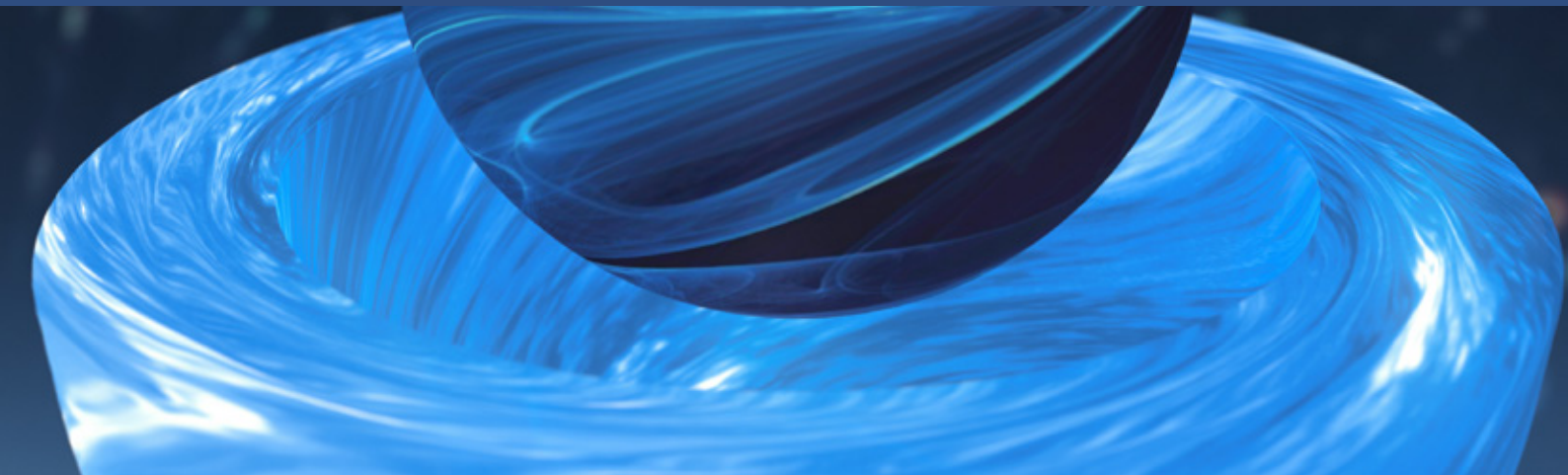
Making a difference

Australian Government
Australian Research Council

Outcomes of ARC supported research

2019–20



THE AUSTRALIAN RESEARCH COUNCIL

The Australian Research Council (ARC) is a non-corporate Commonwealth entity within the Australian Government. The ARC's purpose is to grow knowledge and innovation for the benefit of the Australian community through funding the highest quality research, assessing the quality, engagement and impact of research and providing advice on research matters.

The ARC funds research and researchers under the National Competitive Grants Program (NCGP). The NCGP consists of two elements—Discovery and Linkage. Within these elements are a range of schemes structured to provide a pathway of incentives for researchers to build the scope and scale of their work and collaborative partnerships. The majority of funding decisions under the NCGP are made on the basis of peer review.

The ARC evaluates the quality of Australian university research through the Excellence in Research for Australia (ERA) program. ERA is an evaluation framework that identifies research excellence in Australian universities by comparing Australia's research effort against international benchmarks. ERA assesses quality using a combination of indicators and expert review by research evaluation committees.

The ARC is also responsible for administering the Engagement and Impact (EI) assessment. EI assesses the engagement of researchers with research end-users and shows how universities are translating their research into economic, social, environmental, cultural and other impacts. Assessments are made by expert panels of researchers and research end-users using narrative studies and supporting quantitative indicators.

The Australian Research Council acknowledges the Traditional Owners of Country throughout Australia and their continuing connection to lands, waters and communities. We pay our respects to Aboriginal and Torres Strait Islander cultures and to Elders past, present and emerging.

Please note: Aboriginal and Torres Strait Islander people should be aware that this publication may contain the names or images of deceased persons.

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A MESSAGE FROM OUR CEO

Welcome to the fourth edition of the Australian Research Council's (ARC) *Making a difference* publication, in which we draw together a diverse sample of outcomes from ARC-supported research projects that have occurred over the previous year. In 2020 the ARC celebrates 55 years of competitive grants delivery to the research sector. While we have existed in our current legislated form since 2001, it was in May 1965 that we first came to shape the delivery of government research funding as the Australian Research Grants Committee.

From the very beginning, the ARC has supported research projects of dazzling variety and scope, on both fundamental and applied research themes. In this edition, we feature stories of research to uncover the hidden secrets of neutron stars and radio signals from deep space, of efforts to revive the world's damaged coral reefs, and industry-focussed projects that are reducing agricultural methane emissions, and bringing new life to the humble old pair of jeans. The legacy of Australia's first Archbishop is unpacked, as is a scheme to double the number of Indigenous entries in the *Australian Dictionary of Biography*.

All of this, and much, much more, is made possible with the funding support of the ARC, which often flows through a multitude of individual grants and across different schemes. Entire research teams are supported at multi-million-dollar ARC Centres of Excellence and Industrial Transformation Training Centres and Research Hubs, which often additionally make use of equipment and facilities purchased through successful ARC Linkage Infrastructure, Equipment and Facilities grants. Individual researchers are supported at different career stages by ARC fellowships—ten stories in this publication are the product of a Discovery Early Career Researcher Award. And of course, funding from ARC Discovery Projects and Linkage Projects is woven through many researcher careers, nurturing ambitious research projects and creating collaborations with industry and beyond.

This ecosystem of research support helps to create a rich and varied landscape of innovation and knowledge production, which in turn supports our industries, our higher education sector, and the wider Australian community. I hope this snapshot of projects gives you a rewarding insight into the socially transformative and productive work of Australian researchers.

Professor Sue Thomas
Chief Executive Officer
Australian Research Council

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Earth's horizon. iStock.com/AdobeBox.

UNDERSTANDING OUR WORLD THROUGH FUNDAMENTAL RESEARCH

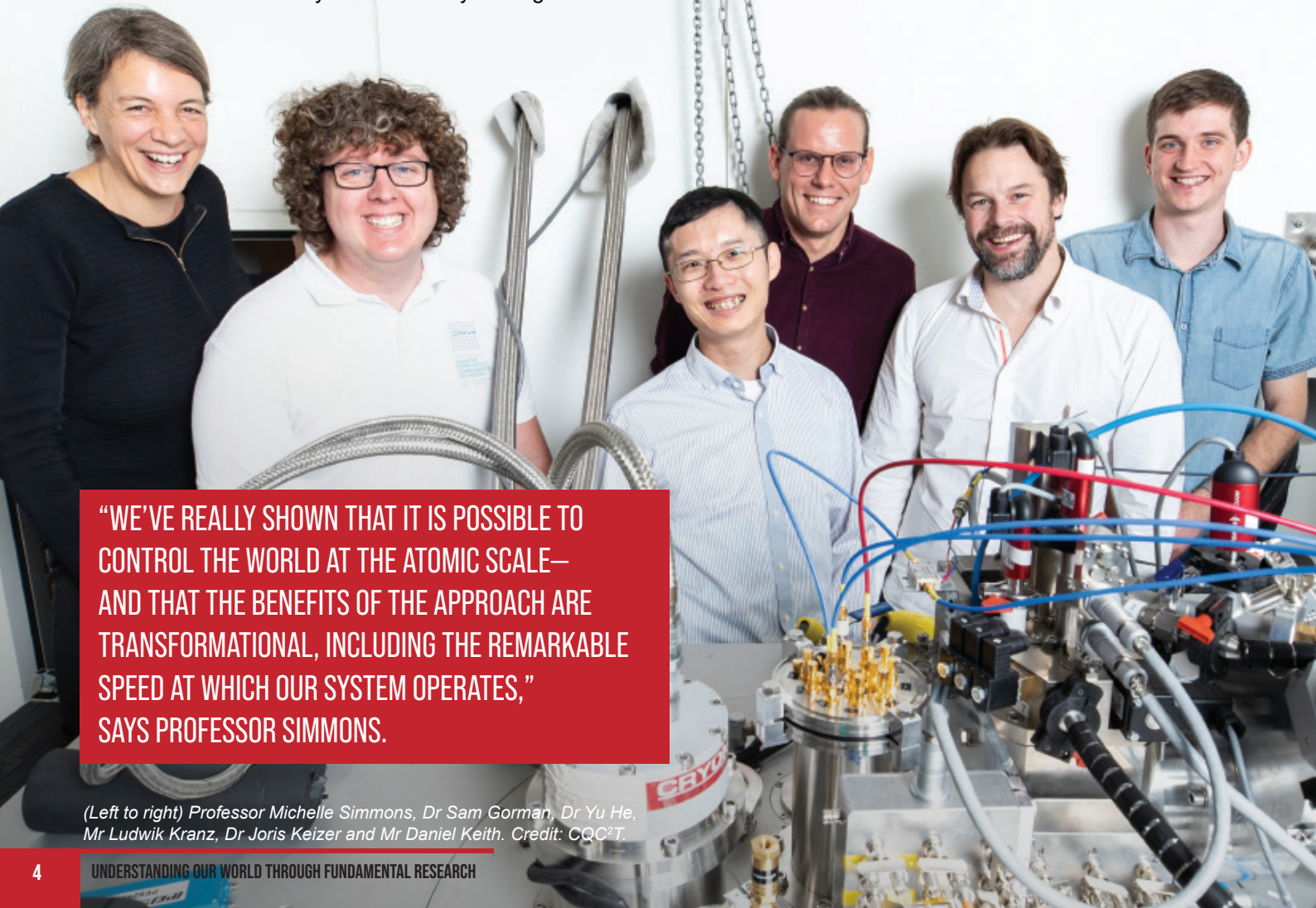
SMASHING THE QUANTUM SPEED RECORD

A group of physicists at the *ARC Centre of Excellence for Quantum Computation and Communication Technology* (CQC^{2}T) at The University of New South Wales (UNSW) has built a super-fast version of the central building block of a quantum computer.

The research team has achieved the first 2-qubit gate between atom qubits in silicon—a major milestone in the team's quest to build an atom-scale quantum computer, a vision first outlined by scientists 20 years ago.

A 2-qubit gate is the central building block of any quantum computer, and the UNSW team's version of it is the fastest ever to be demonstrated in silicon, completing an operation in 0.8 nanoseconds, which is ~200 times faster than other existing spin-based two-qubit gates.

2018 Australian of the Year, Professor Michelle Simmons, who is an ARC Australian Laureate Fellow and Director of CQC^{2}T, says the result is the culmination of two decades' worth of work, and has set the team up to shift the boundaries of what's thought to be 'humanly possible'.



"WE'VE REALLY SHOWN THAT IT IS POSSIBLE TO CONTROL THE WORLD AT THE ATOMIC SCALE— AND THAT THE BENEFITS OF THE APPROACH ARE TRANSFORMATIONAL, INCLUDING THE REMARKABLE SPEED AT WHICH OUR SYSTEM OPERATES," SAYS PROFESSOR SIMMONS.

(Left to right) Professor Michelle Simmons, Dr Sam Gorman, Dr Yu He, Mr Ludwik Kranz, Dr Joris Keizer and Mr Daniel Keith. Credit: CQC^{2}T.

"IF WE WERE TO STAND ON THE MOON AND LOOK DOWN AT THE EARTH WITH THIS PRECISION, WE WOULD BE ABLE TO TELL NOT ONLY WHICH CITY THE BURST CAME FROM, BUT WHICH POSTCODE—AND EVEN WHICH CITY BLOCK," SAYS CSIRO RESEARCHER, DR KEITH BANNISTER.

MILLISECOND RADIO REFLEXES FIELD A CURVEBALL FROM DEEP SPACE

For the first time, an ARC-supported team of researchers has determined the location of a one-off 'fast radio burst'. Scientists don't know what causes these mysterious and intense radio bursts from outer space, but determining their location is a significant technical achievement and may help explain the cause of the phenomena.

Since the discovery of fast radio bursts in 2007, 85 more bursts were identified by 2019, with each one appearing and then disappearing again within about 1 millisecond. Concerted follow-up of one special source that gave off 'repeat' bursts led to its localisation in 2017, but pinpointing the origin of one of the much more common 'one-off' bursts had not previously been achieved.

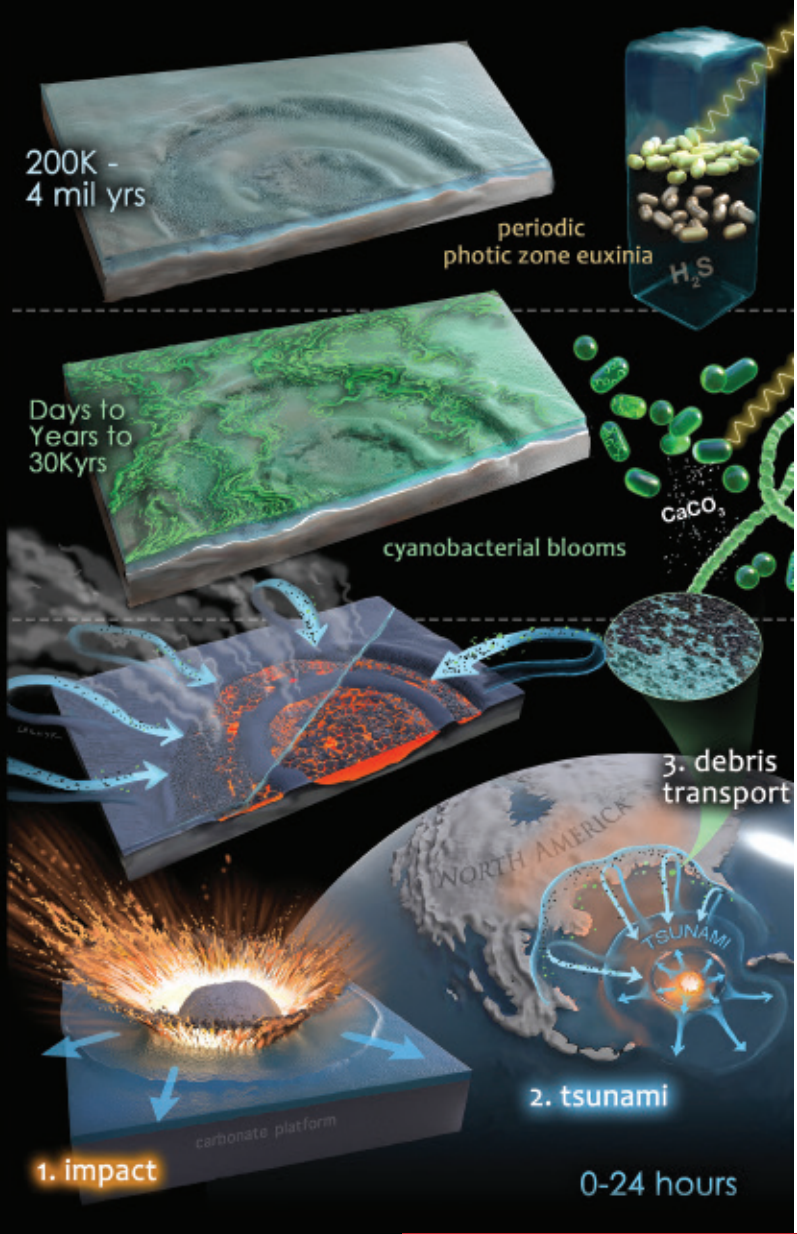
The discovery was made with support from an ARC Discovery Projects grant led by Associate Professor Jean-Pierre Macquart, based at Curtin University, and an ARC Future Fellowship awarded to Associate Professor Adam Deller, who is based at Swinburne University of Technology.

They pinpointed the burst to the outskirts of a Milky Way-sized galaxy about 3.6 billion light-years away.

The discovery was made using the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Australian Square Kilometre Array Pathfinder (ASKAP) radio telescope in Western Australia, and the home galaxy was subsequently imaged by three of the world's largest optical telescopes.

In 2020 a new ARC Linkage Infrastructure, Equipment and Facilities (LIEF) grant was awarded to the team that will provide a major increase in performance to the Parkes radio telescope, particularly in sensitivity and survey speed, to aid in future observations of Fast Radio Bursts and other deep space phenomena.

CSIRO's Australian Square Kilometre Array Pathfinder (ASKAP) radio telescope, located at CSIRO's Murchison Radio-astronomy Observatory in Western Australia. Credit: CSIRO/Dragonfly Media.



An illustration of the timeline of the asteroid's impact. Credit: Victor Leshyk.

GIANT TSUNAMI FOLLOWED DINOSAUR-KILLING ASTEROID

Researchers from Curtin University have taken part in a scientific expedition to retrieve core samples from the Chicxulub meteorite crater in the Gulf of Mexico, uncovering evidence that the asteroid that caused the mass extinction of the dinosaurs also triggered a giant tsunami.

The asteroid impact that formed the crater on the Yucatán Peninsula in Mexico, where the research was carried out, is thought to be the cause of the late Cretaceous Period mass extinction event, in which 76 per cent of all plant and animal species in the ancient world, including all non-flying dinosaurs, were killed off.

The research team, including ARC Discovery Projects grant recipient, John Curtin Distinguished Professor Kliti Grice from Curtin's School of Earth and Planetary Sciences, drilled into the crater in order to retrieve rocks from 500 metres to 1300 metres below the seafloor, finding evidence of the events of the days after the asteroid's impact.

Specific molecules from fungi in soil and wildfires helped to track the giant tsunami that was several hundreds of metres high, which flooded the crater in the aftermath of the impact.

Further ARC-supported research by the team has revealed that microbial life quickly re-established itself in the crater, leading to 'post-apocalyptic microbial mayhem' and demonstrating how resilient microorganisms are to hostile environments.

THE RESEARCH HELPS ANSWER THE TANTALISING QUESTION OF EXACTLY WHAT HAPPENED IN THE HOURS, DAYS AND WEEKS FOLLOWING ONE OF THE MOST SIGNIFICANT EVENTS IN EARTH'S HISTORY.

ANCIENT HYENA POO SHEDS NEW LIGHT ON HUMAN EVOLUTION

Fossil animal droppings, charcoal from ancient fires, and bone fragments littering the ground of one of the world's most important human evolution sites have revealed fascinating insights into an obscure branch of early humans and predators.

The team of Australian and Russian scientists, including ARC Future Fellow, Associate Professor Mike Morley at Flinders University and the Director of the *ARC Centre of Excellence for Australian Biodiversity and Heritage*, Professor Richard 'Bert' Roberts at the University of Wollongong, used modern geoarchaeological techniques to unearth new details of day-to-day life in the famous Denisova Cave complex in Siberia's Altai Mountains.

Their microscopic analysis of the sedimentary deposits of the cave suggests that large carnivores once dominated the landscape, competing with ancient humans for prime space in cave shelters for more than 300,000 years.

The Siberian site came to prominence more than a decade ago with the discovery of the fossil remains of a previously unknown human group dubbed the Denisovans, after the local name for the cave.

