha holds a number of leadership and governance roles in the Matilda Centre and the wider LGBTQA+ community.

The focus of Sasha's research is on improving the understanding and prevention of mental ill-health and substance use among gender- and sexuality-diverse (LGBTQA+) young people in Australia and internationally. Using data from the Longitudinal Study of Australian

Children, she has produced Australia's first-ever population-level, nationally representative estimates of the number of LGBTQA+ young people affected by mental ill-health, substance use, victimisation, and discrimination, within Australia, identifying just how much an LGBTQA+ affirming school climate can protect and buffer against the mental ill-health effects of victimisation and discrimination. Her research is complemented by her active advocacy for improved LGBTQA+ public health action, with her nominators noting that she is called upon routinely by senior executives at the University to deliver speeches about LGBTQA+ visibility at the University.

Jayden McKinnon is a PhD student in the Molecular Horizons Research Institute and the School of Chemistry and Molecular Biosciences at the University of Wollongong, following his BMedSc (Hons) degree studies at UoW. His PhD studies are in the field of mass spectroscopy imaging, the aim of which is the development of innovative methods for the detection of metabolites in tissues.

Now in his second year of his PhD, he has achieved a first-author paper in the journal, *Analytical Methods*. In addition, he has been recognised through two significant awards at the University of Wollongong Higher Degree Research Symposium — the Student Choice Award for Best Oral Presentation and the Best Oral Presentation Award. In addition to his research studies, Jayden has also taken on academic and scientific leadership positions, notably as the Vice President of the Medical and Health Sciences Association at the University of Wollongong from 2018–2020, and currently as a student representative on the board of the Australian and New Zealand Society for Mass Spectrometry.

Bicentennial Early Research Career Scholarships

The RSNSW Bicentennial Early Career Research and Service Citations are awarded each year to recognise outstanding contributions to research and service to the academic and wider community. Applicants must on 1 January of the year of nomination be no more than 5 years after the award of their PhD or equivalent by a university or other research institution in NSW or the ACT.

For 2023, three RSNSW Early Career Citations have been awarded:

- Dr **Jacinta Martin** — University of Newcastle
- Dr **Abhimanu Pandey** — Australian National University
- Dr **Shoujin Wang** — University of Technology Sydney

Since 2021, **Dr Jacinta Martin** has been a Lecturer and postdoctoral researcher in the University of Newcastle (UoN) College of Engineering, Science and Environment and the Hunter Medical Research Institute (HMRI) Infertility and Reproduction Research Program. She works with a multidisciplinary group of researchers using human and animal models to characterise the processes of gamete maturation — the process by which oocytes and spermatozoa are formed. The goal of her research is to improve the understanding of factors that lead to infertility and pregnancy loss in women.

After graduating from UoN with a PhD in 2019, Jacinta has established a strong academic record that includes 24 research articles and nearly \$1 million in research funding. During her PhD, Jacinta received the Best HDR Publication Award in 2016 and 2018 and received a

number of travel grants that allowed to to present her work at major international meetings. Following her PhD, she undertook post-doctoral research at the McGill University Health Centre in Montreal, Canada, from 2019–2021. Dr Martin’s academic career extends beyond her personal research performance into the development of her discipline. She has served the Society for the Study of Reproduction (USA) on the Board of Directors as their trainee representative and has had significant professional roles at McGill University, HMRI, and the University of Newcastle as a facilitator, chair, adjudicator, and committee member.

Dr Abhimanu Pandey is a postdoctoral researcher at the John Curtin School of Medical Research (JCSMR) at the Australian National University, following the completion of his PhD at JCSMR in 2022 and undergraduate studies in India prior to that. He works in the research group of Professor Si Ming Man FRSN which studies innate immunity and inflammasomes. At the time of the application for this award, he has 15 peer-reviewed publications, nine of which were generated during his PhD, and has been awarded three early career research grants. In his research, he has identified a novel biomarker for bowel cancer that can sense DNA and inhibit the development and progression of bowel inflammation and cancer. The identification of precise structural locations within the immune protein that are druggable, using small molecule drugs, is expected to be transformational in the improvement of treatment outcomes in patients with inflammation and cancer.

