Making a difference

Australian Government
Australian Research Council

Outcomes of ARC supported research

2020–21

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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Cover: Credit: Curtin University.

Inside cover: Turquoise watercolor wave. Credit: iStock.com/Anna Rodionova.

Contents page: **'Contents':** The Figueira Brava cave on the Portuguese coast was used as a shelter by Neanderthal populations over the course of twenty millennia. Credit: Pedro Souto. **Empowering Australian industry:** The tuneable emission colour of a solution of various bromide-based perovskite nanocrystals under UV light. Credit: Dr Wenping Yin. **Advancing social and cultural outcomes**: Soda pop. Credit: iStock.com/carlofranco. **Discovery and fundamental research**: View of one of the excavation areas at Figueira Brava cave. Credit: João Zilhão. **First Australians' collaborations and knowledges**: NAIDOC Week. Credit: Curtin University. **Responding to COVID-19**: Professor Warwick McKibbin AO, CEPAR Chief Investigator, Director of Policy Engagement and ANU. Node Leader Credit: *ARC Centre of Excellence in Population Ageing Research*. **Improving health and wellbeing**: Beach. Credit: iStock.com/magedepotpro. **Understanding the natural world**: Associate Professor Adriana Vergés measuring crayweed. Credit: John Turnbull.

Scheme Information: Background with turquoise watercolor. Credit: iStock.com/Anna Rodionova.

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 2 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.

A MESSAGE FROM OUR CEO

Welcome to the fifth edition of the Australian Research Council's (ARC) *Making a difference* publication, where we showcase a year of ARC-supported research from universities from all around the country, and across the full range of research disciplines. The range of research on display in this publication gives a snapshot of the extraordinarily wide variety of research that ARC funding support enables, and the exciting outcomes and new knowledge that results from the hard work of our world-class research sector.

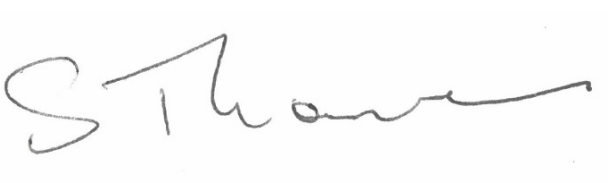
This year, 2021, marks 20 years since the ARC became a statutory agency responsible for Commonwealth research grants administration. Previously managed by the Department of Education and the National Board of Employment, Education and Training, or 'NBEET', the ARC came into its own with the passage of the *Australian Research Council Act 2001*.

The legislation that created the ARC contained advisory functions, establishing us as a source of expertise and knowledge for Government and for the research community, as well as setting the funding caps for our research grant schemes. The ARC's Discovery and Linkage programs, and

their flagship schemes, Discovery Projects and Linkage Projects, date back to this moment. The dual nature of our funding – for fundamental discovery or 'blue sky' research, as well as collaborative research that facilitates linkages within universities and outside the university sector – continues today as an important balance of our research investment. All kinds of research effort are supported through our portfolio of funding schemes, and the research featured in this publication is funded through both the Discovery and Linkage streams.

This year's *Making a difference* also covers the period when the impacts of COVID-19 began to seriously impact the research community, and we have worked hard to support the many researchers who have experienced difficulties during this time. Border controls and lockdowns have had countless flow-on effects, impacting both fieldwork and lab work, as well as the ability of PhD students and other researchers to return from overseas. But the silver lining is that some research teams have been able to turn their skills to combat these new challenges, or seize opportunities that emerged as circumstances rapidly evolved. This year, we have included a new section that showcases some of these individuals and teams who were able to transform their research programs to tackle the new challenge of COVID-19. I am proud of the speed and skill with which our entire research sector has been able to contribute in so many ways to Australia's response to the global pandemic.

We hope you enjoy this year's publication, for the variety of research projects on display, as well as the demonstrable outcomes which are only possible through the efforts of our amazing research community. I congratulate everyone whose research is highlighted in this year's publication, though of course there is always so much remarkable research activity that we don't have room to capture. Thank you all for 'making a difference', by your contributions to Australia's research and innovation effort.