The research implies that these ancient people probably came and went for short-lived episodes. It also reveals new information about the climate inside the cave through prehistoric time, and the use of fire.

> "EARLY NOMADIC HUMAN GROUPS AND LARGE CARNIVORES SUCH AS HYENAS AND WOLVES LEFT A WEALTH OF MICROSCOPIC TRACES THAT ILLUMINATE THE USE OF THE CAVE OVER THE LAST THREE GLACIAL-INTERGLACIAL CYCLES," SAYS ASSOCIATE PROFESSOR MIKE MORLEY.

Hyena Smiling. Istock.com/rkraan.

THE DISCOVERY GIVES RESEARCHERS A NEW LEAD IN SOLVING THE PROBLEM OF FINDING THE ULTIMATE 'PLATE TECTONIC DRIVING FORCE'—WITH WIDE-RANGING IMPLICATIONS FOR THE EARTH SCIENCES.

Lava. iStock.com/Justinreznick.

THE MAKING OF A SUPERPLUME: HUGE UNDERGROUND MOUNTAINS OF HOT ROCK

ARC-supported researchers at Curtin University have analysed thousands of rock samples to uncover the movements of mountains of rock deep within the earth, adding to our understanding of the driver for the formation and break-up of supercontinents like Pangaea, and plate tectonics in general.

ARC Australian Laureate Fellow, John Curtin Distinguished Professor Zheng-Xiang Li, and members of his team from Curtin University's School of Earth and Planetary Sciences utilised data from over 40,000 basalt rock samples taken from Earth's continents and the ocean floors.

Professor Li says that nearly 3,000 kilometres below the Earth's surface, just above the boundary between the Earth's liquid outer core and solid mantle layer, is where these hot, dense piles of rocks are located.

These mountains are hundreds of kilometres high and thousands of kilometres in diameter, and are known as Large Low Shear Velocity Provinces, or 'superplumes'.

The researchers found that these superplumes form and disintegrate in a cyclical manner over hundreds of millions of years. More surprising is that their activity is almost exactly synchronised with a 500 to 700 million-years-long cycle of supercontinents forming and breaking up through the last two billion years of the Earth's history.

Professor Li says that the supercontinent cycle leads to the superplume cycle, but at the same time, the superplumes cause the break up of the supercontinents, leading to a 'chicken-and-egg' relationship. However, scientists think that the plates appear to have a slight upper hand in the process.

SYNTHETIC BIO-COMPUTERS MAY HOLD THE KEY TO SOLVE THE UNSOLVABLE

Hybrid half-living, half-synthetic bio-computers smaller than a full stop are being tested as a possible solution to the problem of creating truly lifelike artificial intelligence.

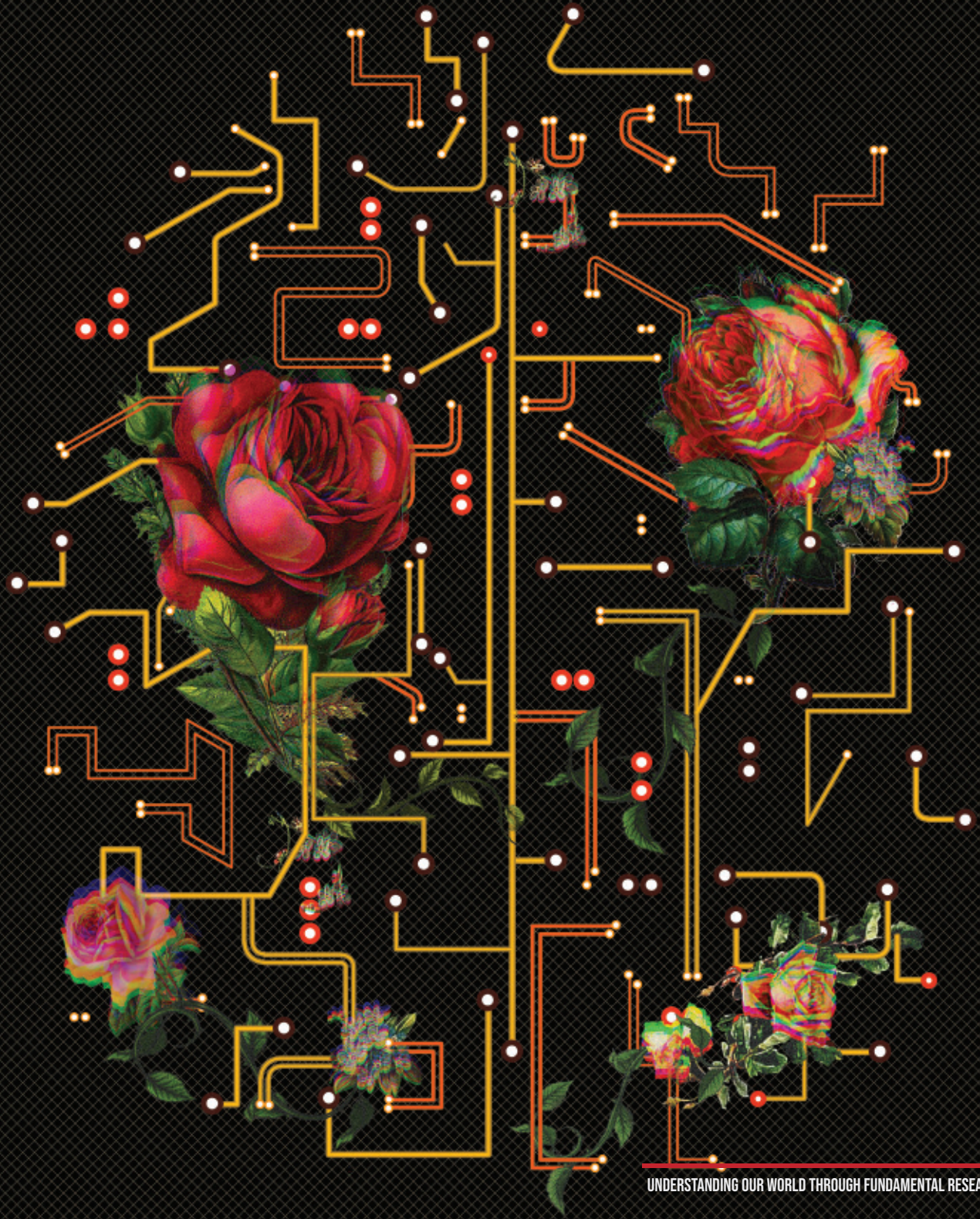
The computers created by ARC Future Fellow, Associate Professor Dan Nicolau, based at Queensland University of Technology (QUT) and Oxford University (UK), have the properties of life: they can do calculations in a massively parallel way, just as we do when we walk, talk, breathe and do thousands more things, all at the same time. And, like living things, they use almost no energy to exist.

Associate Professor Nicolau says that the problem of how long it was taking a computer to wade through extreme amounts of data kept cropping up, partly because of a computer's inability to accept imperfection. With support from his Future Fellowship, he is now developing disruptive computer technology that provides a way to solve the 'unsolvable' problems at the heart of computer science.

So far, the research has led to the creation of 'living, breathing' devices powered by microscopic pieces of rabbit muscle and pig brain that are able to do maths at roughly the level of a primary school child.

Caption: 'Love' artwork by Amiti Singh, 2019.

> "WHEN COMPUTERS WERE FIRST DEVELOPED, THEY WERE SEEN AS BEING ABLE TO SOLVE EVERY POSSIBLE PROBLEM WE COULD THINK OF, GIVEN ENOUGH TIME. BUT MOST OF THE IMPORTANT CHALLENGES WE FACE, FROM DRUG DEVELOPMENT TO REASONING ABOUT OUR WORLD TO FINDING LOVE, TURN OUT TO BE IMPOSSIBLE FOR THEM TO COMPLETE WITHIN A HUMAN LIFETIME, OR EVEN WITHIN THE LIFETIME OF A GALAXY. BIOCOMPUTATION IS AN ATTEMPT TO OVERCOME THIS LIMITATION." SAYS ASSOCIATE PROFESSOR NICOLAU.



Greg Ashton (left) and Paul Lasky (right). Credit: Carl Knox, ARC Centre of Excellence for Gravitational Wave Discovery (OzGrav).

"VELA IS FAMOUS NOT ONLY BECAUSE ONLY 5% OF PULSARS ARE KNOWN TO 'GLITCH', BUT ALSO BECAUSE VELA GLITCHES ABOUT ONCE EVERY THREE YEARS, MAKING IT A FAVOURITE OF 'GLITCH HUNTERS," SAYS DR GREG ASHTON.

GLITCHING NEUTRON STAR OPENS UP TO RESEARCHERS

Neutron stars are among the densest objects in the Universe. They rotate extremely fast and regularly—until they don't. Occasionally, these neutron stars start to spin even faster, caused by portions of the inside of the star moving outwards. It's called a 'glitch' and it's a rare glimpse into the interior of these mysterious objects.

Researchers from Monash University, the *ARC Centre of Excellence for Gravitational Wave Discovery* (OzGrav), McGill University in Canada, and the University of Tasmania, have studied the interior of the Vela Pulsar, a neutron star in the southern sky that is 1,000 light years away.

Dr Paul Lasky, an ARC Future Fellow from the Monash School of Physics and Astronomy, and a member of the OzGrav team that studied Vela, says that for the first time, the scientists have got a glimpse into the interior of the Vela Pulsar—revealing that the inside of the star actually has three different components.

Their observations suggest a slower spinning core of superfluid neutrons acts like a clutch which slows the fast spinning star back down to regularity. Although this had been partly predicted by previous theoretical work, the researchers made another observation which defies explanation—immediately before the glitch, they noticed that the star seems to slow down its rotation rate before spinning back up.

Dr Greg Ashton, also from the Monash School of Physics and Astronomy, and a member of OzGrav, says that the research team currently has no idea why this is, and it's the first time it has ever been seen. But they speculate it is related to the cause of the glitch and hope their research will spur some new theories on neutron stars and glitches. OzGrav is administered by Swinburne University.

Countryside. iStock.com/Katharina13.

INDUSTRY DRIVEN RESEARCH TO GENERATE ECONOMIC IMPACTS

PROTECTING WHEAT FROM SALTY SOILS

Researchers from the *ARC Centre of Excellence in Plant Energy Biology* led by The University of Western Australia (UWA) have discovered two enzymes that explain the sensitivity of wheat plants to salty soils. The findings could lead to advances that strengthen crops against salinity, an issue costing WA farmers more than $500 million a year.

The research was led by an ARC Future Fellowship recipient, Dr Nicolas Taylor, from the UWA School of Molecular Sciences, with a team at the *ARC Centre of Excellence in Plant Energy Biology* and The National University of Malaysia.

An improved understanding of the effects of salinity on crops at a molecular level is essential for developing more tolerant wheat varieties.

The research described two enzymes in wheat that are especially sensitive to salt, and that appear to be the 'weak link' that leads to plant death in saline soils. The researchers also discovered wheat has a natural defence system that can bypass one of the sensitive enzymes, partially protecting against salt.

Dr Taylor said that by understanding exactly how salt is damaging wheat plants, they can look for varieties with improved natural salt tolerance and introduce them into wheat breeding programs.

> SALINITY IS A GLOBAL AGRICULTURAL ISSUE, AND IN AUSTRALIA IT AFFECTS MORE THAN TWO MILLION HECTARES OF FARMLAND, HALF OF WHICH IS IN WESTERN AUSTRALIA. FARMERS IN AFFECTED AREAS SEE CROP YIELDS REDUCED BY MORE THAN A QUARTER.

(Left to right) Dr Nicolas Taylor, Dr Richard Jacoby and Professor Harvey Millar. Credit: ARC Centre of Excellence in Plant Energy Biology.

DEBUNKING THE MYTH ABOUT WHEAT BREEDING AND ALLERGIES

Research at Charles Sturt University has disproven the idea that modern wheat varieties are somehow more allergenic than wheat grown by our ancestors.

Dr Chris Florides investigated 170 wheat varieties grown in Australia from 1860 to 2015 as part of his PhD research through the *ARC Industrial Transformation Training Centre for Functional Grains* (The Functional Grains Centre).

While examining the allergenicity of the different varieties, including those brought from England that were bred to suit Australia's climate, he discovered that one of the most allergenic varieties was one grown in the 1800s.

This contradicts a common belief that early wheat varieties were not immunogenic, and that modern genetic techniques have created wheat varieties that are more allergenic.

The outcome of Dr Florides' research includes the development of a new diagnostic method, and a database with information on the allergenicity of these wheat varieties for use by researchers and industry.

It is hoped this research will contribute to the development of low-allergenic wheat varieties that could be made into products suitable for people who have mild gluten intolerance.

Dr Florides was one of four graduates from the Training Centre awarded PhDs by Charles Sturt University in 2019. Other PhD graduates investigated the antioxidant properties of wholegrain cereals like rice, sorghum, barley and oats, the health benefits of Australian-grown coloured rice and the impact of water efficiency measures on the quality of rice produced.

The Functional Grains Centre, led by Charles Sturt University, has focused on improving the value of grain through research on markets, production systems, grain processing and the development of high-value grain products.

WHILE IT IS NOT POSSIBLE TO DEVELOP COMPLETELY NON-ALLERGENIC WHEAT BECAUSE THE GLUTEN PROTEINS ARE NECESSARY FOR THE FUNCTIONALITY OF THE FLOUR, RESEARCHERS HOPE THAT VARIETIES WITH A LOW CONTENT OF IMMUNOREACTIVE PROTEINS CAN NOW BE USED IN WHEAT BREEDING PROGRAMS.

Wheat. Credit: Charles Sturt University.

GONE WITH THE WIND—REDUCING AGRICULTURAL METHANE EMISSIONS

An international research team led by ARC Discovery Early Career Researcher Award (DECRA) recipient, Associate Professor Chris Greening at Monash University's School of Biological Sciences, has made an important discovery in the quest to help lower global agricultural methane emissions, vital for the ongoing health of the planet.

In a collaboration with a wider team as part of the Global Research Alliance on Agricultural Greenhouse Gases, the researchers have identified new processes that control methane production in the stomach (rumen) of sheep and other ruminants.

Specifically, they determined which microbes and enzymes control the supply of hydrogen, which is the main energy source for microbes which produce methane.

The researchers found that these methane-producing microbes were the main hydrogen users in high-emitting sheep. On the other hand, non-methane producing microbes and enzymes—including acetogens, fumarate, nitrate and sulphate reducers—dominated in low-emitting sheep.

This new understanding will allow scientists to manipulate the process and form strategies to reduce methane production from sheep, cattle and deer. One strategy suggested is to introduce feed supplements that encourage non-methane producing microbes and enzymes to outcompete those that produce methane.

CONTROLLING THE BALANCE OF MICROBES AND ENZYMES IN THE STOMACHS OF RUMINANTS SUCH AS SHEEP AND CATTLE WILL LEAD TO REDUCED AGRICULTURAL METHANE EMISSIONS, WHICH CONTRIBUTE SIGNIFICANTLY TO HUMAN-DRIVEN CLIMATE CHANGE.

Sheep at the AgResearch farm in Aorangi, Palmerston North, New Zealand. Credit: AgResearch.

THE MANUFACTURERS IN THE STUDY EXPRESSED A RESPONSIBILITY TO MUCH MORE THAN INCREASING PROFITS AND MAXIMISING RETURNS. THIS COMMITMENT TO BUSINESS MOTIVATIONS BEYOND PROFIT WAS DISPLAYED ACROSS ALL THE ENTERPRISE TYPES.

THE KEY TO SUCCESS IS A COMPANY'S CULTURE

A study by researchers at Western Sydney University and The University of Newcastle has emphasised the importance of creating and maintaining a strong work culture in companies in Australia's manufacturing sector, and the benefits of implementing more environmentally sustainable practices.

Funded through the ARC's *Discovery Projects* scheme, the Chief Investigators in the study, Professor Katherine Gibson, Dr Stephen Healy and Associate Professor Jenny Cameron with Research Project Manager Dr Joanne McNeill, interviewed ten New South Wales-based manufacturers.

A mix of successful manufacturers were surveyed, including family businesses, multi-nationals, cooperatives and social enterprises, from those who had been established within the last five years, to those who have been operating for over 100 years.

The researchers note that manufacturing is rarely discussed in cultural terms. However, they found that all the participating companies referred to their distinctive 'culture' of operation and articulated specific commitments that indicate a forward-looking culture beyond what could be considered 'business as usual'.

A key finding from their research is that to have a strong culture, company growth has to be carefully considered—and that decent jobs and an inclusive economy is created by companies that see workers as valued contributors, and factories as sites of inclusion.

The research also highlighted how a smaller ecological footprint is achieved by companies seeing themselves as contributing to environmental care and repair in the long-term, which includes producing high-quality and durable products, viewing waste reduction as an efficiency, and considering product circularity—that is, a commitment to extending the product's lifecycle and stewardship across the supply chain.

Specialist vehicle components. Credit: Varley Group.

DE-ODOURISING SHEEP MAKES THEM LESS APPEALING TO BLOWFLIES

A global research project involving the collaboration of an ARC-supported researcher at The University of Western Australia (UWA) with Dr Johan Greeff at the Department of Primary Industries and Regional Development Western Australia, has identified compounds in Merino sheep wool that are attractive to Australian blowflies.

The discovery could help breeders develop fly-resistant flocks of sheep, which will improve animal welfare and productivity.

The research team, which included ARC Discovery Early Career Researcher Award (DECRA) recipient at UWA, Dr Bjorn Bohman, says that the findings could help to prevent flystrike, a distressing disease caused by blowflies, which poses a significant health risk to sheep and which has been estimated to cost the agriculture industry $280 million annually.

The researchers say that identifying the compounds which attract flies, octanal and nonanal, is a step towards the development of approaches for preventing flystrike that are more clean, green and ethical in that they avoid the use of insecticides and mulesing.

The research was supported by Australian Wool Innovation Ltd and was undertaken as a part of the PhD studies of Dr Guanjie Yan, who was working at UWA with the support of the China Scholarships Council. Dr Yan established a technique for studying the sense of smell in flies and was able to show that blowflies react to individual odour compounds that are heritable in Merino sheep. This work now needs to be expanded to demonstrate whether it could lead to a more effective way to breed sheep that are resistant to flystrike.

THE STUDY SHOWED THAT MERINO SHEEP CLEARLY HAVE INDIVIDUAL DIFFERENCES IN THE CHEMICAL CONTENT OF THEIR WOOL—THE FLY-ATTRACTIVE WOOL CONTAINS VOLATILE COMPOUNDS NOT FOUND IN NON-ATTRACTIVE WOOL.

Images of Merino sheep used in the trial. Credit: UWA.

RECYCLING DENIM IN A NEW WAY

ARC-supported researchers at the *ARC Industrial Transformation Research Hub for Future Fibres*, based at Deakin University, have found an efficient, low-cost method that can convert waste denim into useable viscose-type fibres.

Previously, researchers have used ionic liquids—liquid salts—to dissolve cotton textiles into their cellulose building blocks. The cellulose was then spun into new viscose-type fibres that could be woven into textiles. However, ionic liquids are expensive and difficult to work with due to their high viscosity.