In addition to his research profile, Dr Pandey has demonstrated leadership within his profession. Within JCSMR, he organised the first School HDR Student Conference in 2022, while within the wider University, he volunteers and raises funds for the Multiple Sclerosis Mega Swim event, and serves as a mentor for undergraduate science students. Externally, he is a reviewer for five international research journals.

Dr Shoujin Wang is a Lecturer in Data Science at the University of Technology Sydney, following the completion of his PhD at UTS in 2019. His research interests are in data mining, machine learning, recommender systems, and fake news mitigation, and in the past five years he has authored 60 publications that have received 2,400 citations. His research record includes a number of IEEE awards and a growing research grant profile.

His research activities have a range of real-world applications and impacts, notably his pioneering work on fake news mitigation via recommendation that is helping to mitigate disinformation on the web. His work addresses challenges faced across a range of sectors, including infrastructure, banking, accounting, and agriculture, and involves collaborators that include EY, Sydney Water, Suncorp, and Agriweb. His work with Sydney Water has led to a novel prediction model that automatically and effectively provides early detection of water-quality issues in reservoir catchments.

Royal Society Service Awards

2023 Royal Society of NSW Medal

Judith Wheeldon AM FRSN

The Royal Society of New South Wales Medal recognises an individual who has made meritorious contributions to the advancement of knowledge in any field, and also to the Society’s

administration, organisation, and endeavours. The RSNSW Medal was first awarded in 1884, revived in 1943, and has been awarded periodically thereafter.

Judith Wheeldon is first mentioned in the annual report of the RSNSW in 2013, being one of four panellists in the Society’s third Forum at the Powerhouse Museum. Elected as a Fellow of the Society and Councillor in 2014, there began a continuous and meritorious involvement with the Society for the next decade. Her Fellowship citation reads “Judith Wheeldon is recognised for eminent and long-standing service to Australian secondary education at senior levels and for service to professional organisations.”

Judith was elected to the RSNSW Council as a member in 2014 and as Vice-President in 2015, a position she held until her retirement in 2023. In addition, she served as a member of the Fellows, Nominations, Membership, Events, Voice and Outreach, Community Engagement, and Fundraising Committees. Her contributions to the Society are typified by her work to establish strong relationships with other organisations including the State Library of NSW, the Sydney Mechanics School of Arts, and Government House in Sydney where she established the series “Ideas@theHouse.”

Judith’s impact in the wider community is as a leader in education and the arts. She is a recognised innovator in the education of girls through her roles as principal or headmistress of four schools, including Abbotsleigh and Queenwood. As a director on the Australian Learning and Teaching Council, Judith contributed to the management and planning of teaching across Australia and was a Trustee of the Museum of Applied Arts and Science (Powerhouse Museum). She was honoured as a Member of the Order of Australia in 2006 in “Recognition of contribution to Australian public life, specifically in education leadership and pro bono work in the community.”

2023 Royal Society of NSW Citation

Mr Jason Antony MRSN

The Royal Society of New South Wales Citations recognise individuals who have made significant contributions to the Society, but who have not been recognised in any other way. The RSNSW Citation was first awarded in 2019.

Jason Antony has been indispensable in the production of fifteen issues of the *Journal & Proceedings of the Royal Society* since 2016, and as editor (and producer) of 28 issues of the *Bulletin* from 2020 to 2023. To appear, publications — both on-line and printed — require knowledge, skills, and effort. Providing all of these, Jason has contributed hugely to the improved presentation and appeal of both publications, which are very important for the Society’s outreach, heritage, and communications. This Citation is a measure of his value and continuing importance to the Society.



Events in 2023

Meetings held by the Society in four places: Sydney; Newcastle by the Hunter Branch; Mittagong by the Southern Highlands Branch; and western NSW by the Western NSW Branch.