Professor Sue Thomas
Chief Executive Officer
Australian Research Council

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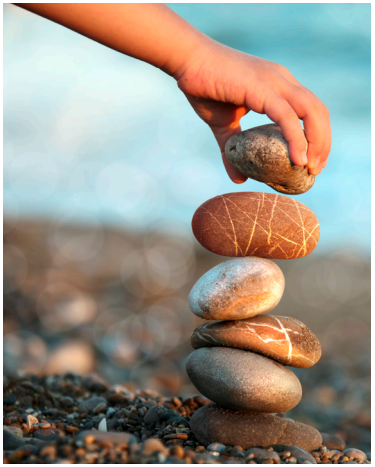

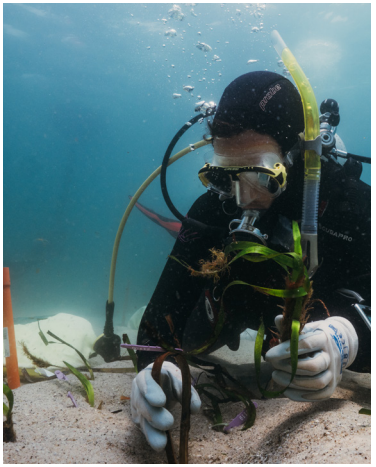

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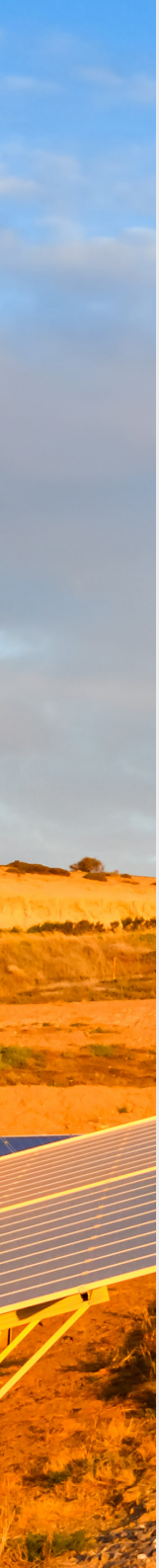
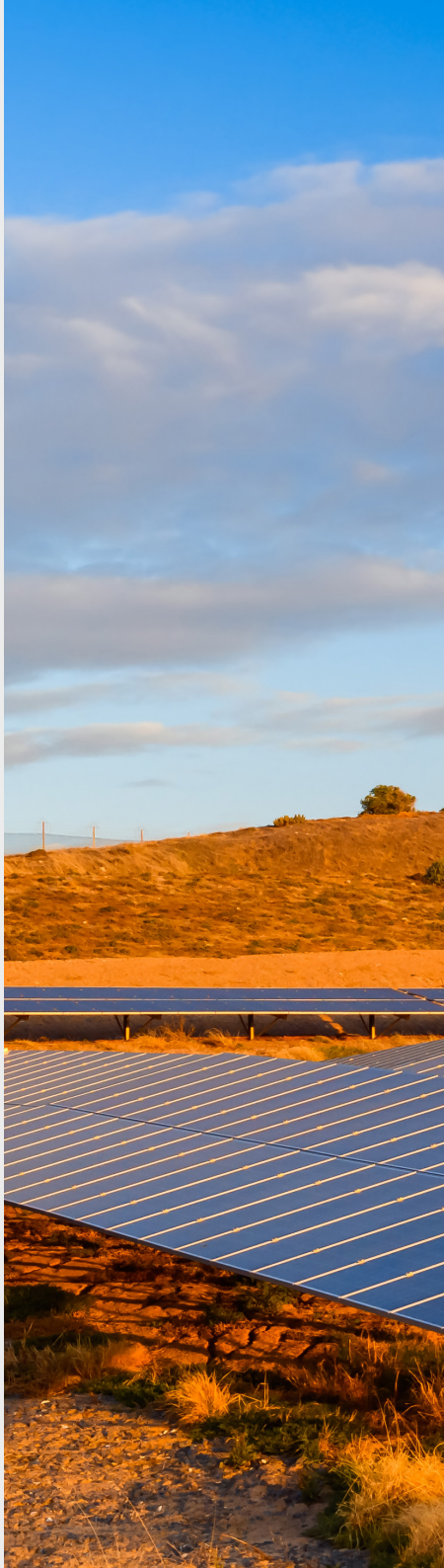