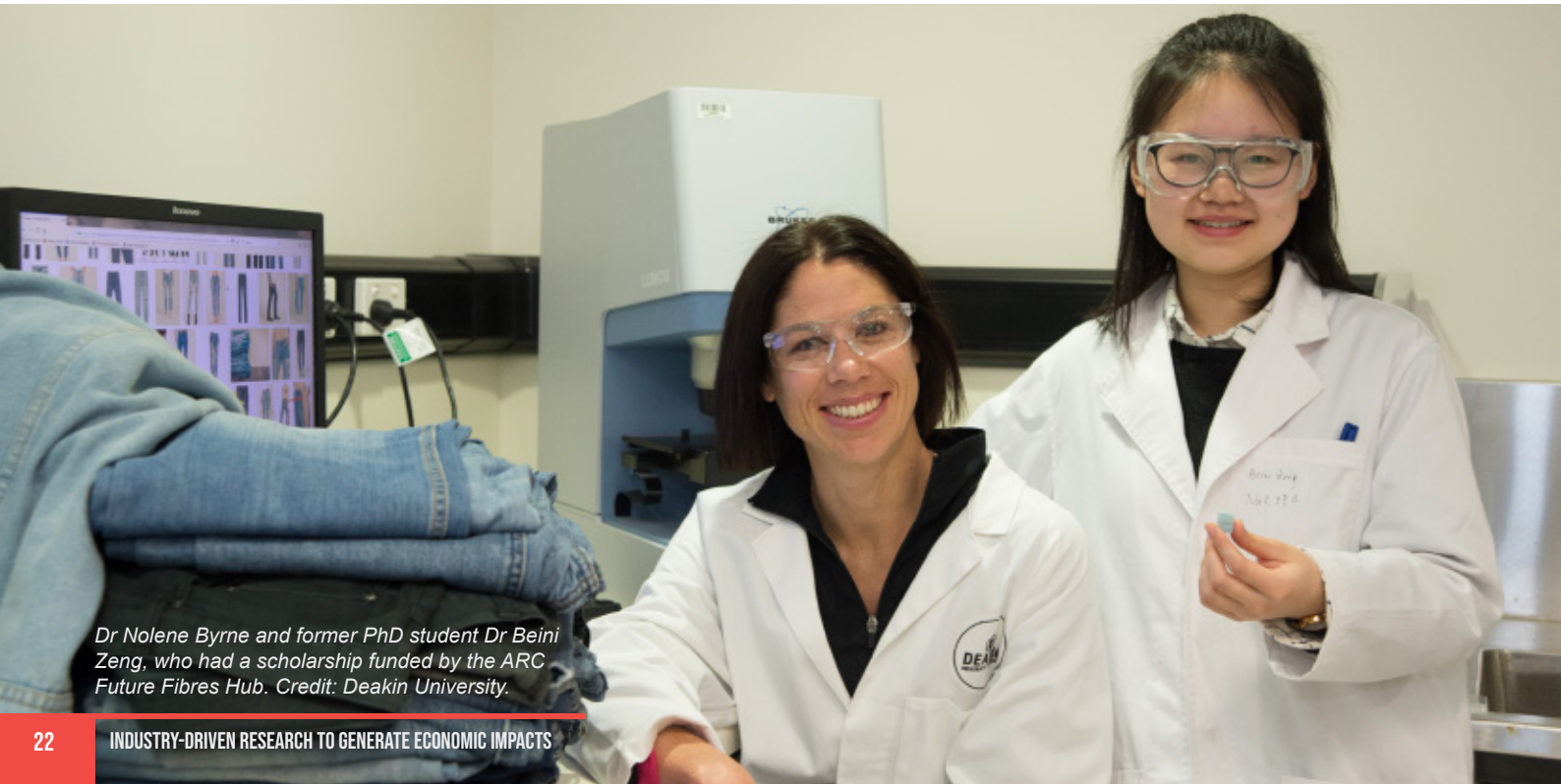
Given these issues, Chief Investigator Dr Nolene Byrne and her research team wanted to find a way to reduce the amount of these solvents required to recycle denim.

The researchers ground three textile samples (blue denim fabric, red denim pants and a mixed-colour t-shirt) into powders. Then they dissolved the powders in a mixture that included dimethyl sulfoxide (DMSO), using much less ionic liquid than other methods.

In addition, DMSO reduced the viscosity of the ionic liquid solution, making it easier to spin the cellulose into new fibres. Because DMSO is much cheaper than the ionic liquid, the new process reduced the cost of solvent by 77 per cent.

These new low-cost methods for textile recycling present a way for industry to reduce the vast quantity of clothing waste sent to landfill every year.

> THE NEW TECHNIQUE IMPROVES ON EXISTING RECYCLING METHODS, WHICH CAN BE INEFFICIENT AND EXPENSIVE, AND PROMISES TO REDUCE BOTH LANDFILL AND THE NEED TO GROW SO MUCH NEW COTTON.



Dr Nolene Byrne and former PhD student Dr Beini Zeng, who had a scholarship funded by the ARC Future Fibres Hub. Credit: Deakin University.

REINVENTING SUGARCANE INTO ENERGY

Professor Robert Henry, Director of the Queensland Alliance for Agriculture and Food Innovation (QAAFI) at The University of Queensland, has conducted experiments to tailor sugarcane production to produce biofuels and bioplastics.

This research, supported by the ARC *Linkage Projects* scheme, will support the Australian sugar industry through times of increased international competition and declining sugar prices.

Sugar is the last major cultivated plant to have its genome sequenced, and the researchers expect to see it fully decoded by the end of 2020.

Professor Henry says that having sugar's genetic template will allow them to look at growing sugarcane as a biofuel and a source of 100 per cent recyclable bioplastic, making it a viable substitute for petroleum in the production of countless items, from cosmetics to car parts.

The project has been supported by collaborating organisations, the US Joint BioEnergy Institute and Sugar Research Australia, working with QAAFI researchers to test a range of sugarcane varieties and identify which types produce ethanol most effectively and efficiently.

Sugarcane is ideal for renewables because it is fast-growing with abundant biomass and it is the research team's goal to reinvent sugarcane as a crop with a wider range of end uses.

> PROFESSOR HENRY SAYS THAT THE INDUSTRY MUST THINK BEYOND JUST PRODUCING SUGAR, TO ALSO PRODUCING ELECTRICITY, BIOFUELS FOR TRANSPORTATION, AND OILS TO REPLACE TRADITIONAL PLASTICS.

Professor Robert Henry. Credit: UQ.

BREAKTHROUGH IN PLANT NUTRIENT DETECTION

Findings from the La Trobe University node of the *ARC Centre of Excellence for Plant Energy Biology*, which is led by Professor James Whelan, could lead to less fertiliser wastage, saving millions of dollars for Australian farmers.

Lead researcher of the project, Dr Ricarda Jost, said that in countries like Australia where soils are phosphorus poor, farmers are using large amounts of expensive, non-renewable phosphorus fertiliser, such as superphosphate or diammonium phosphate (DAP), much of which is not being taken up effectively by crops at the right time for growth.

Using *Arabidopsis thaliana* (thale or mouse-ear cress) shoots, the research team, under the supervision of Dr Jost and including PhD student Marina Borges Osorio, conducted genetic testing by adding phosphorus fertiliser and observing the behaviour of mutants with altered phosphorus levels.

Bioinformatic analysis uncovered a protein called SPX4 that can sense vital phosphorus levels—the 'fuel in the tank'—in plants and then adjust growth and flowering in response.

Dr Jost says that the protein senses when the plant has taken in enough phosphorus and tells the roots to stop taking it up. If the fuel pump is turned off too early, this can limit plant growth. Interestingly, the researchers found that the same protein seems to have a 'moonlighting' activity, where it activates beneficial processes such as seed production.

The findings provide a deeper understanding of the mechanisms whereby plants sense how much and when to take in the essential nutrient, phosphorus, for optimal growth. The *ARC Centre of Excellence for Plant Energy Biology* is administered by The University of Western Australia.

Lead Researcher Dr Ricarda Jost from the Department of Animal, Plant and Soil Sciences at La Trobe University. Credit: La Trobe University.

GREATER UNDERSTANDING OF HOW SPX4 OPERATES COULD LEAD TO A MORE PRECISE IDENTIFICATION OF THE GENES IT REGULATES, AND AN OPPORTUNITY TO CONTROL THE PROTEIN'S ACTIVITY USING GENETIC INTERVENTION—SWITCHING ON THE POSITIVE AND SWITCHING OFF THE NEGATIVE RESPONSES.

"TRYING TO FIND MATHEMATICAL PATTERNS AND SOLUTIONS THAT MAY IMPROVE BUSINESS OPERATIONS AND PROCESSES FOR INDUSTRY IS A CHALLENGING, BUT REWARDING TASK," SAYS PROFESSOR LOXTON.

Professor Ryan Loxton. Credit: Curtin University.

SPEARHEADING A MATHEMATICAL APPROACH TO SOLVE BUSINESS PROBLEMS

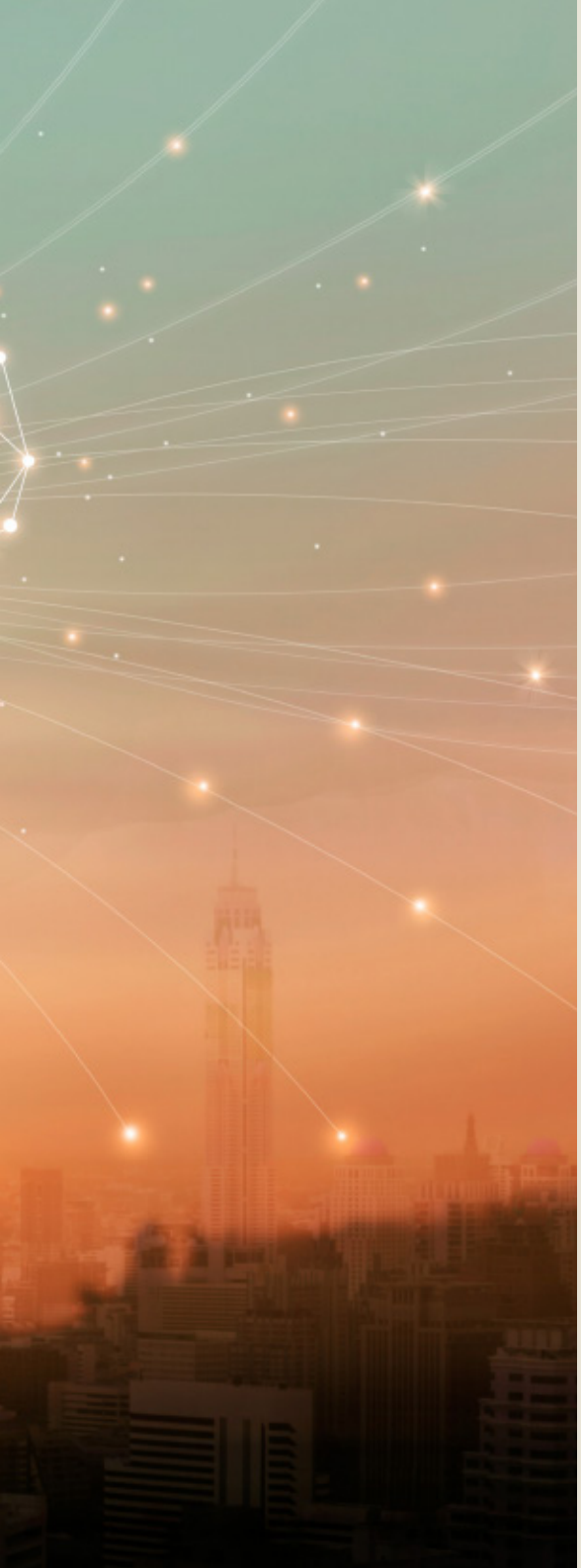
Professor Ryan Loxton, a mathematician from Curtin University's School of Electrical Engineering, Computing and Mathematical Sciences, is taking mathematics into new domains with an ARC Future Fellowship that tackles complexity in business decision-making with rigorous mathematical theory.

Professor Loxton's research uses mathematical techniques to solve real-world problems by optimising processes in the oil and gas, agriculture, and mining industries, and making them more efficient, cost-effective and less environmentally damaging.

Professor Loxton has worked on a number of collaborative projects with industry partners, and as a Chief Investigator and theme leader at the *ARC Training Centre for Transforming Maintenance through Data Science*, he is working with a team of researchers to analyse maintenance data and develop optimal strategies for long-term maintenance planning. This research is a collaborative effort with the Training Centre's partner organisations which include Alcoa Ltd, BHP Billiton and Roy Hill Holdings.

At the Training Centre, Professor Loxton supervises two postdoctoral researchers, one PhD student, and one honours student, and he is a mentor for other junior researchers in the centre, providing opportunities for them to get involved in applied mathematics projects with industry partners to complement their academic experience.

Abstract science. iStock.com/ipopba.



DEVELOPING INNOVATIVE TECHNOLOGIES

2D MATERIALS FOUND TO THRIVE IN SPACE CONDITIONS

Dr Tobias Vogl and ARC Australian Laureate Fellow, Professor Ping Koy Lam, along with colleagues at The Australian National University (ANU) node of the *ARC Centre of Excellence for Quantum Computation and Communication Technology* (CQC^2T), have discovered a number of 2D materials that can not only withstand being sent into space, but can potentially thrive in the harsh conditions.

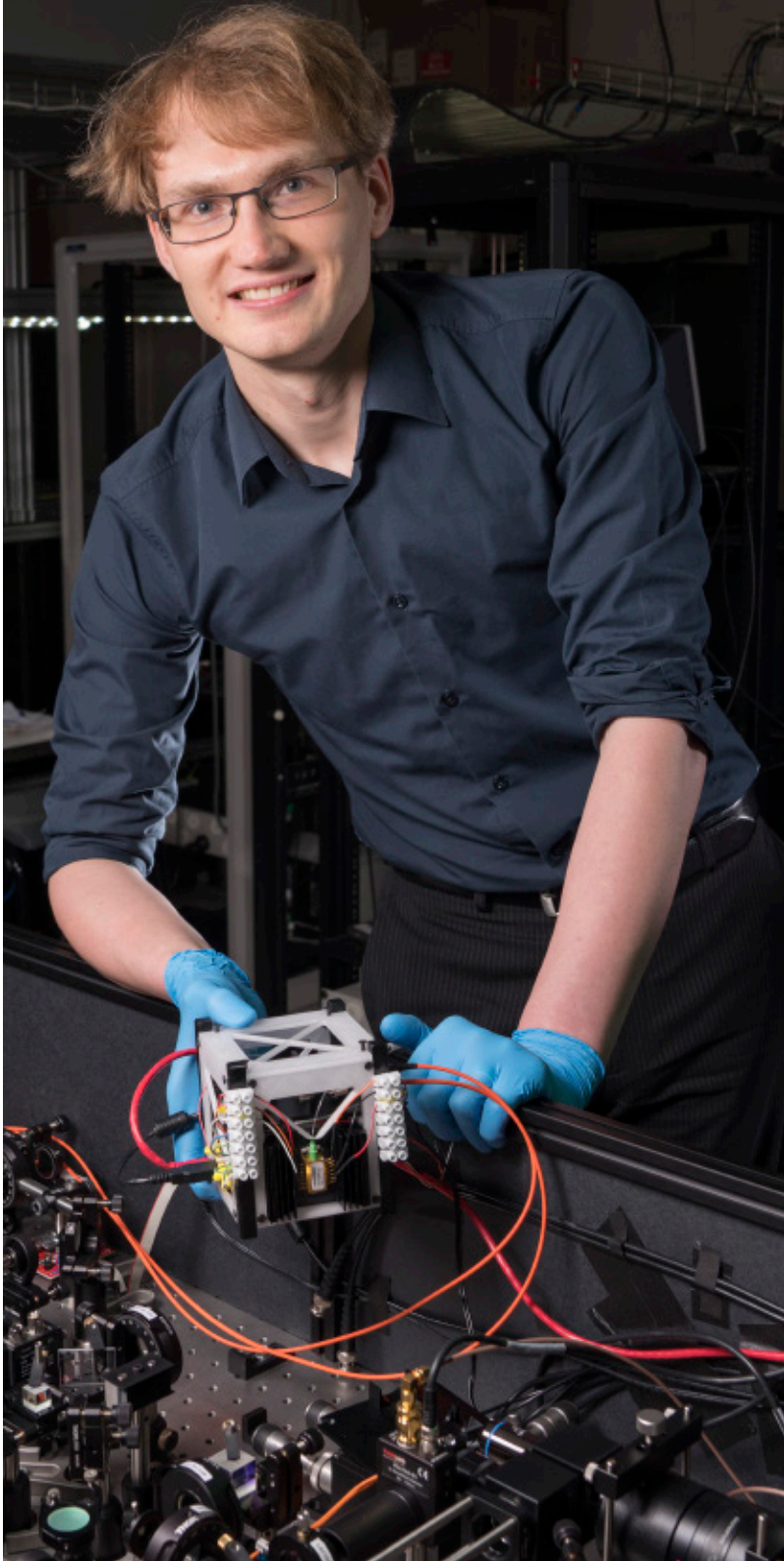
During a satellite's orbit around the earth, it is subject to heating, cooling, and radiation. Previous research has demonstrated the robustness of 2D materials when it comes to temperature fluctuations, but the impact of radiation was unknown.

The researchers set out to test a range of 2D materials to radiation levels comparable to what is experienced during a satellite's orbit around the earth. Surprisingly, they found the properties of some materials actually improved after exposure to radiation.

> "A MATERIAL GETTING STRONGER AFTER IRRADIATION WITH GAMMA RAYS—IT REMINDS ME OF THE INCREDIBLE HULK!" SAID ANU RESEARCHER, DR TOBIAS VOGL.

The discovery could influence the type of materials used to build everything from satellite electronics to solar cells and batteries—making future space missions more accessible, and cheaper to launch.

In light of the recent establishment of the Australian Space Agency, the work also shows that Australian researchers can compete internationally in using quantum technology to enhance space instrumentations. CQC^2T is administered by The University of New South Wales.



Dr Tobias Vogl, holding a prototype of a CubeSat which contains a fully operational quantum light source, alongside an experimental setup for testing it. Credit: Lannon Harley, ANU.

ARTIFICIAL LEAVES TO ABSORB CO_2

A team of researchers including ARC-supported Professor Jun Huang from The University of Sydney's School of Chemical and Biomolecular Engineering is developing a carbon capture method that aims to go one step beyond storage, instead converting and recycling carbon dioxide (CO_2) into raw materials that can be used to create fuels and chemicals.

The team built microplates of carbon, layered with carbon quantum dots with tiny pores that absorb CO_2 and water, in order to simulate the natural process of photosynthesis. Once carbon dioxide and water are absorbed, a chemical process occurs that combines both compounds and turns them into hydrocarbon, an organic compound that can be used for fuels, pharmaceuticals, agrichemicals, clothing, and construction.

While the CO_2-absorbent plates are currently small, Professor Huang says that the end goal is to create large panels, similar to solar panels, that can be used by industry to absorb and convert large volumes of CO_2.