1310th OGM and Open Lecture

“Drones, Smart Munitions, and Cyberspace: the 21st Century Defence of Ukraine and its implications for Australia,” Major General (Retd) Fergus (Gus) McLachlan AO & Colonel (Retd) Andrew Condon CSC; 1 February, Venue: Gallery Room, State Library of NSW, Shakespeare Place, Sydney

Southern Highlands Branch Meeting 2023-1

“A comprehensive review of the safety and efficacy of COVID-19 vaccines,” Dr Phillip Altman; February 16, Venue: RSL Moss Vale

Ideas@theHouse: March 2023

Ideas@theHouse presented by Her Excellency the Honourable Margaret Beazley AC KC, Governor of NSW. “Aristotle on life and thought in the sub-lunary sphere,” Dr John Vallance FRSN FAHA State Librarian of NSW; March 2, Venue: Live streamed from Government House Sydney

RSNSW 2023 Annual Dinner and Presentation of Awards

March 10, Venue: Sydney Modern, Art Gallery of NSW

1311th OGM and 2022 Student Award Presentations

Royal Society of NSW 2022 Student Award Presentations: Shankar Dutt, ANU, Clara Liu Chung Ming, UTS, Thomas Mesaglio, UNSW Sydney, Anyang Zhao, ANU. March 15, Video presentation: YouTube video

Hunter Branch Annual General Meeting 2023 and Branch Meeting 2023-1

“From floods to drought? What might this year bring and what is causing these extremes,” Dr Danielle Verdon-Kidd, Associate Professor, Environmental and Life Sciences, University of Newcastle; March 16, Venue: 40 Newcomen Street, Newcastle

Southern Highlands Branch Meeting 2023-2

“The Kindness Revolution,” Hugh Mackay AO FRSN; March 16, Venue: RSL Mittagong

Annual Meeting of the Four Societies 2023

“Energy in Germany and Europe — 2022 and beyond,” Franziska Teichmann, Head, German Secretariat for Energy Cooperation with Australia and New Zealand. A joint meeting of the Australian Institute of Energy, the Australian Nuclear Association, the Sydney Division of Engineers Australia, and the Royal Society of NSW; March 21, Venue: Engineers Australia Sydney Auditorium, 44 Market Street, Sydney

Frontiers of Science Forum 2023

“Exploring major discoveries and theories in physics, mathematics, biology, and chemistry,” Hon Prof Robert Booy, University of Sydney; Dr Anna Romanov, UNSW Sydney; Assoc Prof David Bishop, UTS; Assoc Prof Susanna Guatelli, University of Wollongong. A joint meeting of the Australian Institute of Physics (AIP), the Teachers’ Guild of NSW (TGNSW), the Royal Australian Chemical Institute (RACI), and the Royal Society of NSW. March 24, Venue: Concord Golf Club, 190 Majors Bay Road, Concord

1312th OGM and 2019 Clarke Memorial Lecture; 156th Annual General Meeting

“Reconstructing ancient oceans, sea-level fluctuations, the deep carbon cycle and biodiversity,” Professor Dietmar Müller FAA FAGU, Professor of Geophysics School of Geosciences, University of Sydney; April 5, Venue: Gallery Room, State Library of NSW, Shakespeare Place, Sydney, video

Western NSW Branch Meeting 2023-1

“Children should be seen AND heard: the importance of communication so children can thrive,” Professor Sharynne McLeod FRSN FASSA, Professor of Speech and Language Acquisition, School of Education, Charles Sturt University; April 20, Venue: Engineering Building, Building 1305, Charles Sturt University, Bathurst, video

Southern Highlands Branch Meeting 2023-3

“Most of our universe is missing — Adventures in the dark side of the cosmos,” Professor Geraint Lewis FRSN FLSW, Professor of Astrophysics, Sydney Institute of Astronomy, University of Sydney; April 20, Venue: RSL Mittagong, Alexandra Room