EMPOWERING AUSTRALIAN INDUSTRY



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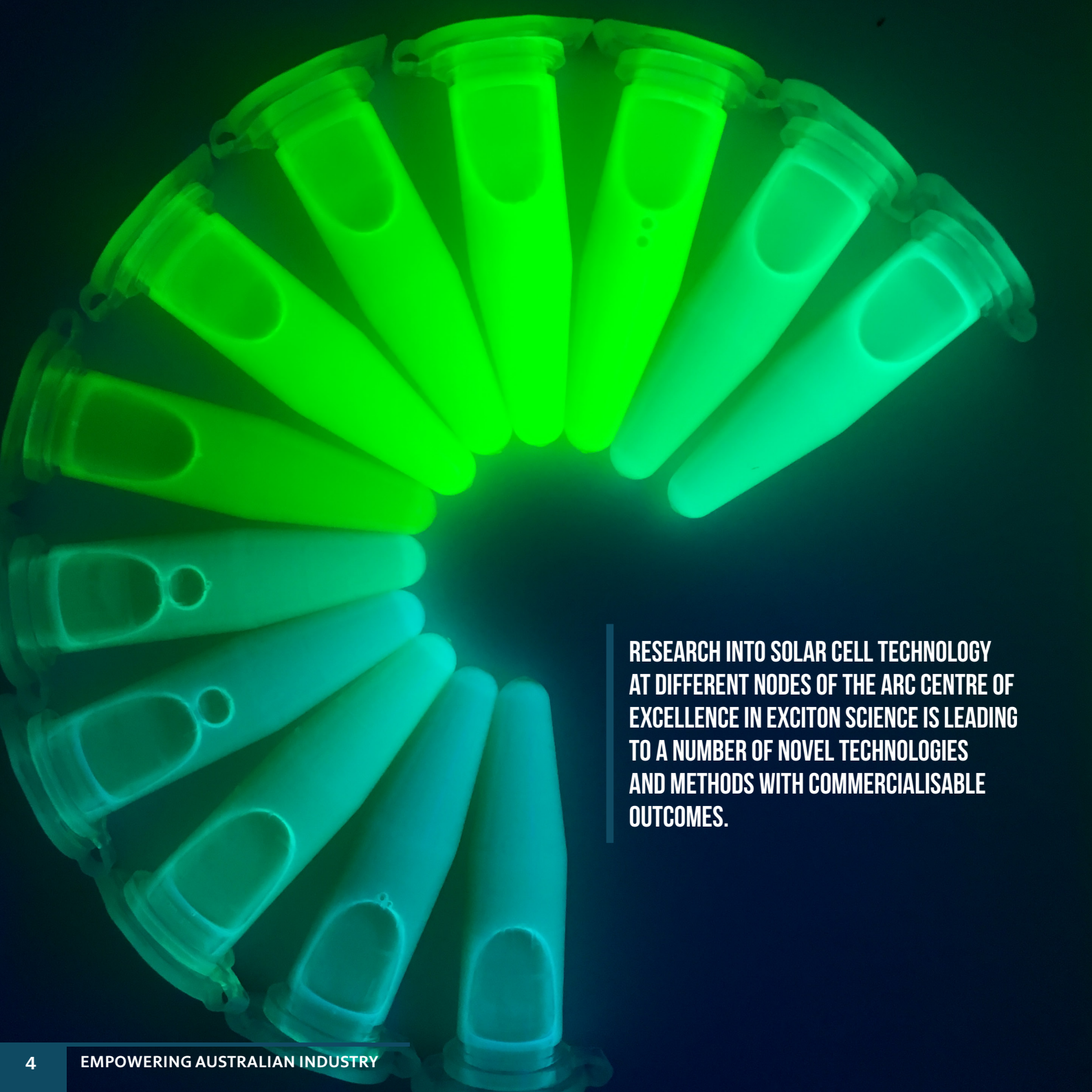


RESEARCH INTO SOLAR CELL TECHNOLOGY AT DIFFERENT NODES OF THE ARC CENTRE OF EXCELLENCE IN EXCITON SCIENCE IS LEADING TO A NUMBER OF NOVEL TECHNOLOGIES AND METHODS WITH COMMERCIALISABLE OUTCOMES.

CENTRE OF EXCELLENCE GIVING SOLAR ENERGY A TWIST

The *ARC Centre of Excellence in Exciton Science* (Exciton Science) has several research teams working at different Australian universities with international partners looking into possibilities for transforming light into energy – and energy into light – for innovative renewable energy solutions, including solar technology, energy efficient lighting and security systems.