Eventually the technology could be used by power stations to capture emissions from burning fossil fuels, which along with transport, are recognised by scientists as the main cause of global warming, contributing up to 65 per cent of the total global greenhouse gas emissions.

The researchers say that, in contrast to carbon capture and storage, carbon conversion could be financially viable as it would allow for the generation of industrial quantities of materials, such as methanol, which is a useful material for production of fuels and other chemicals.

> "DRAWING INSPIRATION FROM LEAVES AND PLANTS, WE HAVE DEVELOPED AN ARTIFICIAL PHOTOSYNTHESIS METHOD," SAYS PROFESSOR HUANG.

Plants absorb carbon dioxide and 'breathe' out oxygen. Credit: Luisa Low/University of Sydney.

ULTRATHIN GRAPHENE FILM EFFICIENTLY ABSORBS ENERGY FROM THE WARM RAYS OF THE SUN

ARC Discovery Early Career Researcher Award (DECRA) recipient, Professor Baohua Jia, has led a group of researchers at the Centre for Translational Atomaterials (CTAM), Swinburne University of Technology, The University of Sydney and The Australian National University in a collaboration to develop an ultrathin graphene film with unique properties that has great potential for solar thermal energy harvesting.

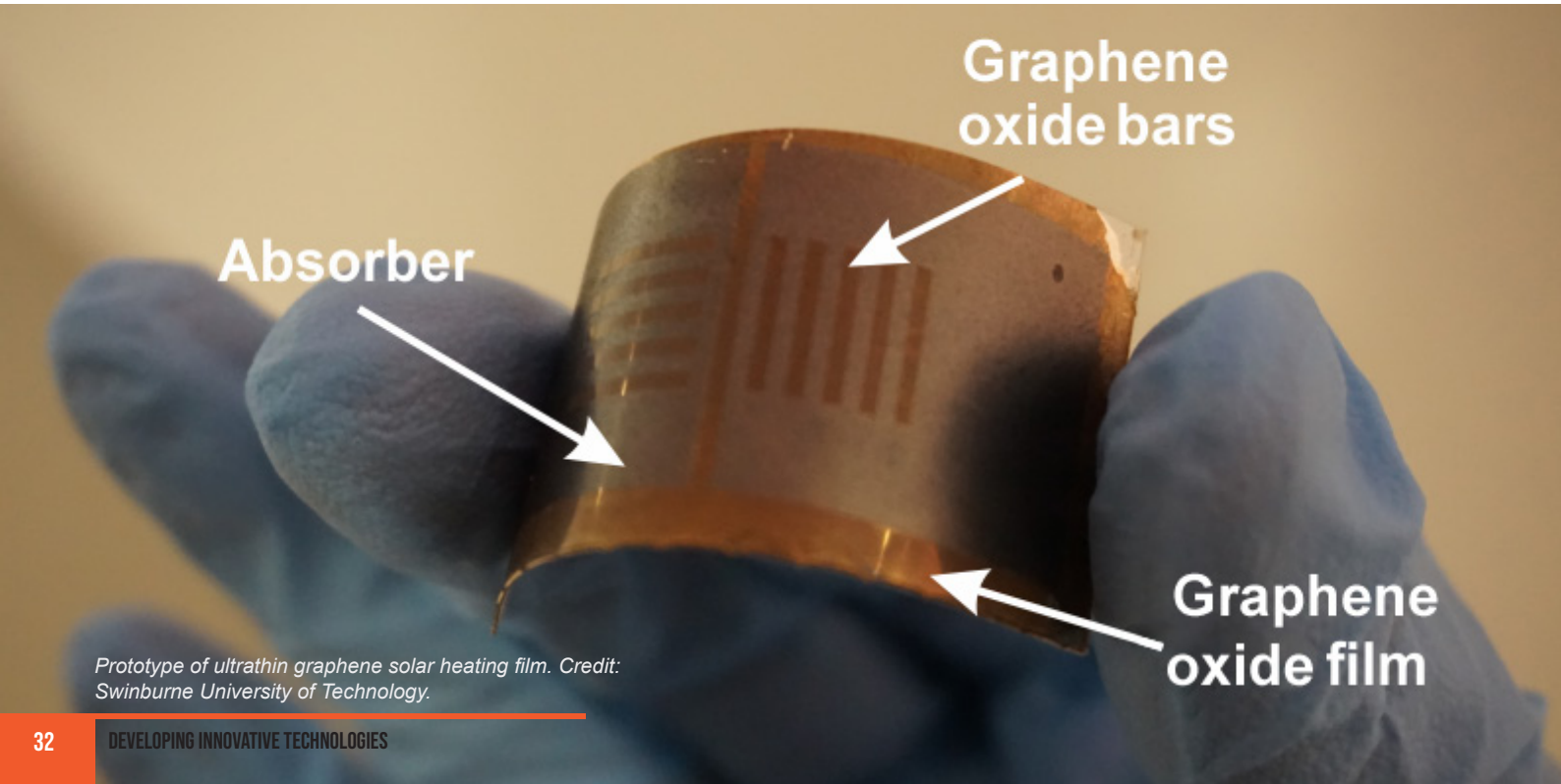
The research team developed a new class of optical material that is 1000 times finer than a human hair, and able to rapidly heat up to 160°C under natural sunlight in an open environment.

The material includes a layer of graphene oxide with special coated grating structures that were fabricated with a method using lasers that is scalable and low cost.

The discovery opens up many exciting applications, with potential for the conversion of the sun's heat into electricity, solar-powered seawater desalination, optical interconnectors and photodetectors.

The researchers say that the collaboration, which was supported through the ARC's *Discovery Projects* scheme, shows what can be achieved when different universities bring their own expertise to discover new science and its applications.

> RESEARCHERS SAY THE NEW ULTRATHIN FILM COULD EVEN LEAD TO THE DEVELOPMENT OF 'INVISIBLE CLOAKING TECHNOLOGY' THROUGH DEVELOPING LARGE-SCALE THIN FILMS ENCLOSING THE OBJECTS TO BE 'HIDDEN'.



Prototype of ultrathin graphene solar heating film. Credit: Swinburne University of Technology.

20 YEARS OF RESEARCH LEADS TO AIRPORT EXPLOSIVES DETECTOR

A University of Tasmania (UTAS) research team led by Professor Michael Breadmore has taken an invention from its first inception at the UTAS-based Australian Centre for Research on Separation Science, right through to commercialisation—with ARC support all along the way.

Separation science involves the study of fundamental processes and materials for the separation and measurement of specific molecules, usually when these are present in very complex mixtures. With innovation partner Grey Innovation, the research team has developed a device which uses techniques from separation science to identify inorganic explosives in under a minute. A new company, GreyScan Australia Pty Ltd, has been formed to market the device for use by first responders and checkpoint operatives in a variety of detection scenarios—including military, public security, cargo and mail screening, passenger screening, commercial premises and major events.

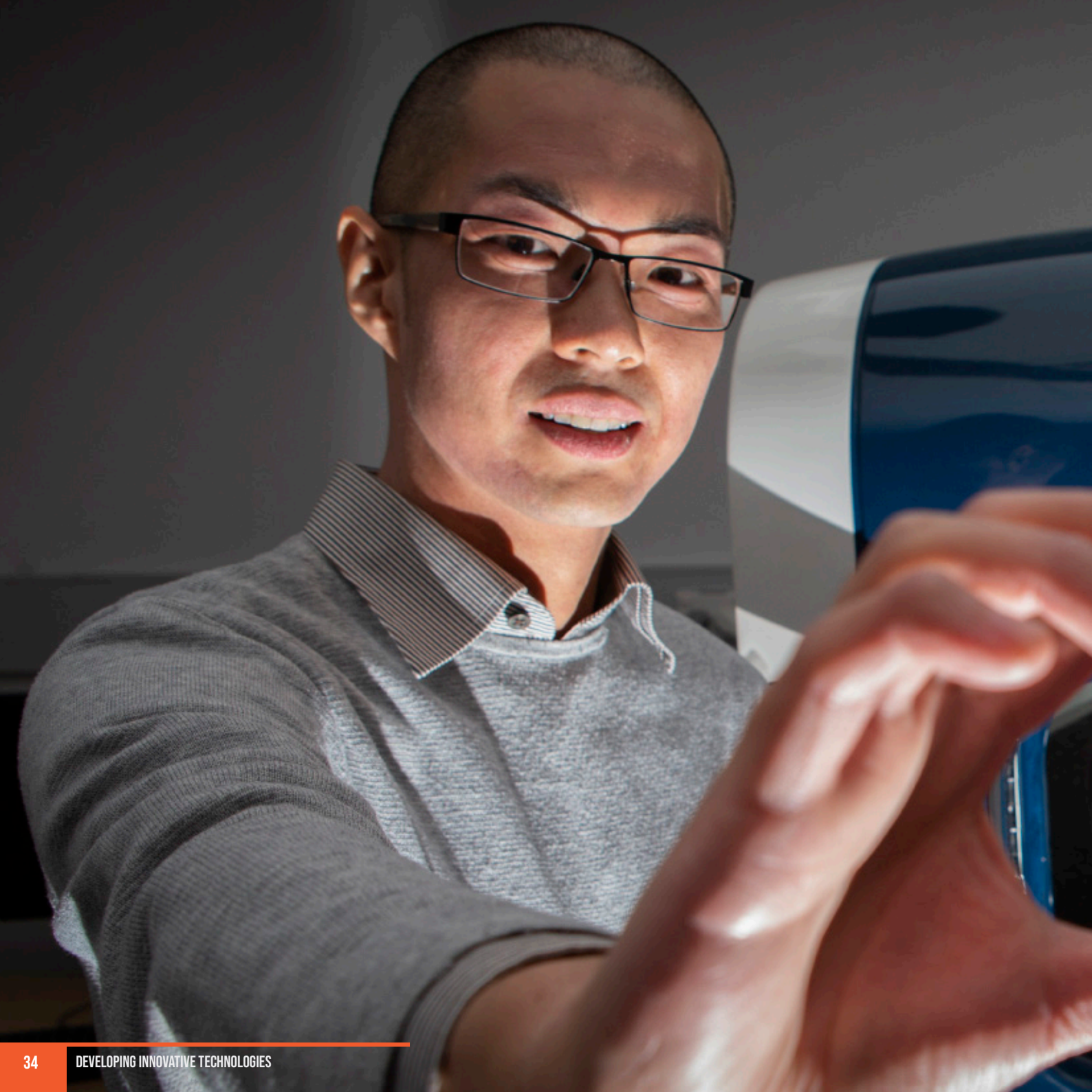
Until now, it has not been possible to detect the full range of inorganic explosives materials with speed and accuracy in the field. The new device quickly and accurately identifies ingredients commonly used in improvised explosives devices, extending current security capabilities by complementing traditional explosives trace detectors. The device received national academic and commercial recognition, with the team awarded the 2019 Eureka Prize for Outstanding Science in Safeguarding Australia.

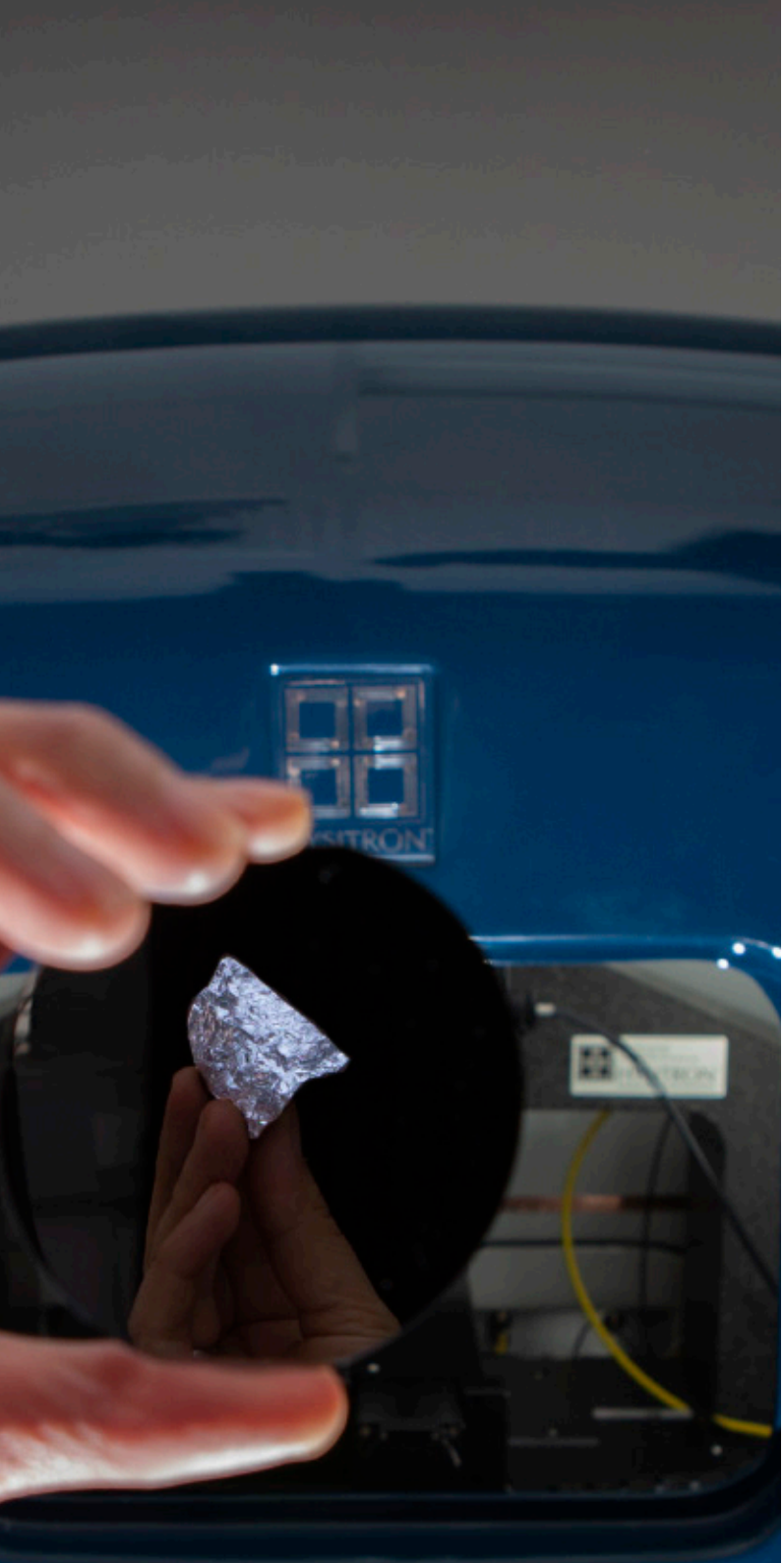
Professor Breadmore says the project was underpinned by fundamental research supported through Discovery Projects grants awarded to Paul Haddad in the late 1990s and early 2000s, and through partnerships with the Australian Customs Service, Australian Federal Police and National Institute of Forensic Science, which began in 2006.

Through a Linkage Projects grant, the team has leveraged this technology base for near real-time monitoring of nutrients, with a second company, EcoDetection Pty Ltd, created to bring it to market.

> "CONTINUED FUNDING SUPPORT THROUGH THE ARC MEANT I INITIALLY HAD SPACE TO FOCUS ON FUNDAMENTAL RESEARCH. NOW I'M TURNING THIS EXPERTISE INTO RESEARCH TRANSLATION FOR INDUSTRY," SAYS PROFESSOR BREADMORE.

The GreyScan device can identify organic explosives in under a minute. Credit: GreyScan Pty Ltd.





TWEAKING SILICON TO IMPROVE SOLAR CELLS FOR CHEAPER ENERGY

An international research team led by researchers at The Australian National University (ANU), including ARC Future Fellowship recipient, Professor Jodie Bradby, has made a new type of silicon that better uses sunlight and promises to cut the cost of solar technology.

Silicon is a preferred raw material for solar cells due to its abundance, low cost and non-toxicity, even though the standard form of silicon used in solar cells cannot make use of all the available solar energy.

The researchers discovered that by simply prodding the silicon with a microscopic hard tip, they could change its crystal form into something more efficient. The new type of silicon is called r8-Si. Instead of the atoms being square or cubic, as in standard silicon, they form a complex shape, like a diamond in 3D.

Discovered while exploring a little-known property of silicon—its ability to exist in different crystal forms—the researchers say their world-first invention could help reduce the costs of renewable electricity through more efficient solar cells.

The team is now using a unique high-pressure facility at the ANU to develop ways of making enough material to produce a prototype solar cell, which will enable them to measure exactly how the new silicon absorbs light and behaves electrically.

> "WE NOW NEED TO SCALE UP AND THEN WORK ON INTEGRATING THIS MATERIAL INTO EXISTING SOLAR INDUSTRIES," SAYS PROFESSOR BRADBY.

Dr Sherman Wong worked on the study of the new type of silicon for his PhD at ANU. Credit: ANU.

Coral in a reef at Febrina, Papua New Guinea.
Credit: Morgan Bennett-Smith.

ADVANCING ENVIRONMENTAL SCIENCE AND MANAGEMENT

HELP OR HINDRANCE? UNTANGLING THE ROLE OF WOODY LIANA VINES

A research team led by ARC Future Fellow, Associate Professor Andy Marshall from the University of the Sunshine Coast, is focussing on determining whether lianas—woody vines—help or hinder the recovery of forests after damage caused by tree-felling or cyclones, through the Forest Restoration and Climate Experiment (FoRCE).

Collaborating with the Wet Tropics Management Authority, various levels of government, local conservation groups, and private landowners, the researchers are gathering the data that underpins the daily forest management decisions about the finely balanced positive and negative impacts of these vines.

Dr Marshall says that lianas often grow extensively over the top of trees in disturbed tropical forests, slowing their growth and hence affecting the global carbon sink. But these lianas also protect forests from fire and cyclones, and if not properly managed, dried lianas can act as fuel for fires.

Increasing fire resulting from climate change is likely to worsen this effect because some forests will likely become too dry for lianas, leaving dried out vegetation behind for fires to spread—even up into the forest canopy. Such fire behaviour is unusual for rainforest areas, but Dr Marshall says that such fires have occurred recently in north Queensland, which is of great concern for forest managers.

Conducting the research involves gruelling, tropical field work. In Australia, the primary focus is the cyclone-impacted region around the Cassowary Coast and Atherton Tablelands, as well as areas from Lockhart River all the way down into areas of New South Wales where lianas grow. At the same time, the research team is mirroring the work in East Africa.

The research is helping to inform forest managers about how best to manage lianas that are smothering disturbed areas of forests—and answer questions such as whether liana vines should be cut away to free the trees, or left in place to protect trees from strong winds and fire.

By analysing the effects of lianas on forest recovery globally, the research is also revealing fundamental information about how forests work. In particular, the team will be searching for ‘thresholds’ of liana abundance that might be critical to forest recovery.