RSNSW Online Lecture 2023-1

“Artificial Intelligence myths debunked — how AI is transforming humanity for the global good,” Professor Michael Blumenstein FACS, Professor and Acting Dean, Faculty of Engineering & IT, University of Technology Sydney; May 3, Venue: Zoom webinar

Hunter Branch Meeting 2023-2

“Invention, Innovation, Impact — the I’s have it!,” Kevin Galvin FAA FTSE FIEAust CPEng, Laureate Professor and Director, ARC Centre of Excellence for Enabling Eco-efficient Beneficiation of Minerals, Newcastle Institute for Energy and Resources, University of Newcastle; May 11, Venue: Hunter Room, Newcastle City Hall, 290 King St, Newcastle

Southern Highlands Branch Meeting 2023-4

“Brief Encounters: Literary Travellers in Australia,” Susannah Fullerton OAM FRSN, Author, Literary Lecturer, and Tour Leader; May 18, Venue: Chevalier College, Performing Arts Centre

1313th OGM and Open Lecture

“Making rights a reality — the need for a Human Rights Act for Australia,” Emeritus Professor Rosalind Croucher AM FAAL, President, Australian Human Rights Commission; June 7, Venue: Gallery Room, State Library of NSW, Shakespeare Place, Sydney, video

Ideas@theHouse: June 2023

Ideas@theHouse presented by Her Excellency the Honourable Margaret Beazley AC KC, Governor of NSW. “Importance of scientific ideas and discovery to Australia’s future,” Dr Cathy Foley AO PSM DistFRSN FAA FTSE, Australia’s Chief Scientist; June 14, Venue: Live streamed from Government House Sydney

Southern Highlands Branch Meeting 2023-5

“Machines behaving badly: the morality of AI,” Professor Toby Walsh FAA FACM FAAAS, Scientia Professor of Artificial Intelligence, UNSW Sydney; June 15, Venue: RSL Mittagong, Carrington Room

Western NSW Branch Meeting 2023-2

“A new history of Australian political thought,” Professor Wayne Hudson FAHA, Adjunct Research Professor, Australian Centre for Christianity and Culture, Charles Sturt University, Canberra; June 15, Venue: Charles Stuart University, 15 Blackall Street, Barton, ACT, video

Joint AIP, RACI, RSNSW, and ANSTO Presentation

“The Invisible Revealed,” Dr Joseph Bevitt, Senior Instrument Scientist, ANSTO, June 20, Venue: Hybrid — ANSTO Discovery Centre, New Illawarra Road, Lucas Heights NSW, video

RSNSW Online Presentation 2023-2

“What we need to know about the Voice — before we vote,” Panel comprising: Peter Baume AC DistFRSN, Megan Davis FRSN FASSA, Christopher Puplick AM, and Dean Ashenden, July 5, Venue: Zoom webinar, video

Hunter Branch Meeting 2023-3

“Groundwater: When will we learn we can’t drink money?” Professor Craig T. Simmons FAA FTSE FAGU, Pro Vice-Chancellor, College of Engineering, Science, and Environment, University of Newcastle; July 20, Venue: Hunter Room, Newcastle City Hall, 290 King St, Newcastle

Southern Highlands Branch Meeting 2023-6

“A recent study of nuclear energy usage in Canada and the USA,” Robert Parker, Founder, Nuclear for Climate Australia; July 20, Venue: RSL Mittagong, Carrington Room

1314th OGM and Open Lecture

“Convergence: the hybridisation of the future,” In conversation: Associate Professor Catherine Ball Futurist, Author, Researcher, Rebel and Maria MacNamara Director, Government Affairs and Innovation Strategy, Kyndryl; August 2, Venue: Gallery Room, State Library of NSW, video

Charles Perkins Centre Annual Lecture 2023

“Public health sovereignty and public reason: a comparative perspective,” Professor Sheila Jasanoff, Pforzheimer Professor of Science and Technology Studies, Harvard Kennedy School; August 2, Venue: University of Sydney, Camperdown Campus