One Exciton Science research project, featuring Elham Gholizadeh as lead researcher and supervised by Chief Investigator Tim Schmidt at The University of New South Wales (UNSW), has made a breakthrough in light conversion that could potentially impact solar photovoltaics, biomedical imaging, drug delivery and photocatalysis. The team has been able to 'upconvert' low energy light into high energy light, which can be captured by solar cells, in a new way.

Most solar cells are made from silicon, which restricts the range of light that can be absorbed. This means that some parts of the light spectrum are going unused by many current devices and technologies.

To extend the sensitivity range of these devices, the team has turned low energy light into more energetic, visible light that can be absorbed by silicon.

Contributing researcher Professor Jared Cole from RMIT University says that using oxygen to transfer energy is a breakthrough that goes against the grain for that particular atom.

'Often without oxygen, upconversion works well enough. However, as soon as you allow oxygen in, the process stops working,' Jared said. 'It was the Achilles heel that ruined all our plans, but now, not only have we found a way around it, suddenly it helps us.'

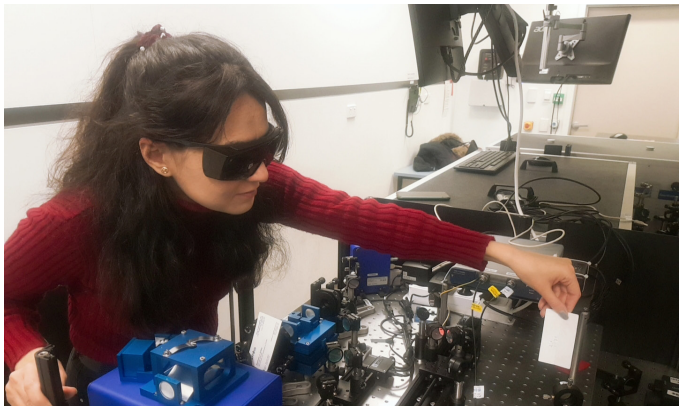
Meanwhile, at the Monash University-based team at Exciton Science, researchers are adapting solar energy technology in a different way. The team has adapted a technology that's being used to improve solar power – synthetic nanocrystals based on a perovskite structure – and turned it into a detection method.

'Perovskite nanocrystals have proved to be a very efficient light emitter,' says lead researcher Dr Wenping Yin.

The researchers discovered that perovskites change colour within seconds of coming into contact with a common, although toxic, agricultural fumigant, which could previously only be detected using expensive laboratory instrumentation with long delays.