> “IF FORESTS HAVE FEW LIANAS THEN THEY HAVE LESS PROTECTION AND LESS DIVERSITY, WHICH MEANS THEY’RE LESS HEALTHY—BUT IF THEY HAVE TOO MANY LIANAS, THEN THESE FORESTS MAY NOT RECOVER. BOTH SCENARIOS WILL HAVE LASTING IMPACTS ON THE EARTH AND SO OUR RESEARCH IS WORKING TO GET ONE STEP AHEAD OF THAT,” DR MARSHALL SAYS.

Research assistant Gerard Kyasapa cutting a vine thicket in Tanzania. Credit: Andrew R Marshall.

FOR A FISH, IT'S NOT JUST WHO YOU ARE, BUT WHERE YOU ARE

ARC-supported research has determined that the long-term success of clownfish depends more on living in a 'good neighbourhood' than it does on good genes.

The natural home of the clownfish is the anemone, but not all anemones are equal.

Professor Geoff Jones, from the *ARC Centre of Excellence for Coral Reef Studies* at James Cook University, and his international research collaborators, found that the reproductive success of the clownfish depends almost entirely on having a high-quality anemone home.

Finding a suitable anemone to live in often comes down to luck—being in the right place at the right time—although in terms of their genes, clownfish strive to be as good as they can be at finding a suitable habitat.

The quantitative genetic study comprises ten years of research on the coral reefs of Papua New Guinea. Family trees for up to five generations were established for the entire clownfish population at an island in Kimbe Bay, a well-known biodiversity hot spot.

One implication of the findings is that as long as high-quality anemones remain healthy, this will ensure the clownfish population can persist. However, the researchers note, anemones, and coral reefs in general, are under direct threat from the impacts of climate change.

> "THE SUCCESS OF BIG CLOWNFISH FAMILIES THAT EXTEND OVER MANY GENERATIONS IS LINKED TO HIGH-QUALITY HABITATS, NOT THEIR SHARED GENES," SAYS PROFESSOR JONES.

The research team at Kimbe Bay in 2017. Credit: Tane Sinclair-Taylor.

‘WHOOPI’ THE MANTA RAY SHOWS HOW HEALING’S DONE

‘Whoopi’ the manta ray—a regular visitor to Western Australia’s Ningaloo Reef—has helped ARC-supported researchers at The University of Queensland (UQ) and Murdoch University to study the impressive ability of rays to heal.

Whoopi, who has swum with thousands of tourists over the years, was hit by a boat in 2015, suffering propeller cuts measuring up to 20 centimetres to the edge of her wing.

Dr Christine Dudgeon from UQ’s School of Biomedical Sciences said such a strike was relatively rare, but could cause significant injuries to the animal.

Dr Dudgeon said that manta rays don’t surface to breathe, which you think would reduce their susceptibility to boat strike. But these rays, like whale sharks, tiger sharks and other sharks and rays, spend considerable time in surface waters for activities like basking and feeding.

The research team analysed Whoopi's propeller cuts using laser photogrammetry, and found that the wounds had healed by 50 per cent only 46 days after the boat strike, and by day 295, had healed by 95 per cent.

Professor Anthony Richardson from UQ’s Centre for Applications in Natural Resource Mathematics, and Chief Investigator on an ARC Linkage Projects grant which supported the research, said the results were impressive.

The findings have implications for wound healing rates in other elasmobranchs (rays and sharks), and for policies to reduce the impact of vessels on manta rays and protect their critical habitat.

Whoopi the Manta Ray. Credit: Alex Kydd.

> “WHOOPI SHOWED US JUST HOW FAST THESE BEAUTIFUL CREATURES CAN HEAL,” SAYS PROFESSOR ANTHONY RICHARDSON.

PLASTIC POLLUTION HARMS OXYGEN-PRODUCING OCEAN BACTERIA

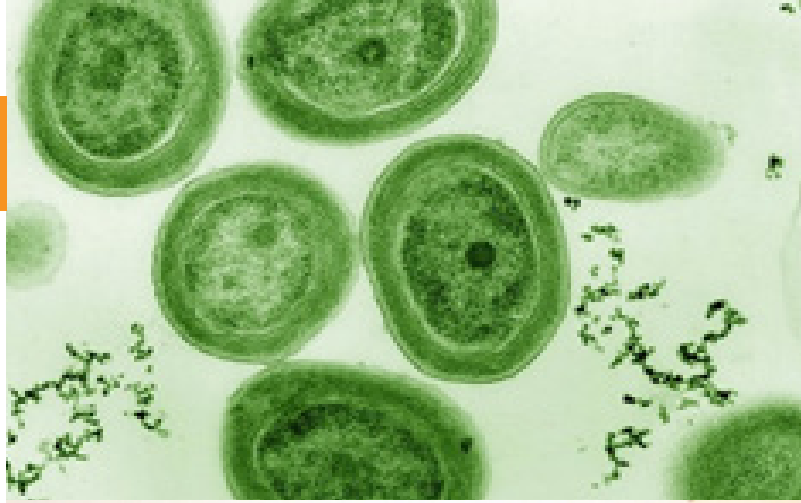
A research team led by ARC Discovery Early Career Researcher Award (DECRA) recipient, Dr Sasha Tetu, and including ARC Australian Laureate Fellow, Professor Ian Paulsen, has shown that a group of ocean bacteria, critical to the world's oxygen supply, are susceptible to plastic pollution.

Researchers have estimated that plastic pollution causes more than US$13 billion in economic damage to marine ecosystems each year, and the problem is only getting worse. The amount of marine plastic pollution is estimated to be so large, and increasing so much, that it will outweigh the fish in the oceans by 2050.

This pollution poses well-known threats to animals who are injured or killed by ingesting it or by getting entangled in plastic debris. However, plastic can also leach a variety of chemical additives into marine environments, and the threat that these leachates pose to marine life has received comparatively little attention.

The research team performed laboratory experiments to show that these leached chemicals impair the growth and function of a tiny, green bacteria called Prochlorococcus, which is probably the most abundant *photosynthetic* organism on Earth, responsible for up to ten percent of global oxygen production.

These photosynthetic bacteria are also critical to the marine food web and contribute to carbon cycling. The implication of the discovery is that plastic pollution may have serious widespread ecosystem impacts beyond the already known effects on larger animals.



TEN PER CENT OF THE OXYGEN WE BREATHE COMES FROM JUST ONE KIND OF BACTERIA IN THE OCEAN.

(Top): SEM of Prochlorococcus marinus pseudo-coloured. Source: Wikipedia.
(Below): Dr Sasha Tetu, with PhD student, Ms Indrani Sarker. Flasks show healthy marine bacteria Prochlorococcus *(green) and bleached, dead cultures following exposure to plastic leachates.*

"WHAT WAS CONCERNING WAS THAT THE DEAD MANGROVE FOREST EMITTED ABOUT EIGHT TIMES MORE METHANE THAN THE LIVING FOREST," SAYS DR LUKE JEFFREY.

MANGROVE DIEBACK REVEALS AN UNEXPECTED SOURCE OF METHANE

ARC-supported researchers from Southern Cross University were some of the first on the scene to investigate the unprecedented dieback of mangrove forests along a 1000 kilometre stretch of coastline in northern Australia's Gulf of Carpentaria.

The loss of 7,400 hectares of mangrove forest occurred during 2015-2016, and is thought to be the result of a combination of extreme temperatures, drought and lowered sea levels.

Supported by ARC funding, Dr Luke Jeffrey, who was a PhD candidate at the time, and a large multidisciplinary research team led by ARC Discovery Early Career Researcher Award (DECRA) recipient, Associate Professor Damien Maher, headed to the Gulf of Carpentaria to examine the consequences.

The team had an opportunity to compare methane emissions from mangrove tree-stems in living forest with those from the dead mangrove forests, to understand what happens when climatic-change stressors result in forest mortality.

The researchers say the results revealed that while living mangroves emit some methane, dead mangroves emit much more. This discovery has significant implications for greenhouse gas emissions from these valuable coastal habitats. It is also the first time that scientists have been able to quantify emissions from mangrove tree-stems, and adds to our understanding of the role of these ecosystems globally.

The research team on the way to measuring methane emissions from a forest of dead mangroves in the Gulf of Carpentaria.
Credit: Southern Cross University.

REVEALING THE WORLD'S BIGGEST PARROT: 'HERACLES'

Australasian palaeontologists, with ARC funding support, have discovered the world's largest parrot from a fossil deposit in Central Otago, New Zealand. The new bird has been named *Heracles inexpectatus* to reflect its Herculean myth-like size and strength—and the unexpected nature of the discovery.

The fossil is approximately the size of the giant 'dodo' pigeon of the Mascarenes, and twice the size of the critically endangered flightless New Zealand kakapo, previously the largest known parrot.

The researchers estimate Heracles to have stood one metre tall, weighing about seven kilograms, and believe that with a massive beak able to crack most food sources, it may have dined on more than conventional parrot foods, perhaps even on other parrots.

The experts include Discovery Early Career Researcher Award (DECRA) recipient, Associate Professor Trevor Worthy from Flinders University, as well as colleagues at The University of New South Wales and Canterbury Museum in New Zealand.

The fossil deposit that the researchers are slowly working through contains the remains of many terrestrial birds, and other animals that lived in New Zealand since the time of the dinosaurs. Professor Worthy says that they are likely to unearth many more surprises and new species.

> NEW ZEALAND IS WELL KNOWN TO PALAEONTOLOGISTS FOR ITS GIANT BIRDS, INCLUDING MOAS, GIANT GEESE, ADZEBILLS, AND A GIANT EAGLE, BUT UNTIL NOW NO-ONE HAS EVER FOUND AN EXTINCT GIANT PARROT.

(Top): Reconstruction of the giant parrot Heracles, dwarfing a bevy of 8cm high Kuiornis—small New Zealand wrens scuttling about on the forest floor. Illustration by Dr Brian Choo, Flinders University. (Left): Graphic showing the Heracles inexpectatus *silhouette next to an average height woman and common magpie. Credit: Professor Paul Scofield, Canterbury Museum.*

SCIENTISTS MEASURE THE LOSS OF SHARK BAY SEAGRASS

An international research team led by ARC-supported researchers at Edith Cowan University has investigated the huge loss of seagrass that was the result of a marine heatwave in the Shark Bay UNESCO World Heritage site in Western Australia.

Halfway up Australia's west coast, the bay is home to the world's largest and most diverse seagrass ecosystem, an important habitat for a wide variety of fish and other marine animals such as dugongs.

But since the heatwave during the summer of 2010-11, up to nine million metric tons of carbon dioxide (CO_2) have been released into the atmosphere as a result of seagrass loss—the equivalent to the annual CO_2 output of 800,000 homes or 1,600,000 cars driven for 2 months.

Co-lead author and ARC Discovery Early Career Researcher Award (DECRA) recipient, Dr Oscar Serrano, is examining how global issues such as coastal development and climate change are impacting seagrass in Australia.

Dr Serrano says the heatwave and subsequent release of carbon dioxide was unprecedented, with more than 20 per cent of meadows lost, equivalent to 1,000km2.

Through this research, the researchers are highlighting the need to develop strategies to deal with the impact of climate change and extreme weather events, and helping to highlight the importance of seagrass beyond its importance to the marine ecosystem.

THE RESEARCH INTO THE HEALTH OF SHARK BAY'S SEAGRASS MEADOWS IS INFORMING POLICY ON CLIMATE CHANGE AND THE PROTECTION OF COASTAL ECOSYSTEMS.

A researcher holds a lump of dead seagrass. Credit: Paul Lavery.

FIGHTING POLLUTION WITH MATHS

ARC-supported researchers at the *ARC Centre of Excellence for Mathematical and Statistical Frontiers* (ACEMS), in collaboration with scientists at the Queensland Department of Environment and Science, have developed statistical predictive tools that could lead to the deployment of low-cost sensors to measure sediment and nutrient levels in the rivers and streams that flow into coastal waters along the Great Barrier Reef.

The researchers say the sensors will help to manage one of the biggest threats facing the Great Barrier Reef, which is pollution from land making its way to the ocean. The ACEMS researchers, including Associate Professor Erin Peterson, Professor Rob Hyndman, Dr Catherine Leigh, Dr Sevvandi Kandanaarachchi and Professor Kerrie Mengersen, say there is a desire to complement water quality data from long-term monitoring stations with finer scale data from lower cost sensors to ultimately provide more frequent data from more locations.

At present, low-cost sensors aren't yet able to show the two things that are most important in determining water quality—direct measures of sediments and nutrients. However, the new statistical tools developed by ACEMS will have the potential to take sensor measurements like turbidity and conductivity data and use them to predict levels of sediments and nutrients in the water. This will enable water agencies to forecast levels of sediments and nutrients in rivers, and automatically plot how those values change over time.

A total of seven ACEMS researchers from QUT and Monash worked together on the project, a collaboration between ACEMS researchers and the Queensland Government that came together because of a need by Queensland Government to manage big data. A new ARC Linkage Project, led by Professor Mengersen, partnered with the Queensland Government and in collaboration with researchers from QUT, Monash, and RMIT University is now expanding on this work to revolutionise water quality monitoring in the information age. ACEMS is led by The University of Melbourne.

> "RIGHT NOW, SOMEONE HAS TO PHYSICALLY GO TO WHERE THE MONITORING STATION IS, GET A SAMPLE, TAKE IT BACK TO A LAB AND TEST IT. IF WE CAN AUTOMATE THIS PROCESS WITH THE SENSORS, WE CAN GET A LOT MORE FREQUENT PREDICTIONS OF WHAT'S HAPPENING," SAYS DR KANDANAARACHCHI.

DES Water Quality & Investigations (WQI) team members on the Mulgrave River. Image courtesy of the Queensland Government.

To avoid disrupting the light-sensitive corals, researchers wear red headlamps as they work in the National Sea Simulator during coral spawning. Credit: Marie Roman, Australian Institute of Marine Science.

LEADING AN EVOLUTION IN CORAL

ARC Australian Laureate Fellow, Professor Madeleine van Oppen, is leading a research team based at the Australian Institute of Marine Science (AIMS) and The University of Melbourne, on a visionary research project—attempting to breed coral able to withstand climate change.

Rising temperatures and acidification in oceans pose existential threats to coral reefs around the world, with Australia's Great Barrier Reef suffering from extensive coral bleaching in 2016, 2017 and 2020. There is now great concern that the rate of environmental change is outpacing the natural capacity of corals to acclimatise, adapt and survive.

Working with corals housed at the AIMS National Sea Simulator in Townsville, using cross breeding, microbiome manipulation and algae adaptation techniques, Professor van Oppen and her team are working against the clock to develop resilient breeds of coral that can survive in warmer ocean temperatures. By approaching the challenge from diverse directions, van Oppen hopes that they can 'assist evolution', by introducing more robust genetic stock into damaged coral reef ecosystems.

The concept was first floated in a paper Professor van Oppen published in 2015 with Ruth Gates, a renowned coral biologist and conservation advocate from the University of Hawaii who sadly passed away in 2018. The duo progressed the idea with a $USD 4 million grant from the charitable foundation of the late Paul Allen, a co-founder of Microsoft.

The research team has begun field trials, with the introduction of baby hybrid corals growing on terra cotta tiles into the Great Barrier Reef in 2019, to monitor their survival and growth. By increasing our understanding of what makes coral resilient, and taking direct intervention, Professor van Oppen hopes to increase the chance of coral reefs persisting for future generations to enjoy.

> "IT'S HUMANITY'S FAULT THAT CORALS ARE IN HOT WATER. NOW IT'S UP TO HUMANITY TO HELP THE CORALS KEEP UP," SAYS PROFESSOR VAN OPPEN.

Rock Painting. iStock.com/Cay-Uwe.

INDIGENOUS RESEARCH AND COLLABORATION

Please note: Aboriginal and Torres Strait Islander people should be aware that this section contains an image and the names of deceased persons.

INDIGENOUS COLLABORATION VITAL TO CONSERVATION RESEARCH OUTCOMES

ARC-supported researchers have produced hard data that demonstrates that collaborating with Indigenous peoples changed the outcome of a scientific research project. It is the first empirical evidence that culturally-diverse teams produce improved results in conservation research.

Dr Georgia Ward-Fear, a conservation biologist and herpetologist (someone who studies amphibians and reptiles) from the School of Life and Environmental Sciences at The University of Sydney, said this was the first published study to measure the scientific contribution that Indigenous peoples bring to a research project, beyond the moral or ethical value.

Dr Ward-Fear and her team have been working to protect large goannas from the devastating impacts of invasive, poisonous cane toads.

The aversion training, developed with ARC Australian Laureate Fellow, Emeritus Professor Rick Shine, has been hugely successful and is now being rolled out on a large scale via the Cane Toad Coalition, a consortium of scientists, and conservation organisations with extra support from the WA Parks and Wildlife service.

The researchers say the success of the initial project would not have been possible without the input of the Balanggarra Rangers, who are traditional owners of the land. Working with their unique skillsets, the animals spotted by the Indigenous rangers responded better to the conservation technique and drove the significant results.

"THE INDIGENOUS RANGERS HAVE AMAZING OBSERVATION SKILLS AND ABILITY TO SEE ANIMALS IN A LANDSCAPE. THEY COULD SEE THE SHAPE OF A GOANNA WHEN THEY WERE NOT MOVING, WERE IN THE SHADE OR DAPPLED LIGHT, OR FROM MUCH FURTHER AWAY," DR WARD-FEAR SAYS.

Dr Georgia Ward-Fear, with brothers Herbert (left) and Wesley Alberts about to release 'Barney.' Melissa Bruton. Credit: The University of Sydney.


RANGER

INCLUDING INDIGENOUS STORIES IN THE AUSTRALIAN DICTIONARY OF BIOGRAPHY

Please note: Aboriginal and Torres Strait Islander people should be aware that this article contains an image and the names of deceased persons.

Dr Shino Konishi, a Yawuru woman and researcher at The University of Western Australia, is leading a project with Dr Malcolm Allbrook and Professor Tom Griffiths—both from the Australian National University—under the *Discovery Indigenous* scheme to double the number of Indigenous biographies, adding 190 new entries, within the online *Australian Dictionary of Biography* (ADB) as well as producing a standalone published volume of Indigenous short biographies in the ADB.

First published in 1966, the ADB tells the stories of more than 13,000 Australians who have passed away, so that their stories are recorded into Australian history. Dr Konishi has analysed these entries, noting that prior to her project only 210 biographies included in the ADB were of Aboriginal and Torres Strait Islander people, representing only 1.5% of all entries.

Dr Konishi and her team have sought to produce new biographies that are more representative of the demographic makeup of past and present Indigenous communities, by increasing the proportion of Indigenous women, and ensuring more language groups and communities from across Australia are represented. They also considered which types of peoples and roles are important to Indigenous people.

70 biographies and collective biographies of 103 Aboriginal and Torres Strait Islander individuals have now been commissioned. Nine articles have been published in the online ADB, and another 26 will soon be published. These articles include biographies of Mungo Lady and Mungo Man, who lived 42,000 years ago on the traditional lands of the Paakantji, Ngyiampaa and Mutthi Mutthi people, and the little-known nineteenth-century woman Woretemoeteryenner (c. 1795-1847), a palawa from North-East Tasmania, and Annie Brice (c. 1849-1931), a Boandik from South Australia. Both women are considered important ancestors in their communities, and the articles were authored by their descendants. Just in time for Anzac Day 2020, an article on Ngarrindjeri serviceman and prisoner-of-war Roland Wenzel Carter (1892-1960) was published.