Ideas@theHouse: August 2023

Ideas@theHouse presented by Her Excellency the Honourable Margaret Beazley AC KC, Governor of NSW. “Ideas for marine stewardship and sustainability in a time of acceleration,” Professor Emma Johnston AO FRSN FAA FTSE, Deputy Vice-Chancellor (Research), University of Sydney; August 10, Venue: Live streamed from Government House Sydney

Western NSW Branch Meeting 2023-3

“Behavioural data science as a game changer for understanding the interface between human and digital systems in the new digital economy,” Professor Ganna Pogrebna, Executive Director, Artificial Intelligence and Cyber Futures Institute, Charles Sturt University; August 16, Venue: Engineering Building, video

Southern Highlands Branch Meeting 2023-7

“Can plant breeding help us manage the challenges of climate change and food insecurity?” Professor Richard Trethowan, Director, Plant Breeding Institute, Sydney Institute of Agriculture, University of Sydney; August 17, Venue: RSL Mittagong, Carrington

1315th OGM and Open Lecture

“Challenges for Open Enquiry and Scholarship in a Divided Age,” Professor Alan Davison, Professor and Dean, Faculty of Arts and Social Sciences, University of Technology Sydney; September 6, video

Southern Highlands Branch Meeting 2023-8

“Gender dysphoria: emerging teen challenges,” Clare Rowe, Principal Psychologist and Director, Rowe & Associates; September 21, Venue: RSL Mittagong, Joadja/Nattai Room

1316th OGM and Open Lecture

“Australia’s nuclear future: a new discourse for the 2040s,” Helen Cook, Principal, GNE Advisory and Dr Adi Paterson FRSN FTSE, Former Chief Executive Officer ANSTO; October 4, Venue: Gallery Room, State Library of NSW, Shakespeare Place, Sydney, video

Southern Highlands Branch Meeting 2023-9

“Are our weeds becoming new native species?” Professor Angela Moles FRSN, Ecology and Evolution Research Centre, UNSW Sydney; October 19, Venue: RSL Mittagong, Joadja/Nattai Room

Hunter Branch Meeting 2023-4

“Electrical Energy Supply. So what’s all the fuss about,” Professor Colin Waters, Professor of Physics, University of Newcastle; October 26, Venue: Hunter Room, Newcastle City Hall

Joint UNE SRI and RSNSW Presentation

“CleanTech Futures 2023: Electrification and opportunities for community and business,” Professor Renate Egan, Executive Director, Australian Centre for Advanced Photovoltaics, UNSW Sydney; October 30, Venue: NOVA, 122 Faulkner Street, Armidale NSW 2350, video

RSNSW and Learned Academies Forum 2023

“Our 21st Century Brain,” November 2, Venue: Live streaming from Government House Sydney Video presentations: YouTube. The proceedings will appear in the *Journal & Proceedings* of June 2024.

1317th OGM and 2022 Clarke Memorial Lecture

“Caves as observatories of groundwater recharge,” Professor Andy Baker FRSN FAGU, School of Biological, Earth, and Environmental Sciences, UNSW Sydney; November 8, Venue: Metcalfe Auditorium, State Library of NSW, Macquarie Street, Sydney, video

Western NSW Branch Meeting 2023-4

“Thirst for power — the rivers of conflict in Southeast Asia,” Professor Lee Baumgartner, Executive Director, Gulbali Institute for Agriculture, Water, and Environment, Charles Sturt University; November 16, Venue: Gum’s Cafe, Thurgoona, Charles Sturt University, Albury

Southern Highlands Branch Meeting 2023-10

“Secrets of cultural heritage revealed at ANSTO,” Dr Joseph Bevitt, Senior Instrument Scientist, ANSTO; November 16, Venue: RSL Mittagong, Joadja/Nattai Room

1318th OGM and Open Lecture

“What do we really know about 20th- and 21st-century sea-level change?” Emeritus Professor John Church AO FAA FTSE FAMS FAGU, Climate Change Research Centre, UNSW Sydney; November 29, Venue: Gallery Room, State Library of NSW, Shakespeare Place, Sydney, video



Note on Gazetting

The Government Gazette of the State of New South Wales is managed by the New South Wales Parliamentary Counsel's Office and has published Government notices, regulations, forms and orders since 1832. It went on line in 2001 and since 2014 is only to be found at <https://legislation.nsw.gov.au/gazette>.