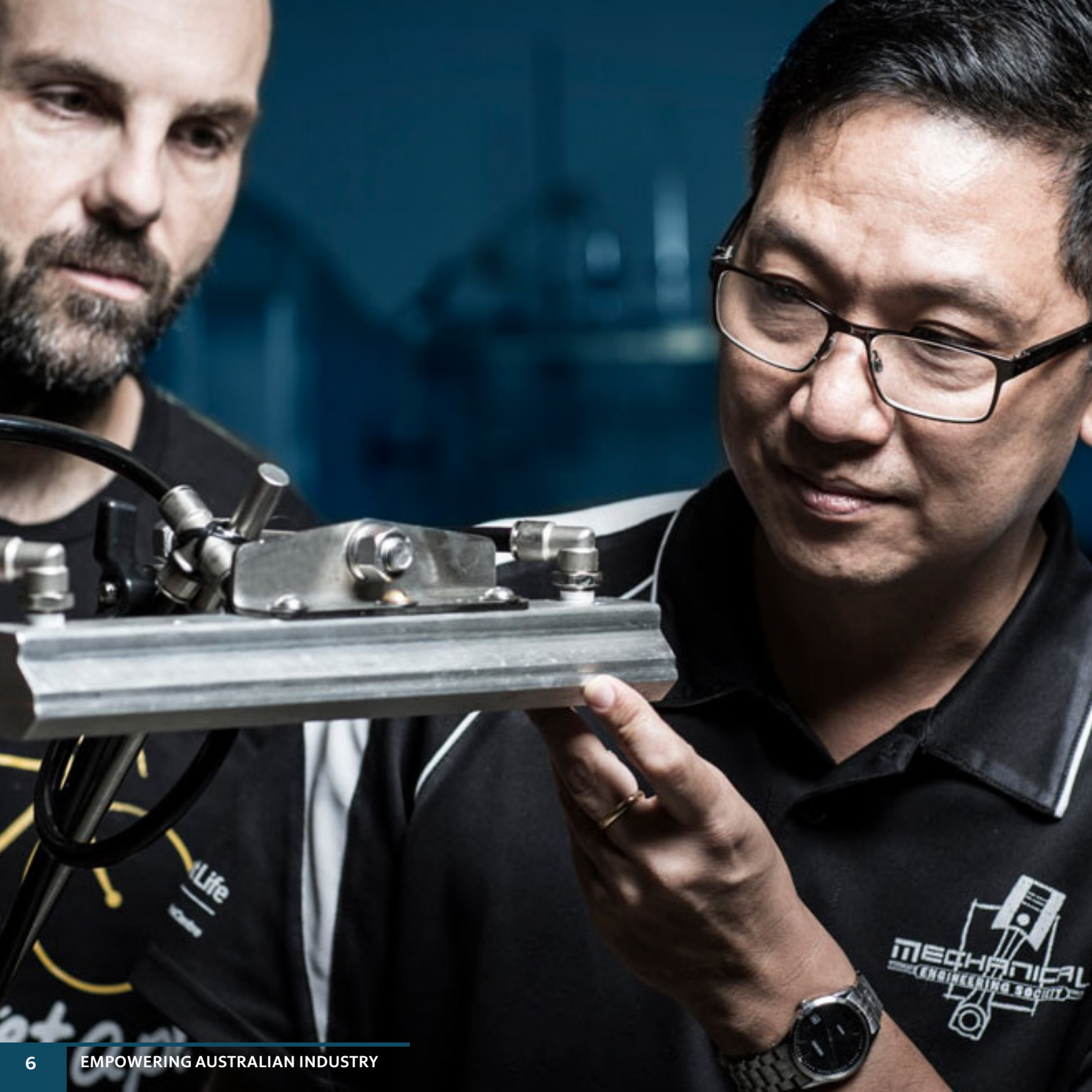
'The underlying detection method can be readily expanded to detect a range of other pesticides and chemical warfare agents,' says senior research leader Professor Jacek Jasieniak, at Monash University.

The next steps are to work with industry partners at Australia's national science agency CSIRO and the Department of Defence to develop the technology for use by defence force personnel and first responders.



(Left) The tuneable emission colour of a solution of various bromide-based perovskite nanocrystals under UV light. Credit: Dr Wenping Yin.

(Above) PhD student Elham Gholizadeh working in the Molecular Photonics Laboratories at UNSW Sydney. Credit: UNSW/Exciton Science.


MECHANICAL
ENGINEERING SOCIETY

IT'S ALL IN THE COATING – CREATING LONGER LASTING STEEL PRODUCTS

BlueScope, a provider of innovative steel materials, products, building systems and one of the world's leading manufacturers of painted and coated steel products, is drawing on expertise at the *ARC Research Hub for Australian Steel Manufacturing* (Steel Research Hub), administered by the University of Wollongong (UOW) to investigate complex manufacturing challenges for creating more durable building products.

One of the critical challenges being addressed by a joint UOW-BlueScope-University of Queensland research team at the Hub is how to produce smooth, uniform, thin metallic alloy coatings on high-quality coated steel products.

Coated steel products – such as corrosion-resistant metallic alloy coated steels – are important for Australian steel manufacturers, particularly in building applications that must withstand the demands of the harsh Australian climate for extended periods.

Associate Professor Buyung Kosasih, a Chief Investigator with the Steel Research Hub, says that the research team has developed mathematical and numerical models that help to predict the coating process under different operating conditions.

Metallic alloy coatings are applied to a strip of steel by first passing the strip through a molten alloy bath, such as in hot-dip galvanising; then, as the strip passes out of the bath, an air jet knife is used to blow or 'wipe' away the excess coating material to achieve the desired coating thickness and uniformity. A uniform coating is a more durable finish, less likely to corrode.

Associate Professor Buyung Kosasih says that their mathematical model is the first that links instability of the air jet knife to potential non-uniformities in the coating surface. This has highlighted a critical operating threshold that produces either a smooth or a rough coating finish of the metallic alloy coating. The team has now employed laboratory-scale experiments carried out at BlueScope facilities to assist in the selection of air jet knife operational and design settings in industry.

The Steel Research Hub originally launched in 2015, with a second successful Hub awarded $5 million from the ARC in 2020, securing a further $23.4 million cash and in-kind from collaborating industry and other university partners.