This co-operative project draws together Indigenous and non-Indigenous authors from across Australia, and is governed by the Indigenous Working Party, a national advisory group of leading Aboriginal and Torres Strait Islander researchers.

> THE AUSTRALIAN DICTIONARY OF BIOGRAPHY WAS ESTABLISHED DURING A TIME KNOWN AS THE 'GREAT AUSTRALIAN SILENCE,' A TIME OF EXCLUSION OF INDIGENOUS PEOPLE AND VOICES FROM AUSTRALIAN SOCIETY. DR KONISHI AND HER TEAM ARE ENSURING THAT THIS IMPORTANT PUBLICATION CONTAINS MORE INDIGENOUS VOICES AND BETTER RECOUNTS THE STORIES OF INDIGENOUS AUSTRALIANS.

Images: (Right): Jack Dale, 'History painting', 2003. Courtesy of Malcolm Allbrook and the family of Jack Dale.
(Left): Annie Brice, on far right, c.1869. Credit: State Records of South Australia.

CELEBRATING AND PRESERVING INDIGENOUS CEREMONIES

Associate Professor Linda Payi Ford identifies as Rak Mak Mak Marranunggu, from Kurrindju and is Principal Research Fellow in the Northern Institute, College of Indigenous Futures, Arts and Society at Charles Darwin University. Associate Professor Ford receives funding for two projects through the ARC's *Discovery Indigenous* scheme: '*Aboriginal Cosmology—what this means for women and policy*' and '*New ways for old ceremonies—an archival research project*'. The projects are helping to preserve, interpret and disseminate the recordings of ceremonial performances in the Wagait-Daly region of the Northern Territory.

The new research digitises recordings of the Mitharr ceremony songs and Kapuk ceremonial songs, which are now stored for future cultural use in the *Pacific and Regional Archive for Digital Sources in Endangered Cultures* (PARADISEC), a curated online repository. It builds on previously published work, documenting the Wangga songs, performances and rituals from the Daly River region of the Northern Territory.

The research has also had a significant impact for local communities, in expanding an outdoor education program where Indigenous children, families and friends can learn about their Wangga ceremonies and their relationships to other clan groups in the region and elsewhere.

> "CEREMONIAL PERFORMANCE IS A KEY PROCESS FOR INTEGRATING INDIGENOUS KNOWLEDGE FROM MANY DIFFERENT DOMAINS, AND A SOCIALLY POWERFUL SITE OF EXCHANGE, TRANSMISSION AND TRANSFORMATION OF RELATIONSHIP TO COUNTRY AND KIN," SAYS ASSOCIATE PROFESSOR FORD.

Associate Professor Linda Ford presenting the 2019 Charles Perkins Oration. Credit: Charles Darwin University.

UNDERSTANDING EXTREME BUSHFIRE BEHAVIOUR AND FIRESTORM DEVELOPMENT

Funded through several *Discovery Indigenous* scheme grants, Bundjalung man and Professor in the School of Science at UNSW Canberra, Professor Jason Sharples, has led research into understanding extreme and dynamic fire behaviour, and predicting firestorm events.

Professor Sharples says that extreme wildfires are fires that exhibit deep or widespread flaming in unstable atmospheric conditions, which are conducive to the development of towering fire clouds known as pyrocumulus or pyrocumulonimbus storms.

Using mathematical models, he has identified several different factors which influence whether deep flaming will occur. Deep flaming can be triggered by strong winds, winds changing direction, fire eruption, lateral spread of fire across the wind (rather than only in the direction of wind), overzealous backburning, mass spotting, fire line merging or a combination of these factors.

The research has also demonstrated that rugged terrain is a key contributing factor. Interactions between the fire and the atmosphere over rugged, forested landscapes can result in highly atypical and dangerous patterns of fire spread, with abrupt increases in fire intensity and fires moving in unexpected directions.

The 'blow-up fire outlook model' developed by Professor Sharples and his colleagues condenses these findings into a predictive tool for fire mangers. It integrates the various factors that contribute to deep flaming with measures of atmospheric instability to determine the likelihood of a fire developing into a firestorm.

THE OCCURRENCE OF FIRESTORMS APPEARS TO BE INCREASING IN FREQUENCY AROUND THE WORLD AND MODELS LIKE THE 'BLOW-UP FIRE OUTLOOK MODEL' WILL ASSIST AUTHORITIES IN FACING THESE UNPREDICTABLE PHENOMENA.

Image: 2013 Grampians Fire, Victoria, exhibiting a towering fire cloud or 'pyrocumulonimbus'. Credit: Randall Bacon.

Children friendship. iStock.com/Chinnapong.

STRIVING FOR CULTURAL AND SOCIAL OUTCOMES

EXAMINING THE CULTURAL LEGACY OF MELBOURNE'S FIRST ARCHBISHOP

Research carried out at The University of Melbourne has explored an historically important collection of books and artworks that is helping to better understand the cultural and architectural development of the city of Melbourne.

James Goold, the first Catholic Archbishop of Melbourne, was a passionate collector and missionary bishop appointed to Melbourne in 1848 when it was still a small provincial town. With the discovery of gold, Goold's architectural patronage helped to shape the rapidly booming metropolis, culminating in the commissioning and construction of the iconic landmark, St Patrick's Cathedral, and some 86 churches. Goold's contribution to the built environment is distinguished and conspicuous.

Professor Jaynie Anderson, who is leading an ARC Discovery Project that examines Goold's collection and patronage, says that Goold imported books and late Italian Baroque paintings as a way to convey the intensity of European religious experience, which he experienced himself as a novice in Italy.

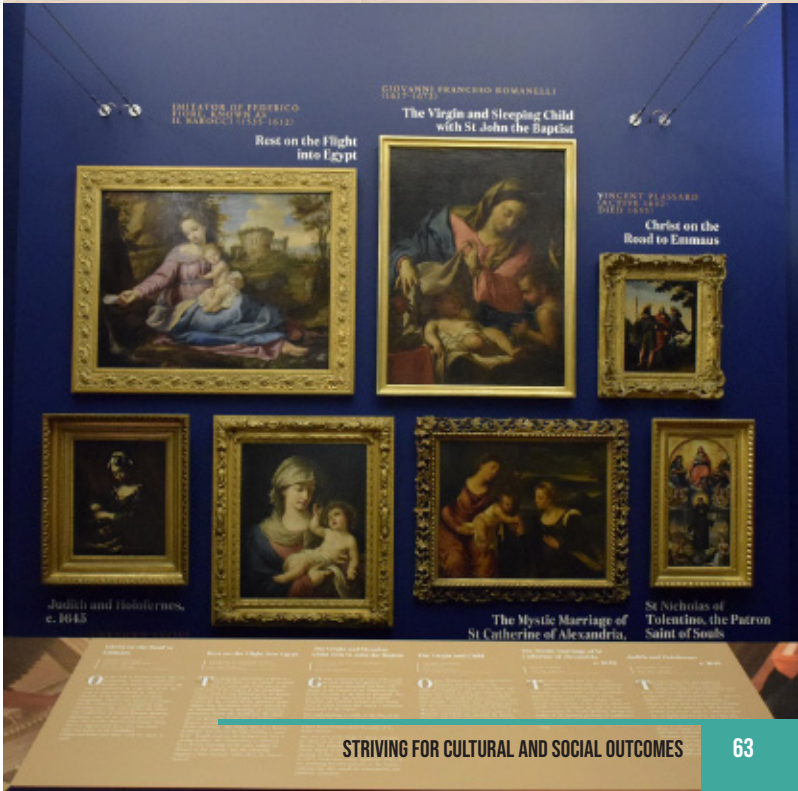
Goold's library contained extensive texts in Theology, Philosophy, Liturgy, Scripture, and the Papacy, as well as works on art and architecture, medicine and poetry, but it was largely forgotten after his death and dispersed in the early 1970s. The research team has rediscovered a large portion of the original collection held in libraries around Melbourne. Examining the remnants has shown that this library ranked amongst the most important private collections in the Colony. A rare book room has been created at the Mannix Library, University of Divinity, to showcase the collection.

(Left): Jacques Stella. Jesus in the Temple ground by his Parents. 1642. Canvas 302 x 219 cm.
Baptistery of St Patrick's Cathedral, Melbourne. Considered by Professor Anderson to be the most important work by the French artist, and one of hundreds of significant acquisitions of Baroque art for Australia. Credit: Catholic Archdiocese of Melbourne.

The research team also analysed the relationship between Goold and his architect William Wardell, which ultimately led to some of the finest examples of Gothic Revival architecture in the world, including St Patrick's—the largest Neo-Gothic Cathedral completed in the 19th century and some fifteen churches to Wardell's design.

The project resulted in a 2020 exhibition at Melbourne's Old Treasury Building, The Invention of Melbourne. *A Baroque Archbishop and a Gothic Architect*, showing major works of art and architectural drawings from the collections of the Catholic Archdiocese of Melbourne for the first time.

> AMONG THE MANY TREASURES IN GOOLD'S LIBRARY, THE RESEARCHERS DISCOVERED A COMPLETE EDITION OF PIRANESI, ALSO RARITIES SUCH AS THREE PREVIOUSLY UNCATALOGUED HAND PRESSED ITEMS, PUBLISHED IN PARIS, RANGING FROM THE MID-16TH TO THE LATE 17TH CENTURY, WHICH WERE MADE BY EARLY WOMEN PRINTERS IN THE PUBLISHING INDUSTRY.



(Top): Charles Nettleton. St Patrick's Cathedral in Construction. C. 1866. Albumen Silver Photograph, 16.4 x37 cm. Credit: State Library of Victoria, Melbourne.
(Below): Installation of the exhibition at the Old Treasury Building. The room in which the Baroque picture collection was partly displayed. Credit: The Old Treasury Melbourne. Credit: The Old Treasury Melbourne

PEOPLE INVOLVED IN THE STUDY WHO GAVE HIGH IMPORTANCE TO ACHIEVEMENT AND POWER WORKED ON AVERAGE AROUND AN HOUR LONGER IN A WORK DAY, AND ONE AND A HALF HOURS LONGER ON A DAY OFF COMPARED TO THOSE WHO DIDN'T. AS A RESULT, THEY SPENT LESS TIME WITH FAMILY AND ENGAGED IN FEWER SOCIAL ACTIVITIES.

VALUES INFLUENCE WHERE WE SPEND OUR TIME AND MONEY

A study funded through an ARC Linkage Project grant, led by Professor Julie Lee at The University of Western Australia, has highlighted the important role that values play in our daily behaviour, including where we invest our time and money.

In collaboration with partner organisation, Pureprofile, the research team surveyed almost 7,500 people across Australia aged between 18 and 75 over a 12 week period, asking a series of questions in three key focus areas—personal values, how people spend their time, and how they spend their money.

The results showed that people hold a much more diverse set of values than they appreciate, and that the influence of values on everyday behaviour has been underestimated.

The study demonstrated that people prioritise different values in life, including benevolence, tradition, conformity, security, power, achievement, hedonism, stimulation, self-direction, protecting the environment, equality and justice and the welfare of others. Some have similar motivations, but others have conflicting motivations.

Despite this diversity, Professor Lee said that people tended to think of others as having similar values to them and that judgements people make about others seem to reflect their own values. Self-projection of values may be an important contributor to misunderstandings.

New insights into the role of deeply-held values in directing behaviour could explain why some habits are difficult for people to break. When something is not good for us or our family, but it is fulfilling a core personal value, the behaviour is likely to be more ingrained and harder to change.

Professor Julie Lee. Credit: The University of Western Australia.

THE UPLIFTING HISTORY OF AUSTRALIAN AVIATION

Fascination with aviation as a key cultural context of modernity is burgeoning worldwide. It has gained particular attention in cultural studies, geography and mobility studies, and in popular and community contexts as the 100th anniversary of civil aviation in Australia approaches in 2021.

Professor Tracy Ireland and a team at the University of Canberra have come together for the ARC Linkage Project '*Heritage of the Air*'—a project that aims to tell a story about how aviation has changed the lives of ordinary people in Australia.

The project has brought together academics, community-based enthusiasts and volunteers, local historical societies and major museums, to learn from 100 years of civil aviation culture, history, heritage and design via the cross-cutting themes of 'modernism, migration, machines and memory'.

Drawing on approaches from contemporary archaeology, visual and material culture studies, oral history and digital humanities, the research is exploring little-known Australian aviation narratives and collections—which will be translated into scholarly and community-focused publications, exhibitions, digital and creative works, and a major conference involving 200 delegates from around Australia and the world.

Now that the future of the aviation industry is being called into question by the global coronavirus pandemic, the historical perspective is more valuable than ever. Professor Ireland's team is drawing on lessons from similar past events—like the Ansett collapse in 2001—and is looking at the serious implications for airline staff and the Australian way of life, which depends heavily on affordable domestic air travel.

"WE IN AUSTRALIA ABSOLUTELY NEED AN AVIATION INDUSTRY. LIFE AS WE KNOW IT CAN'T REALLY GO ON WITHOUT ONE—IT WOULD BE A DIFFERENT LIFE," PROFESSOR IRELAND SAYS.

Sydney Harbour Aerial. iStock.com/davidf

DANCING KIDS ACHIEVE BOOSTED ABILITIES TO SELF-REGULATE

ARC-supported researcher Associate Professor Kate Williams, from the School of Early Childhood and Inclusive Education at the Queensland University of Technology, is investigating the link between young children's experience of rhythm and movement activities and their development of self-regulation skills.

Associate Professor Williams says that self-regulation is the way that we control our own emotions, thinking, intentions and behaviour, in ways that allow us to be well-functioning human beings—and that this ability is an important predictor of school readiness and early school achievement.

Her early work as part of a Discovery Projects grant investigated associations between early shared music activities at home for children aged two to three and their later skill development at ages of four to five.

That study found that although shared book reading was the strongest predictor of vocabulary and school readiness, shared music activities were found to be positively associated with children's vocabulary, numeracy, attentional and emotional regulation, and social skills. The researchers stated that the findings suggest that early educators and parents should be aware of the non-musical benefits of active music participation, even in an informal setting at home, in early childhood development.

Associate Professor Kate Williams has since been awarded an ARC Discovery Early Career Researcher Award (DECRA) and is now examining the effectiveness of a rhythm and movement intervention by early childhood teachers to improve self-regulation for preschool aged children living in disadvantaged communities.

MUSIC CAN MAKE A DIFFERENCE VERY EARLY IN A CHILD'S LIFE. RESEARCH HAS SHOWN THAT REGULAR MOVEMENT WITH CHILDREN, SUCH AS RHYTHMICALLY ROCKING INFANTS, HAS RESULTED IN THESE CHILDREN SHOWING MORE SOCIAL SKILLS AND EMPATHY WITH OTHERS.

QUT early childhood researcher Kate Williams has developed a fun rhythm and movement program linked to pathways in the brain to support young children's attentional and emotional development. Credit: QUT.

EARLY DIFFERENCES AND DISADVANTAGE IN HEALTH OUTCOMES FOR LGBQ PEOPLE

ARC Discovery Early Career Researcher Award (DECRA) recipient, Dr Francisco Perales, based at the *ARC Centre of Excellence for Children and Families over the Life Course* at The University of Queensland, has conducted a study which has shown that Australian lesbian, gay, bisexual and questioning (LGBQ) adolescents are worse off than their heterosexual peers across health and wellbeing outcomes.

The research analysed data from *The Longitudinal Study of Australian Children*, a national probability survey following the lives of almost 10,000 children from around Australia since birth or early childhood.

The study draws attention to the disadvantage experienced by LGBQ youth and shows that these differences in health and wellbeing outcomes start early, during or before adolescence.

It was the first study to identify the domains of health and wellbeing on which disparities between sexual-minority and heterosexual teens differed the most—highlighting which health areas require priority intervention.

In a further study, the researchers have shown that it is the unique pressures faced by LGBQ youth, such as homophobic bullying at school and rejection by family members upon 'coming out', that are the source of these health problems.

Dr Perales says that documenting health disparities between LGBQ and heterosexual adolescents is a first step in addressing health inequalities by sexual orientation. By focusing attention on the issue, it facilitates priority shifts in policy and practice, and developing effective and efficient interventions.

"IDENTIFYING EFFECTIVE AND EFFICIENT INTERVENTIONS TO IMPROVE THE OUTCOMES OF THESE YOUNG PEOPLE NEEDS TO BE AN URGENT TASK FOR RESEARCHERS AND POLICY-MAKERS," SAYS DR PERALES.

Celebrating and Dancing stock photo: Istock.com/FG Trade

CLIMATE AND ECONOMIC FACTORS DRIVING FARMERS FROM THE LAND

The number of farmers has been decreasing in many parts of the world, including Australia, but the causes of this concerning decline are not well known.

ARC-supported researchers have now conducted one of the most comprehensive analyses of farmer exit across the world to date.

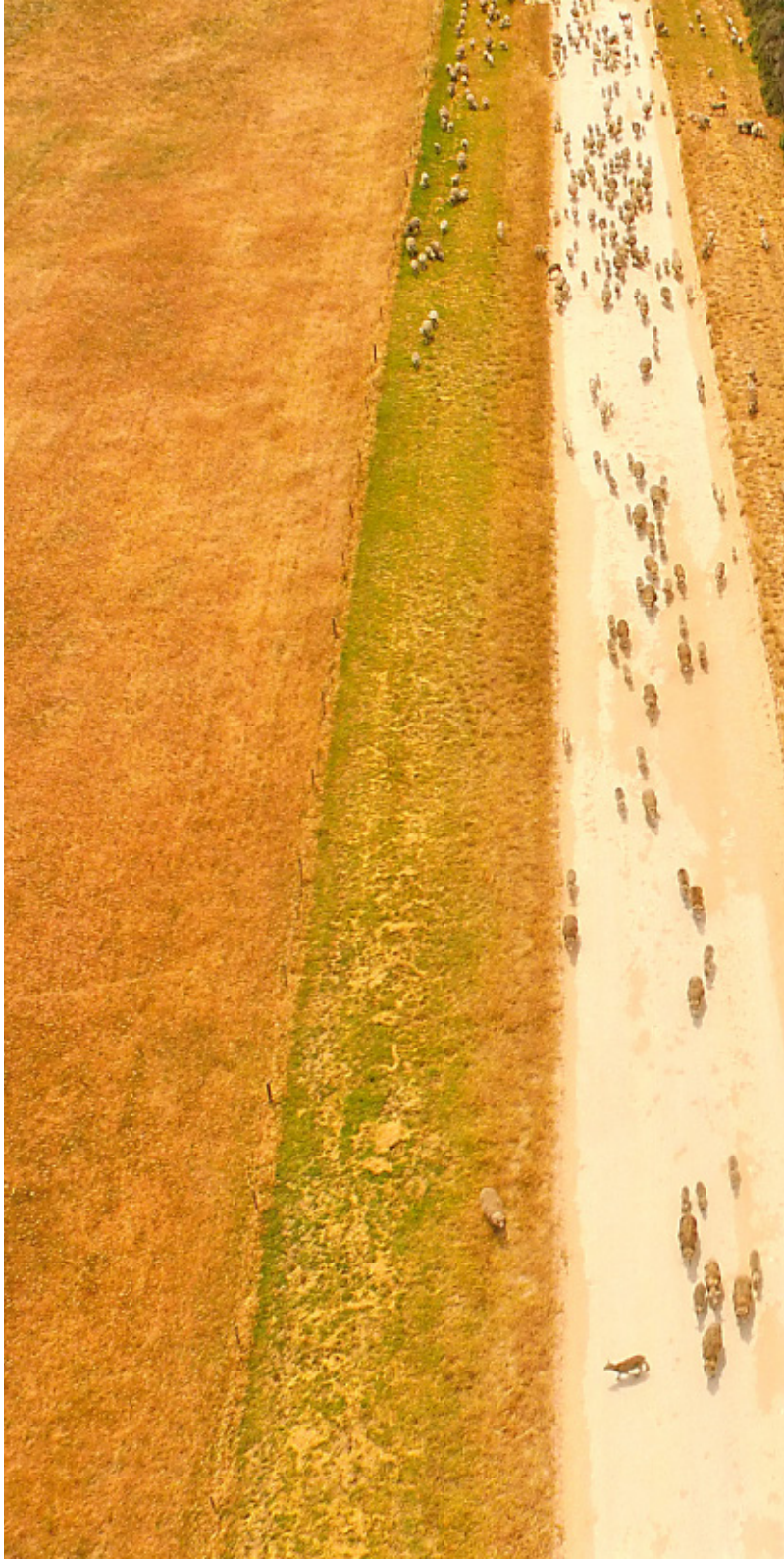
Led by ARC Future Fellow Professor Sarah Wheeler, Professor of Water Economics of The University of Adelaide's Centre for Global Food and Resources and the Environment Institute, the research team has found that in the Murray-Darling Basin, the causes may not be what many suspect.