Government Gazette

of the State of
New South Wales

Number 273—Other
Friday, 23 June 2023

On the initiative of RSNSW Fellow Robert Whittaker AM FRSN, the Society approached His Excellency the Governor to formally gazette fellows of the Society. All current fellows were included in the first gazetting in 2018, and subsequently at the beginning of each year fellows elected in the previous year will appear in the Gazette.

As the Gazette of Friday 23 June 2023 says:

“Her Excellency the Honourable Margaret Beazley AC KC, Governor of New South Wales, as Patron of The Royal Society of New South Wales and in furtherance of the aims of the Society in encouraging and rewarding the study and practice of Science, Art, Literature and Philosophy, is pleased to advise and acknowledge the election of the following as Fellows of the Society in 2022.”

Fellows

Proven leaders and experts in their field, entitled to use the post nominal FRSN. Please note Professorial titles — including adjuncts, conjoint, and professors of practice — have been used where applicable. Details as to their field of expertise, their resident university (or universities) or institution may be ascertained from the Royal Society of New South Wales.

ADKINS, Professor Lisa Adkins FRSN

AHARONOVICH, Professor Igor Aharonovich
FRSN

BALDOCK, Professor Clive Baldock FRSN

BROUGH, Professor Sarah Brough FRSN

CAIRNEY, Professor Julie Marie Cairney FRSN

COHN, Dr Geoffrey Stephen Cohn FRSN

CUNNINGHAM, Professor Anthony Lawrence
Cunningham FRSN

DOWLING, Professor Robyn Dowling FRSN

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Proceedings — Awards, Meetings, Gazetted Fellows

EVANS, Mark Griffith Evans FRSN
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GREEN, Professor Roy Herbert Green FRSN
HEISER, Professor Gernot Alexander Heiser FRSN
HO-BAILLIE, Professor Anita Wing Yi Ho-Baillie FRSN
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KEEGAN, Professor Peter Keegan FRSN
LEISHMAN, Professor Michelle Leishman FRSN
LEMCKERT, Professor Charles James Lemckert FRSN
LEON, Professor Renée Elmina Leon FRSN
LUPTON, Professor Deborah Lupton FRSN
MARSHALL, Professor P David Marshall FRSN
MCGREEVY, Professor Paul Damien McGreevy FRSN
NGUYEN, Professor Tuan Van Nguyen FRSN
PARFITT, Professor Andrew James Parfitt FRSN
POORE, Professor Alistair Gary Beresford Poore FRSN
QUINN, Professor Jane Catherine Quinn FRSN
RAE, Judith Maree Rae (Ms) FRSN
REID, Professor Anna Reid FRSN
RENEWICK, Dr James George Renwick FRSN
RICHARDSON, Professor Desi Raymond Richardson FRSN
ROSS, Professor Allen Guy Patrick Ross FRSN
ROSS, Professor Shawn Adrian Ross FRSN
ROUGHAN, Professor Moninya Roughan FRSN
SOMERVILLE, Professor Margaret Somerville FRSN
SUBRAMANIAM, Professor Rathana Markandan Subramaniam FRSN
SULLIVAN, Professor Elizabeth Sullivan FRSN
THORDARSON, Professor Pall Thordarson FRSN
VAN NUNEN, Mr David John van Nunen FRSN
VAN NUNEN, Professor Sheryl Anne van Nunen, FRSN
WALLMAN, Professor James Wallman FRSN
WIGHTWICK, Professor Glenn Wightwick FRSN

Distinguished Fellows

Those Fellows of exceptional distinction, elected in 2020 by their peers, entitled to use the post nominal DistFRSN.