> **THE STEEL RESEARCH HUB HAS MADE A MEASURABLE IMPACT ON MAINTAINING AN ADVANCED, COMPETITIVE STEEL MANUFACTURING INDUSTRY IN AUSTRALIA, ONE THAT IS ABLE TO PROVIDE HIGH QUALITY, LOCALLY PRODUCED STEEL FOR CUSTOMERS IN RESIDENTIAL CONSTRUCTION, DEFENCE, INFRASTRUCTURE AND TRANSPORTATION SYSTEMS.**

Andrew Johnston and Buyung Kosasih, assessing the performance of the Mark I slotted air jet laboratory equipment. Credit: Paul Jones.

HARVESTING HUMAN WASTE FOR GREEN ENERGY

Associate Professor Qilin Wang is an ARC Future Fellow and winner of the 2020 Eureka Prize for Outstanding Early Career Researcher for his work on a technology that could turn wastewater treatment plants into carbon-neutral energy generators.

An environmental engineer with the Centre for Technology in Water and Wastewater at the University of Technology Sydney (UTS), Associate Professor Wang is working with partners to develop the energy recovery process for industry.

'My goal is to transform the energy-consuming and high emission sewage treatment process into a zero energy – or, even better, energy producing – low-emission process,' Associate Professor Wang says.

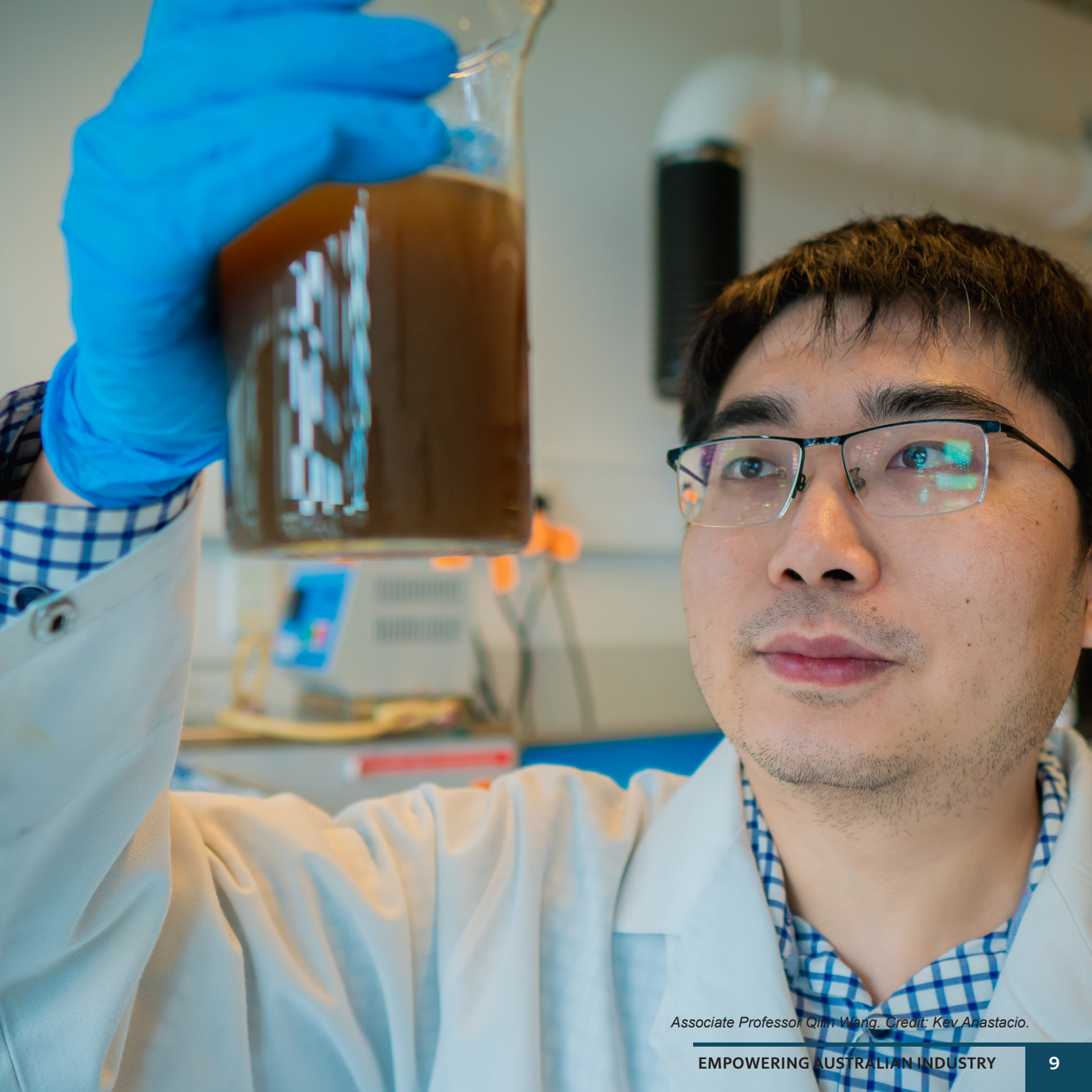
Treating human waste using current methods consumes a large amount of energy and also produces greenhouse gas emissions, while being a major expense for councils and water utilities. While some treatment plants already produce what's known as biogas, existing processes recover just 5-10 % of the energy stored in sewage sludge.