The researchers found that the Murray-Darling Basin has faced considerable change in the form of increased temperatures and drought severity, reduced irrigation water diversions, declining real agricultural commodity prices and declining rural community services.

Sourcing data from the Australian Bureau of Statistics population and agricultural censuses at the statistical local area from 1991 to 2011, the research team matched it with datasets including a variety of climate risk measures, rainfall, temperature, water diversions, location, agricultural commodity prices, unemployment and urbanisation factors to model how farmer numbers (including both dryland and irrigators) changed over time.

Their analysis showed that for the period of 1991-2011, the most important drivers of farmer exit were climate—increased drought risk and higher temperatures—and economic factors, such as commodity prices, unemployment and urbanisation.

There was no significant association between decreasing farmer numbers and measured water extraction in the Basin—this contrasts with the popular view that decreased access to water is the main reason for the decline of farmers in the Basin.



"WHAT WE MUST DO TO HELP OUR RURAL COMMUNITIES IS TAKE NOTE OF THE PROPER EVIDENCE AND DEVELOP POLICY AROUND DROUGHT, CLIMATE CHANGE, RURAL ECONOMIC DEVELOPMENT AND WATER EXTRACTION THAT LEADS TO COMPREHENSIVE STRATEGIES FOR REAL SOLUTIONS," SAYS PROFESSOR SARAH WHEELER.

Outback road. iStock.com/hypedesk.

THE RESEARCH SUGGESTS THAT EMOTIONAL INTELLIGENCE IS IMPORTANT FOR STUDENTS' ACADEMIC PERFORMANCE.

Kids playing in forest stock photo. Istock.com/jacoblund.

EMOTIONAL INTELLIGENCE GETS THE GRADES

Through an ARC Discovery Project grant, Associate Professor Carolyn MacCann at The University of Sydney, Associate Professor Amirali Minbashian, from The University of New South Wales and Dr Kit Double at Oxford University, have analysed data to show that students who are better able to understand and manage their emotions get better grades.

The research team analysed data from more than 160 studies including more than 42,000 students from 27 countries published between 1998 and 2019. The students ranged from primary school to university.

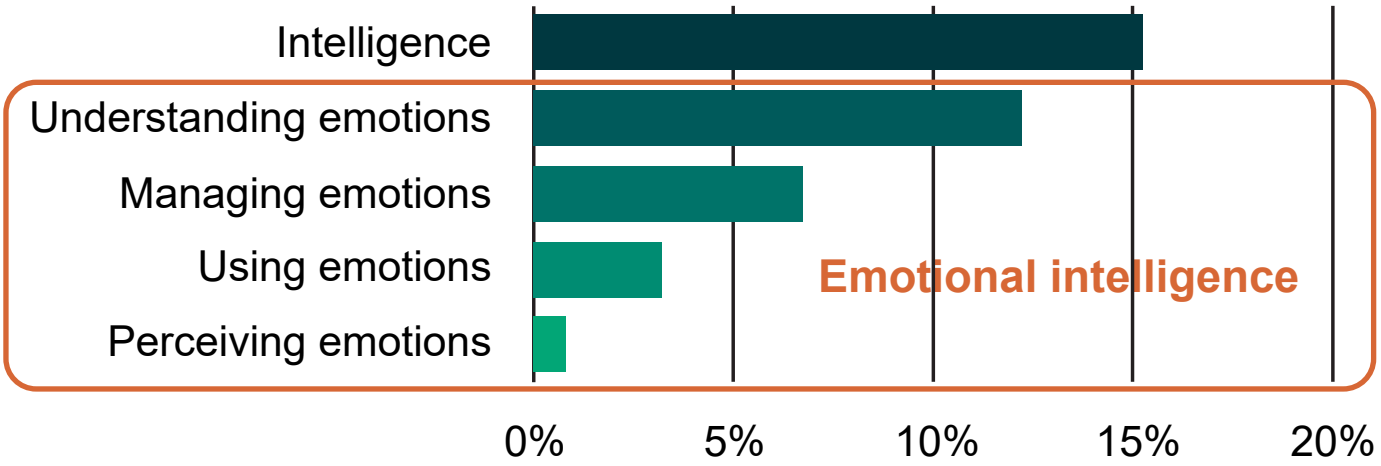
They found that students with higher emotional intelligence received higher grades and better achievement test scores than those with lower emotional intelligence scores. The most surprising result was that this happened regardless of age.

Associate Professor MacCann said that there may be a number of factors to explain the association, including that students with higher emotional intelligence may be better able to manage the social world around them, forming stronger relationships with teachers, other students and family.

There may be an overlap in the skills required to master some subjects and those required for emotional intelligence—for example, understanding human motivation and emotion could assist in humanities subjects.

While the researchers warn against widespread testing of students for emotional intelligence, it is suggested that it would be beneficial if emotional skill development could be integrated into the existing curriculum.

DIFFERENCES BETWEEN STUDENTS IN ACADEMIC PERFORMANCE: HOW MUCH DO DIFFERENT FACTORS EXPLAIN?



Beach. iStock.com/imagedepotpro.

IMPROVING HEALTH AND WELL-BEING

THE BIG ANXIETY FESTIVAL

The Big Anxiety is the biggest mental health and arts festival in the world—a cultural platform for direct engagement with mental health that brings together artists, scientists and communities to question and re-imagine the state of mental health in the 21st century.

Embracing diverse experiences across the vast spectrum of mental health, the festival examines what makes us anxious as individuals and social groups, from fears about the future, concerns about ourselves, other people and belonging, to the question of how people are cared for. It also closes the knowledge to practice gap, developing and testing tools in partnership with communities.

The festival is the brainchild of its Artistic Director, ARC Australian Laureate Fellow, Professor Jill Bennett. Founded in 2017 at The University of New South Wales (UNSW), the festival will move to Melbourne in 2022 with RMIT partnering with UNSW and others across the cultural, education and health sectors.

Professor Bennett says that the arts and communications disciplines are the key to reaching the estimated 65 per cent of Australians with mental health concerns who do not access help. There is a growing body of evidence that art has powerful impacts on mental health. Multimedia and virtual reality tools developed through The Big Anxiety have proved to be effective in areas including suicide prevention and trauma support.

Professor Bennett says that the success of the festival shows that arts are the best means we have for sharing complex experience, illuminating what we don't know about ourselves and others. By shining light on the relationships and social settings that help or hinder mental health, The Big Anxiety is a practical means to renew those relationships.

"RAISING AWARENESS IS NOT ENOUGH. INFORMATION ABOUT MENTAL HEALTH IS NOT ENOUGH. WE NEED NEW WAYS OF THINKING, IMAGINING, FEELING AND ACTING—AND RESOURCES THAT ARE BOTH PRACTICAL AND INSPIRING," SAYS PROFESSOR BENNETT.

Edge of the Present, from The Big Anxiety 2019 (VR environment for mood improvement/suicide prevention). Credit: Jessica Maurer.

"CARING FOR A DYING LOVED ONE CAN BE A FULL-TIME AND EXHAUSTIVE COMMITMENT, BUT THE GRIEF, GENERAL HEALTH AND QUALITY OF LIFE THAT THE CARER EXPERIENCES BEFORE AND AFTER DEATH CAN SOMETIMES BE OVERLOOKED," SAYS ASSOCIATE PROFESSOR BREEN.

THE LASTING IMPACT OF CAREGIVING FOR A DYING LOVED ONE

Family members who have been the primary carer for a dying loved one may experience considerable grief, poor health and quality of life for several months after the person has died, ARC-supported research led by Curtin University has found.

The research also examined whether the grief a carer experiences while caring can predict grief following the death.

ARC Discovery Early Career Researcher Award (DECRA) recipient, Associate Professor Lauren Breen, from the School of Psychology at Curtin University, said family carers are integral to providing end-of-life care for people receiving palliative care, but the tasks of caregiving can have a significant and lasting impact on them.

By measuring how carers were feeling in the time period leading up to the death, and then at three different time periods following the death, the researchers were able to show that it took nine to ten months for the carers' grief, general health, and quality of life to return to 'normal', compared with those who had no caring responsibilities.

The researchers also found that while caring, the carers' quality of life and general health was lower, and their grief was similar, to what they experienced three to four months following the death.

The findings suggest that tailored support is needed to meet the specific needs of carers and that this should be available both before and after the death. Such interventions can help carers prepare for the death, improve their health and quality of life, and promote adaptive grieving.

Helping the needy stock photo. Istock.com/Lighthaunter.

UNCOVERING THE MECHANISM TO HUMAN VIRAL IMMUNITY

Assisted by funding support from the ARC, researchers at the Walter and Eliza Hall Institute of Medical Research have identified a molecular switch that impacts immune responses to viral infections, and determines if they produce protective antibodies.

The team also made the surprising discovery that the immune system protects against different viruses via distinct pathways—findings that could lead to better strategies to develop vaccines for previously hard-to-prevent viruses.

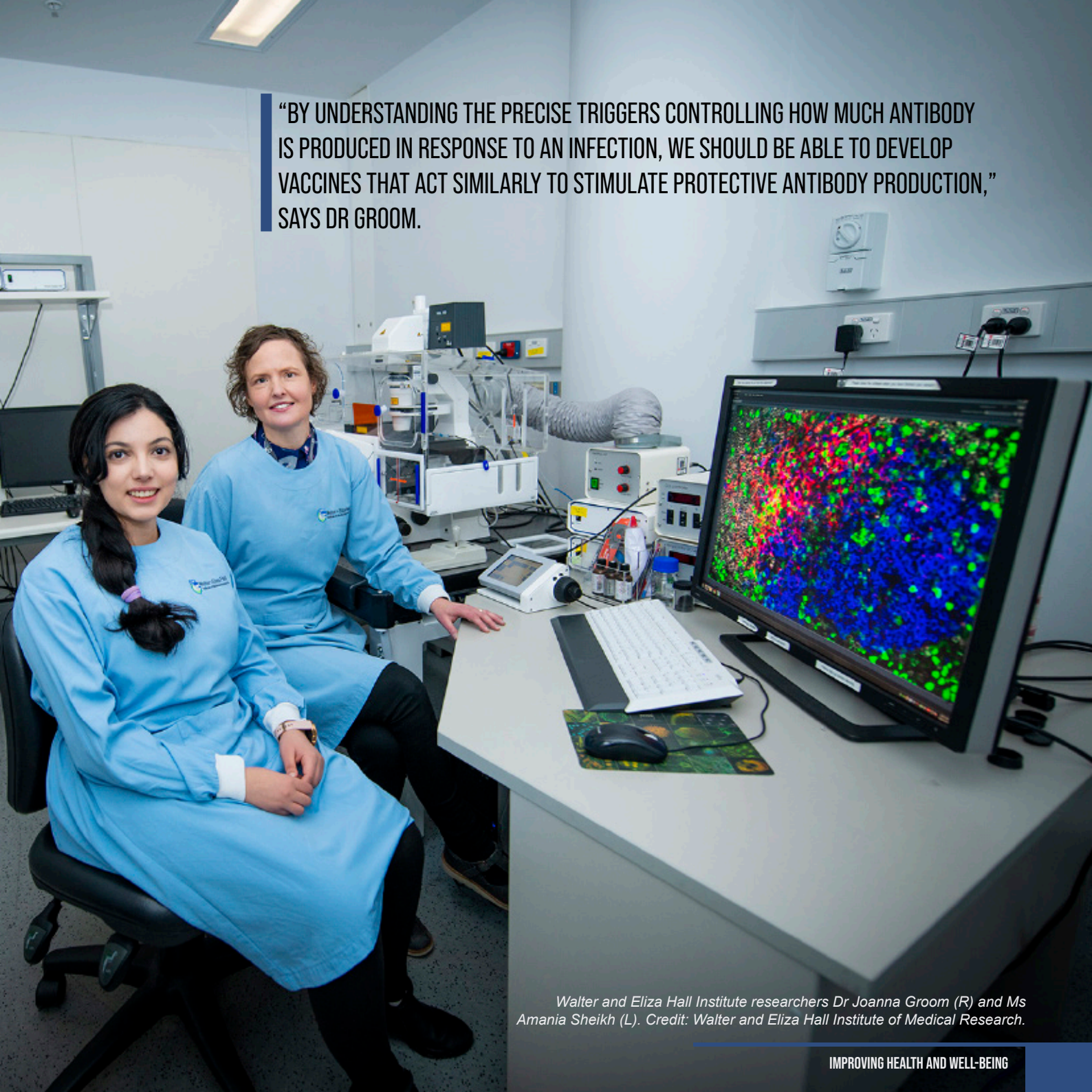
The research, led by ARC Future Fellow, Dr Joanna Groom, and PhD student, Ms Amania Sheikh, identified that the protein 'T-bet' determines how the immune system responds to viral infections.

The T-bet protein enables immune T cells to distinguish between different viral infections, controlling whether or not protective antibodies are produced. Antibodies are an essential component of long-lived immunity to viruses.

The researchers say that their findings help to reconcile a controversy in the field about how the immune system can distinguish between different viral infections, and respond in distinct ways. Their experiments compared immune responses to two viruses, influenza and LCMV, a virus that can cause meningitis. They showed that T-bet was critical for scaling how much antibody production occurred in response to a viral infection.

The discovery could underpin the development of better vaccines to prevent viral diseases, as current vaccines to infectious diseases rely on robust and long-lived antibody production.

Note: This research was funded by the ARC's 2013 Future Fellowships scheme round. Medical Research Institutes were eligible to apply for Future Fellowships from the introduction of the scheme in 2009, until 2014.



"BY UNDERSTANDING THE PRECISE TRIGGERS CONTROLLING HOW MUCH ANTIBODY IS PRODUCED IN RESPONSE TO AN INFECTION, WE SHOULD BE ABLE TO DEVELOP VACCINES THAT ACT SIMILARLY TO STIMULATE PROTECTIVE ANTIBODY PRODUCTION," SAYS DR GROOM.

Walter and Eliza Hall Institute researchers Dr Joanna Groom (R) and Ms Amania Sheikh (L). Credit: Walter and Eliza Hall Institute of Medical Research.

DIY PRESSURE PUMP BREAKS DOWN TECHNOLOGY BARRIER

ARC-supported researchers at RMIT University, in collaboration with the Walter and Eliza Hall Institute of Medical Research, have developed a simple pressure pump, made from balloons and nylon stockings, that will allow more people in sometimes remote and often complex environments to easily test water contaminants and blood samples.

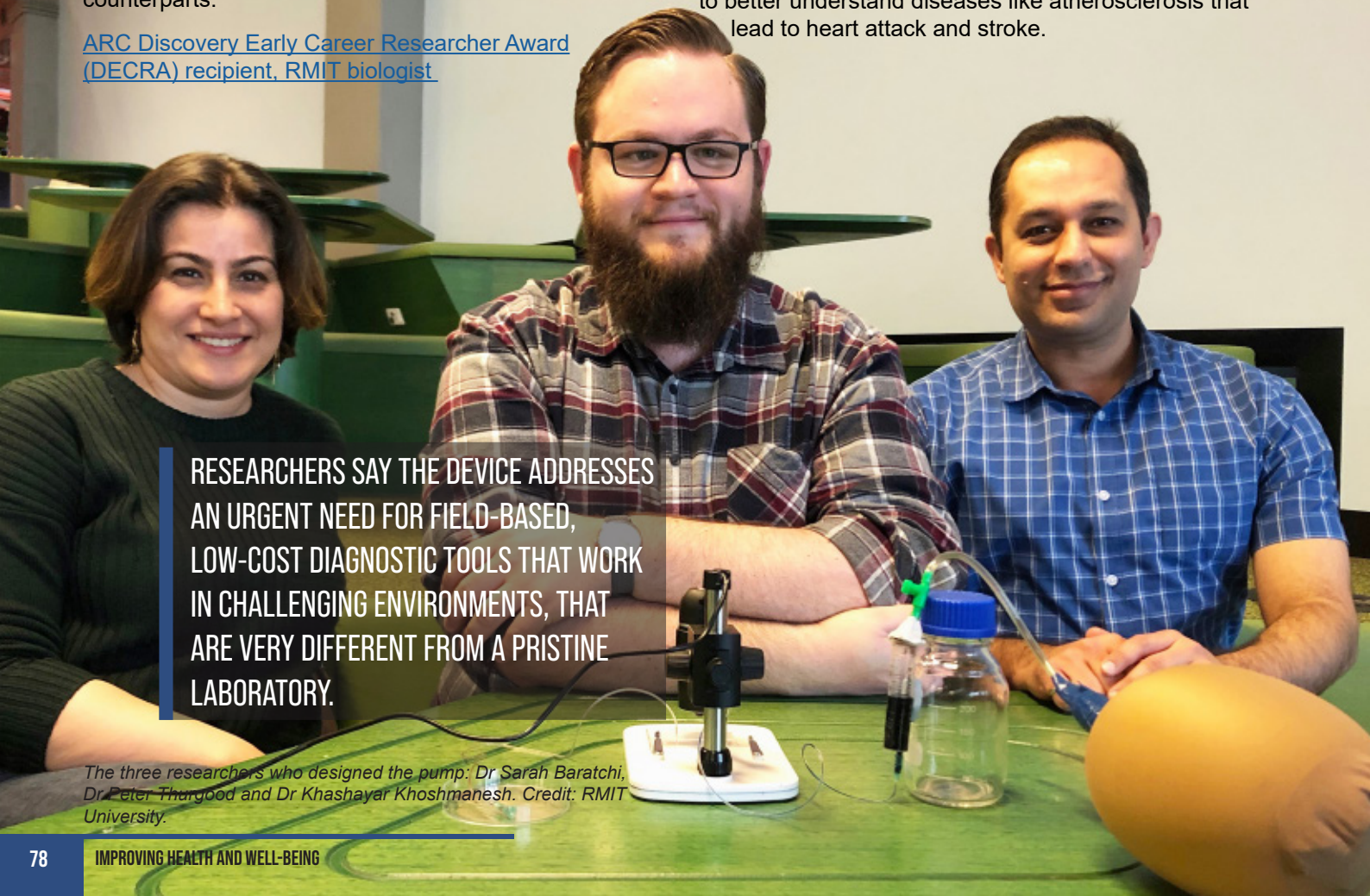
The ingenious device cost just $2.00 to make, yet works almost as well as its expensive and cumbersome lab counterparts.