FOLEY, Dr Catherine Foley AO DistFRSN FAA FTSE

List of Fellows to be degazetted

BARNETT, Professor Allen Barnett
BATHURST, Hon Thomas Frederick Bathurst AC KC
BEAUMONT, Professor Joan Errington Beaumont
BONTHORNE, Mr Ross Bonthorne AM
BUCHAN, Dr Jennifer Buchan
CORKISH, Dr Richard Corkish
CRAIN, Professor Stephen Crain
CROSSLEY, Maxwell John Crossley
DODDS, Professor Susan Dodds
DUNN, Professor Kevin Mark Dunn
FORGAS, Professor Joseph Paul Forgas AM
FOSTER, Professor Neil Russell Foster
GOODING, Professor Justin Gooding
HALL, Professor Kevin Hall
HARLEY, Professor Ross Harley

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Proceedings — Awards, Meetings, Gazetted Fellows

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HOWE, Professor Brian Leslie Howe AO	PEREZ, Professor Pascal Perez
JACOBS, Professor Ian Jacobs	PRICE, Professor William E. Price
KEWLEY, Professor Lisa Kewley	PYKE, Professor Graham Harvey Pyke
KRISHNA, Professor Venni Krishna	RAMAGGE, Professor Jacqui Ramagge
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MCMILLEN, Professor Caroline McMillen	WILLIAMSON, Professor Geordie Williamson
MESSERLE, Professor Barbara Ann Messerle	WOO, Mr Eddie Woo
MILLER, Professor Seumas Roderick Miller	YOUNG, Dr Robert William Young
NEILAN, Professor Brett Neilan	

Members

The following 162 people were Members of the Royal Society on 8 December 2023.

ABBASI, Shahrzad MRSN	BELL, Brian MRSN
ABI-ARRAJ, Jeanne MRSN	BETTEGA, Dyone MRSN
ADAM, Wendy MRSN	BLACK, Peter MRSN
AHYONG, Shane MRSN	BOCHAN, Chad MRSN
ALLEN, Tina MRSN	BOLAND, James MRSN
ANTONY, Jason MRSN	BOSCHIERO, Luciano MRSN
BAILEY, Philip MRSN	BRAKEL, Albert MRSN
BAKER, Eveline MRSN	BROOME, Matthew MRSN
BAZZANA, Susan MRSN	BROWN, Trevor MRSN
BEALE, David MRSN	BRYCE, Ian MRSN

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Proceedings — Awards, Meetings, Gazetted Fellows

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CAMERON, Margaret MRSN	GARRETT, Geoffrey MRSN
CAMERON, John MRSN	GIBB, Zamira MRSN
CAMPBELL, Mary MRSN	GORRIE, Catherine MRSN
CARR, Andrew MRSN	GREEN, Thomas MRSN
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FLOYD, Shaan MRSN	KAUR, Amarjit MRSN
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Proceedings — Awards, Meetings, Gazetted Fellows

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Archibald Liversidge: Imperial Science under the Southern Cross