Associate Professor Wang's breakthrough is to recruit an unwanted by-product of the wastewater treatment process – ammonia – by mixing it in with the sewage sludge to help transform some of its non-biodegradable components, and free up organics for biogas production. Laboratory experiments suggest the process could improve energy recovery from sewage sludge by four to six times. It's also easy to implement, with no need for special equipment or inputs such as chemicals or external energy.

'It's a simple process. Sewage sludge is added into a simple mixing tank, to be joined by free ammonia. Then we just mix them for around for a day or so,' Associate Professor Wang says.

In an added bonus, recent experiments suggest this free-ammonia technology could also reduce the presence of antibiotic resistant genes in the sludge, and therefore in the environment, where they can negatively impact on human health.

> **NAMED AMONG AUSTRALIA'S MOST INNOVATIVE ENGINEERS IN UTILITIES IN 2020 FOR HIS WORK, THE EUREKA PRIZES JUDGING PANEL NOTED THAT ASSOCIATE PROFESSOR WANG'S 'CLOSED SYSTEM NATURE OF THIS INNOVATION IS PARTICULARLY POWERFUL. THIS IS A BREAKTHROUGH TECHNOLOGY THAT HAS DIRECT APPLICATION FOR COMMUNITY AND ENVIRONMENTAL BENEFIT.'**



Associate Professor Qilin Wang. Credit: Kev Anastacio.

FUTURE IS FULLY CHARGED WITH NEW BATTERY TECHNOLOGY

The rechargeable Lithium-ion (LI) battery has become a ubiquitous technology that underpins our lives, powering our mobile devices and electric cars, as well as providing efficient storage for renewably-generated electricity. But there is still an enormous research effort underway to increase their efficiency and reliability, as the technologies of the future will have even greater thirst for the portable energy power of batteries.

Professor Maria Forsyth, a former ARC Australian Laureate Fellow at Deakin University, is Director of the *ARC Industrial Transformation Training Centre in Future Energy Storage Technologies* (storEnergy) and is determined that the next battery technology breakthrough will have a manufacturing home in Australia.

The research teams at storEnergy are working with LI local Australian comanies and organisations to push the frontiers of battery technology in different ways. Some teams are focussed on improving existing LI cells, to make them higher energy density. Other teams are exploring new battery formulations, such as replacing lithium with sodium, which is more readily available and more environmentally friendly.

'One of our partner companies, CALIX Ltd, based in Bacchus Marsh just outside Melbourne – whose expertise is in high surface area inorganic materials, such as oxides for the agricultural industry – is now exploring using their unique calcining method for the manufacture of oxide for more sustainable, high performance electrodes,' says Professor Forsyth.

Meanwhile, storEnergy Chief Investigator, Professor Jennifer Pringle at Deakin University, is working with Boron Molecular Inc. to develop the manufacturing processes for electrolyte components, including polymers and the special salts that go into batteries, to be up-scaled, and to make them cleaner and cheaper.

Professor Forsyth says that the current LI cell dates from 1992, and that the markets are now at the tipping point for deciding what the next generation of batteries will be and who will make them – driven by the need for new kinds of batteries with different properties.

'I'm so excited for what is happening now in Australia, the forces are aligning, and there is real potential for the birth of a new industry from the translation of Australia's research efforts,' says Professor Forsyth.

(Above) Professor Maria Forsyth. Credit: ARC Industrial Transformation Training Centre in Future Energy Storage Technologies.