ARC Discovery Early Career Researcher Award (DECRA) recipient, RMIT biologist Dr Sara Baratchi, said it also had promising applications for early diagnosis of diseases at home or in the doctor's surgery.

Pumps are used to make biological samples flow through microfluidic devices while their contents are identified beneath a microscope. The balloon pump was tested as a point-of-care diagnostic device for detection of very low concentrations of target cancer cells in liquid samples, and found to work.

Dr Baratchi is now working on applying the simplified pump technology to develop ‘organ-on-chip' systems that mimic the flow conditions in dysfunctional vessels, to better understand diseases like atherosclerosis that lead to heart attack and stroke.

> RESEARCHERS SAY THE DEVICE ADDRESSES AN URGENT NEED FOR FIELD-BASED, LOW-COST DIAGNOSTIC TOOLS THAT WORK IN CHALLENGING ENVIRONMENTS, THAT ARE VERY DIFFERENT FROM A PRISTINE LABORATORY.



The three researchers who designed the pump: Dr Sarah Baratchi, Dr Peter Thurgood and Dr Khashayar Khoshmanesh. Credit: RMIT University.

ILLUMINATING THE GOLDEN STAPH

A ground-breaking new technique developed by researchers at the Macquarie University node of the *ARC Centre of Excellence for Nanoscale BioPhotonics* (CNBP), which is led by The University of Adelaide, will slash the time it takes to detect a golden staph infection, from two days to just two hours.

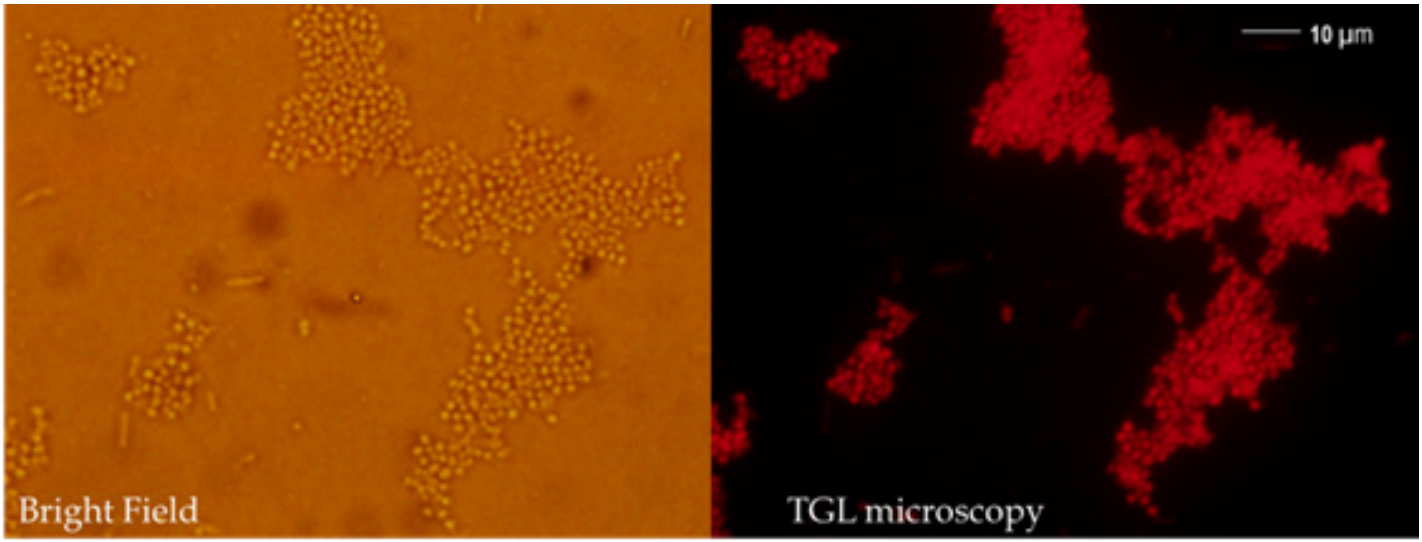
Golden staph (*Staphylococcus aureus*) lives on the skin and in the nose. It is usually harmless, but if it enters the skin through a cut it can cause a range of infections which, in some cases, are fatal.

In the most at-risk patients, it is vital to identify the infection and begin treatment with appropriate antibiotics as quickly as possible. However, current identification techniques involve culturing cells for up to two days to provide a positive infection result.

This innovative approach—known as Time-Gated Luminescent in *Situ* Hybridization (or LISH)—takes just two hours. The researchers are also working on Time-Gated luminescence immuno-detection techniques for rapid diagnosis of prostate cancer and various infectious diseases based on urine and blood samples.

LISH involves binding of a luminescent single-stranded DNA probe with a target nucleic acid within a cell. Often, biological samples such as tissue, blood and urine have their own fluorescence when viewed under microscopes, creating a kind of 'background noise'. Using Time-Gated Luminescence (TGL) microscopy imaging eliminates this, making it far more sensitive in detecting any nucleic acid target than the conventional fluorescence in situ hybridisation (FISH) approach currently used.

> THE RESEARCHERS TARGETED THE BACTERIUM WITH A LUMINESCENT DNA PROBE, ALLOWING THEM TO FIND THE 'NEEDLE IN THE HAYSTACK' BECAUSE ONLY THE 'NEEDLE' LIGHTS UP.



Labelled S. aureus cells illuminated under TGL microscopy (left bright field & right TGL microscopy). Credit: Macquarie University.

EXPLORING COGNITIVE AGEING AND ITS IMPACTS ON INDIVIDUALS

The *ARC Centre of Excellence in Population Ageing Research* (CEPAR) led by UNSW, in collaboration with Neuroscience Research Australia (NeuRA), has undertaken extensive research on cognitive ageing trends in Australia, and is highlighting ways that society can minimise the social burden of cognitive decline and dementia.

The research team, led by ARC Australian Laureate Fellow, Scientia Professor Kaarin Anstey, looked at recent research from around Australia and the world, to develop a research brief for use by policy makers, journalists, health care providers, industry practitioners, and all those who want an insight into the trends in cognitive ageing and dementia in Australia.

Dementia is the leading cause of disability among Australians over 65 and the second leading cause of death in Australia. In 2016, the direct costs alone of dementia were close to $9 billion, with a predicted increase to $12 billion by 2025.

One of the findings highlighted by the research is that the knowledge base around the cause of dementia in the senior community varies greatly, raising the need for in-depth dementia awareness workshops and community involvement. Early retirement has been found to be detrimental to cognitive function and can increase the risk of dementia, suggesting that it is in society's best interests to keep older people engaged in different activities, including work.

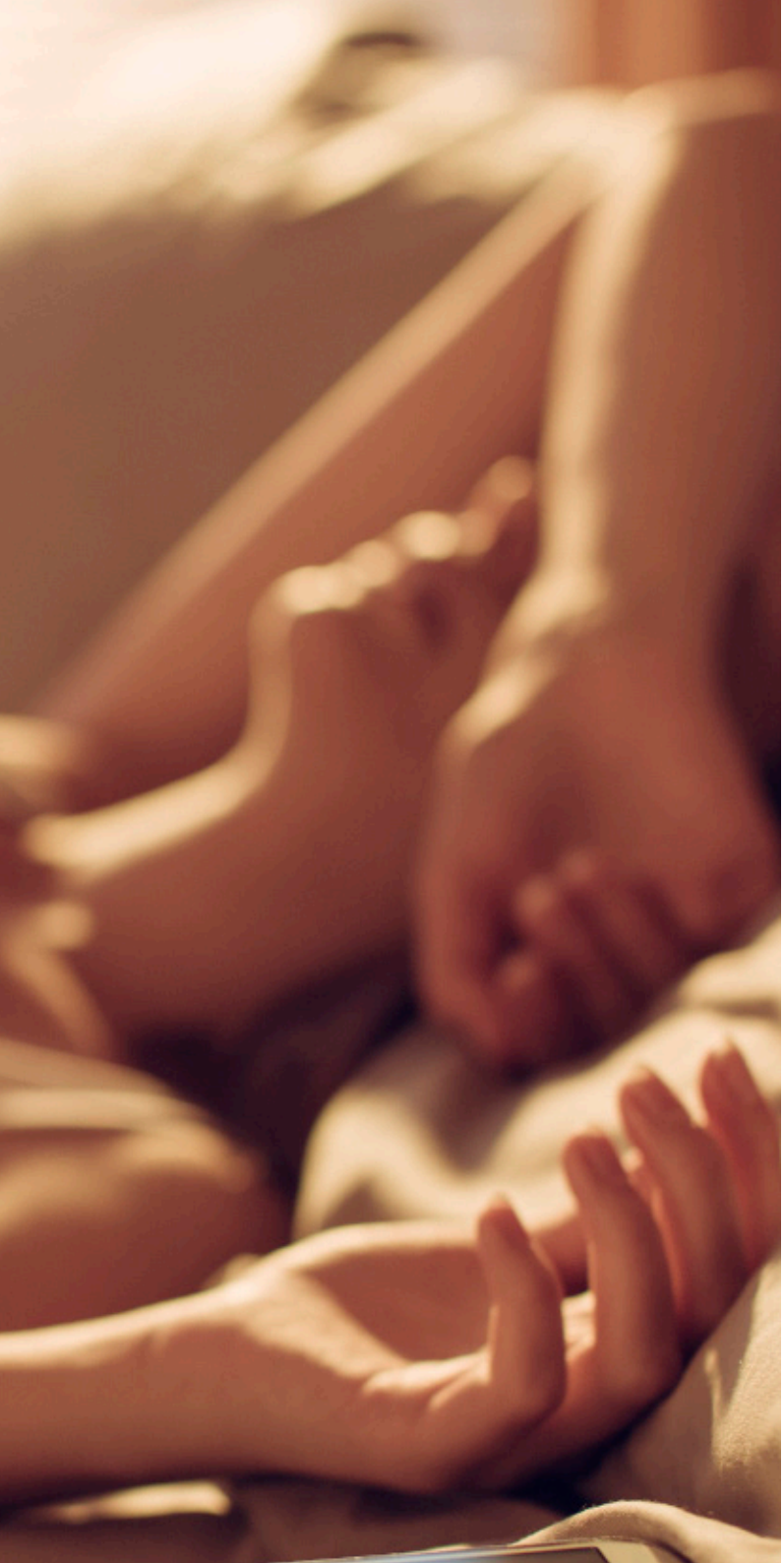
The research also highlights how even mild cognitive limitations and changes in processing speed or acquisition of new knowledge will have significant impacts on how Australians make financial decisions.

Exploring the whole spectrum of cognitive ageing and its impacts on individuals, society and the economy, the CEPAR research highlights seven key modifiable lifestyle factors which are attributed to dementia; the rising numbers of people with dementia; and the increasing cost to families, carers, and the economy.

> THE RESEARCH HIGHLIGHTS THE PREVALENCE OF DEMENTIA IN AUSTRALIA, WHICH DOUBLES EVERY FIVE YEARS BETWEEN AGES 70 AND 84, AND HOW OUR AGEING POPULATION TRENDS WILL RESULT IN GREATER NUMBERS OF PEOPLE WITH DEMENTIA.

Portrait of a man painting. Istock.com/mihailomilovanovic.

> "SLEEP IS LIKELY TO BE IMPACTED WHEN ON-CALL, EVEN IN THE ABSENCE OF A CALL AND THIS SHOULD BE TAKEN INTO ACCOUNT BY EMPLOYERS IN SCHEDULING NEXT-DAY ACTIVITIES," SAYS PROFESSOR FERGUSON.



SLEEPING 'ON-CALL'—OR NOT

Professor Sally Ferguson leads a research team at Central Queensland University (CQUniversity) that is working with industry to study the relationship between sleep, wake and work patterns, particularly for those working irregular hours, including those who are 'on-call' overnight.

On-call work is common in industries such as engineering, aviation and medicine, where workers are required to be available to respond to unexpected peaks in workload or in 24/7 emergency response. Until recently, it has largely been assumed by employers that if no call occurs, then the worker's sleep has been undisturbed, and that the recovery value of that sleep is the same as non-on-call sleep. But the CQUniversity research is showing that this is not necessarily the case.

Supported by ARC Discovery Projects grant funding, Professor Ferguson's team conducted a study using a simulated on-call scenario in a sleep laboratory, and found that certain characteristics of on-call arrangements can impact sleep and also next-day performance.

A key finding is that if the likelihood of a call was unknown (as opposed to certainty of a call, or certainty of no call) sleep and performance were negatively affected. Further to this, when the perceived chance of missing the call alarm was high, sleep outcomes were worse than if there was little to no chance of missing the alarm. Finally, self-reported anxiety levels were higher prior to sleep on nights on-call than not on-call.

Professor Ferguson says that the findings provide evidence-based guidance to employers in relation to scheduling on-call work and support for on-call workers. For example, the research suggests that rostering fewer workers on-call with a *higher* likelihood of being called may be better for sleep quality than more workers with a low likelihood of being called.

Woman asleep. iStock.com/Geber86.

ARC SCHEME INFORMATION:
DISCOVERY PROGRAM

The ***Discovery Projects scheme*** provides grant funding to support research projects that may be undertaken by individual researchers or research teams. The scheme supports excellent basic and applied research and research training by individuals and teams; supports national and international research collaboration; and enhances the scale and focus of research in Australian Government priority areas.

The ***Discovery Indigenous scheme*** provides grant funding to support research projects led by an Aboriginal and Torres Strait Islander researcher. The scheme supports excellent basic and applied research and research training by Aboriginal and Torres Strait Islander researchers as individuals and as teams; supports national and international research collaboration; enhances the scale and focus of research in Australian Government priority areas; and supports and retains established Aboriginal and Torres Strait Islander researchers in higher education institutions.

The ***Australian Laureate Fellowships scheme*** reflects the Australian Government's commitment to excellence in research by supporting world-class researchers to undertake high quality research in Australia. The scheme encourages applications from the highest-quality researchers by providing eligible Australian Laureate Fellows with project funding in addition to a salary supplement and salary-related (on-cost) support. The scheme supports ground-breaking, internationally competitive basic and applied research; forges strong links among researchers, the international research community and/or industry and other research end-users; enhances the scale and focus of research in Australian Government priority areas; attracts and retains outstanding researchers and research leaders of international reputation; and provides an excellent research training environment and exemplary mentorship to nurture early-career researchers.

The ***Future Fellowships scheme*** reflects the Australian Government's commitment to excellence in research by supporting excellent mid-career researchers to undertake high quality research in areas of national and international benefit. The scheme supports excellent basic and applied research and research training by outstanding mid-career researchers to be recruited and retained by universities in continuing academic positions; supports national and international research collaboration; and enhances the scale and focus of research in Australian Government priority areas.

The ***Discovery Early Career Researcher Award (DECRA) scheme*** provides focused research support for early career researchers in both teaching and research, and research-only positions. The scheme supports excellent basic and applied research by early-career researchers; supports national and international collaboration; enhances the scale and focus of research in Australian Government priority areas; advances promising early career researchers and promotes enhanced opportunities for diverse career pathways; and enables research and research training in high quality and supportive environments.

ARC SCHEME INFORMATION:

LINKAGE PROGRAM

The ***ARC Centres of Excellence* scheme** supports prestigious focal points of expertise through which high-quality researchers collaboratively maintain and develop Australia's international standing in research areas of national priority. ARC Centres of Excellence facilitate significant collaboration to allow the complementary research resources of universities, publicly funded research organisations, other research bodies, governments and businesses to be concentrated to support outstanding research in all fields (except clinical medical research).

The ***Industrial Transformation Research Hubs scheme*** engages Australia's best researchers to develop collaborative solutions to Industrial Transformation Priorities, Research Hubs support joint research activity, between the Australian higher education sector and industry, designed to focus on strategic outcomes that cannot be realised independently of each other. This scheme supports collaborative research projects between universities and organisations outside the Australian higher education sector that involve cutting-edge research on new technologies; and leverages national and international investment in targeted industry and other research end-users.

The ***Industrial Transformation Training Centres* scheme** fosters close partnerships between university-based researchers and other researchers. Training Centres deliver innovative Higher Degree by Research (HDR) and postdoctoral training, focusing on creating end-user research capability that is vital to Australia's future through developing solutions relevant to the Industrial Transformation Priorities. The scheme supports HDR candidates and postdoctoral researchers to undertake industrial training; supports research collaboration between universities and organisations outside the Australian higher education sector; and strengthen the capabilities of industry and research end-users in identified Industrial Transformation Priority areas.

The ***Linkage Projects* scheme** supports projects which initiate or develop long-term strategic research alliances to apply advanced knowledge to problems, acquire new knowledge and as a basis for securing commercial and other benefits of research. The scheme supports the development of long-term strategic research alliances between higher education organisations and industry and other research end-users, in order to apply advanced knowledge to problems; provides opportunity for internationally competitive research projects to be conducted in collaboration with organisations outside the higher education sector; and enhances the scale and focus of research in Australian Government priority areas.

The ***Linkage Infrastructure, Equipment and Facilities scheme*** provides funding for research infrastructure, equipment and facilities to Eligible Organisations. The scheme enables researchers to participate in cooperative initiatives so that expensive research infrastructure, equipment and facilities can be shared between higher education organisations and also with industry. The scheme supports excellent basic and applied research and research training through the acquisition of research equipment and infrastructure and access to national and international research facilities; and encourages Eligible Organisations to develop collaborative arrangements with other Eligible Organisations and/or Partner Organisations for the acquisition and use of research equipment and infrastructure or access to national and international facilities.

The ***Special Research Initiatives* scheme** supports high-quality research for targeted areas which the Australian Government has identified as important for advancing Australia's research excellence to be globally competitive and delivering benefits to the community. This extends, but is not limited, to supporting research-related activities which will respond to emerging opportunities or changing priorities. The scheme provides funding to support: cooperative activities amongst researchers; cooperative development of national and international linkages; cooperative development of innovative research areas; and activities aimed at building the scale and focus of research and research training.

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