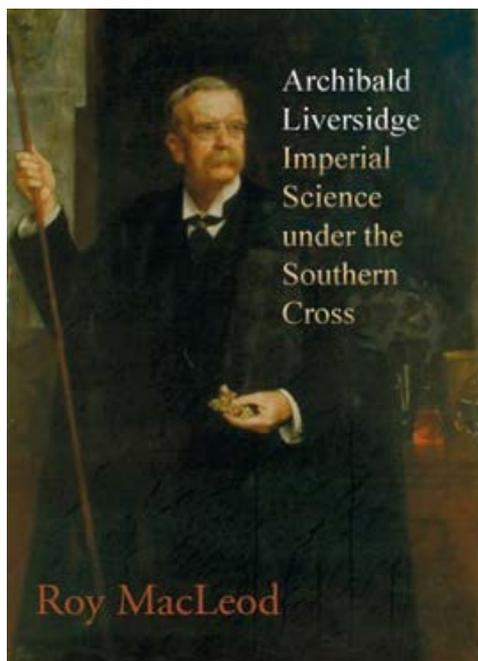
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When Archibald Liversidge first arrived at the University of Sydney in 1872 as Reader in Geology and Assistant in the Laboratory, he had about ten students and two rooms in the main building. In 1874, he became Professor of Geology and Mineralogy and by 1879 he had persuaded the University Senate to open a Faculty of Science. He became its first Dean in 1882.

In 1880, he visited Europe as a trustee of the Australian Museum and his report helped to establish the Industrial, Technological and Sanitary Museum which formed the basis of the present Powerhouse Museum's collection. Liversidge also played a major role in establishing the *Australasian Association for the Advancement of Science* which held its first congress in 1888.

This book is essential reading for those interested in the development of science in colonial Australia, particularly the fields of crystallography, mineral chemistry, chemical geology and strategic minerals policy.



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CONTENTS

<i>Robert E. Marks</i> : Editorial: <i>Gravvy</i> waves, serendipity, and regeneration	191
PAPERS	
<i>Stephen Gaukroger</i> : Does science get the credit for too much?	195
<i>Deborah Beck</i> : The Governor's scrapbook.	201
<i>Peter French</i> : The rôle of serendipity in biotechnology start-up companies — two case studies.	214
<i>Peter Coyne</i> : Ferals — some remote Australian island experiences.	221
<i>Gus McLachlan and Andrew Condon</i> : Drones, smart munitions and cyberspace: 21st century defence of Ukraine & implications for Australia.	243
<i>James Renwick</i> : The Russia/Ukraine conflict — developments in war crimes.	264
<i>Len Fisher</i> : A simple past — a complex future: thoughts from the Heron Island symposium, "Complexity, Criticality and Computation".	281
<i>Jim Falk et al.</i> : Critical hydrologic impacts from climate change: addressing an urgent global need.	291
BOOK REVIEW	
<i>Wilfred Prest</i> : Review of <i>The Search for Truth</i> by Max Bennett (2022).	298
Ph.D. THESIS ABSTRACTS	
<i>Aleese Barron</i> : Archaeobotanical applications of microCT imaging 304, <i>Zoe Louise Bell</i> : Experiences of statelessness and refugee protection: Exploring the "Rohingya Life" in Sydney, Australia 306, <i>Lindie Clark</i> : Embodiment, affect, and relational practice in the emergence of leadership 308, <i>Hudson W. Coates</i> : Substrate-induced activation of the rate-limiting cholesterol synthesis enzyme squalene monooxygenase 309, <i>Allison Henry</i> : Regulatory responses to addressing and preventing sexual assault and harassment in Australian university settings 311, <i>Kirill Koshelev</i> : Advanced trapping of light in resonant dielectric metastructures for nonlinear optics 313, <i>Callum Scott McDiarmid</i> : Introgression, sperm and mitonuclear interactions in the long-tailed finch (<i>Poephila acuticauda</i>). 316, <i>Tamika Worrell</i> : Prioritising Blak voices: representing Indigenous perspectives in NSW English classrooms 318, <i>Zhiheng Zhang</i> : The application of photomediated RAFT polymerisation in 3D printing 320.	304
OBITUARIES	
<i>Robert Marks</i> : Adrian Lee AC FRSN FASM (1941–2023)	322
<i>Conal Condren</i> : Stephen Wallace Gaukroger FRSN FRHistS FRSA FAHA (1950–2023)	324
2023 ROYAL SOCIETY PROCEEDINGS	
2023 Award Winners, 2023 Events, 2023 Gazetted Fellows, Members	327
INFORMATION FOR AUTHORS	Inside Back Cover

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