(Right) Advanced high energy density Lithium-metal battery in Ionic Liquid Electrolyte. Credit: storEnergy.

WITH STRONG INDUSTRY INTEREST IN MAKING AUSTRALIA A WORLD LEADER IN BATTERY MANUFACTURING TECHNOLOGY, PROFESSOR FORSYTH AND HER TEAM AT STORENERGY ARE WELDING TOGETHER THE STRANDS OF RESEARCH, ENGINEERING AND MANUFACTURING EXPERTISE TO CREATE THE FOUNDATIONS FOR A VIABLE BATTERY INDUSTRY ON THESE SHORES.

MAKING TALL TIMBER BUILDINGS FIRE SAFE

The *ARC Industrial Transformation Research Hub to Transform Future Tall Timber Buildings* (ARC Future Timber Hub) is a leading timber research collaboration, administered by The University of Queensland, bringing together experts from industry, government, and academia who are committed to the future development of safe tall timber buildings in the Pacific region.

The Hub's research team is advancing the science of tall timber construction including the development of design solutions for engineered wood products such as Cross-Laminated Timber (CLT). Engineered wood products have multiple beneficial qualities including having naturally-insulative properties, advantageous structural performance, sustainability, and aesthetic features. They also use sustainably managed plantations, and prefabricated construction technologies that minimise waste while enhancing building quality and performance.

To ensure the fire-safe use of mass timber structures in tall timber buildings, researchers from the Hub have developed a design framework to define the conditions that enable the self-extinction of mass engineered timber. This is especially important for timber used in tall buildings, where there is a fear of massive conflagrations and fire-induced progressive collapse.

With industry partners including Hyne Timber, XLam, Queensland Fire and Emergency Services, Lendlease, Knauf and Rockwool International, the team conducted a series of 6 large-scale compartment fire tests to validate the framework. Each test was equipped with more than 500 sensors and a 14m-high buoyancy calorimeter used to acquire essential data for characterising the fire behaviour.

Researchers from the Hub were also among the winners of Australia's 2020 Good Design Awards – the highest honours for design and innovation in the country – receiving a prestigious Good Design Award Gold Accolade in the Engineering Design category for their 'Suspended Remnants' timber pavilion, in recognition of the structure's outstanding design and innovation.

The pavilion, a structure created from a collaboration between two Hub project teams, with additional research partners at Swinburne University of Technology, and Hyne Timber, showcased how under-valued sawmill products can be turned into value-added timber structures. The team coupled inventory constrained design with a form finding process called funicular modelling, famously used by Antoni Gaudi over a century ago.

(Above) The winning Good Design Australia Awards team – Professor Jane Burry, Aurimas Bukauskas, Dr Joe Gattas, Kim Baber and Canhui Chen. Credit: ARC Future Timber Hub.

(Right) PhD Student, Hangyu Xu, in front of the fire test room. Credit: ARC Future Timber Hub.

THE ARC FUTURE TIMBER HUB IS BUILDING A BODY OF RESEARCH EVIDENCE TO GUIDE THE ESTABLISHMENT OF CLEAR GUIDELINES FOR TIMBER-BASED CONSTRUCTION FOR TALL TIMBER BUILDINGS IN AUSTRALIA.

THE RESULTS FOR FIRE TESTING HAVE NOW ENABLED THE VALIDATION OF THE PROPOSED DESIGN FRAMEWORK, OPENING THE WAY FOR PERFORMANCE-BASED DESIGN OF MASS TIMBER BUILDINGS BY FIRE SAFETY ENGINEERS.

INCREASING THE SAFETY OF COAL MINERS

The *ARC Industrial Transformation Research Hub for Nanoscience-based Construction Material Manufacturing* (the Nanocomm Hub) is a multidisciplinary research hub that aims to transform the construction materials industry. Administered by Monash University, the Nanocomm Hub has over 50 partners from Australian industry, research and higher education organisations.

Chief Investigators, Associate Professor Ting Ren and Professor Alex Remennikov, both based at the University of Wollongong node of the Hub, have been working to create a new protective system for continuous miners in underground coal mines.

The project is intended to meet new industry standards that were put in place following a 2014 New South Wales coal mining tragedy in which two miners died 500 metres underground. The men had been operating a continuous mining machine when hundreds of tonnes of coal collapsed on them. This tragedy sparked an investigation that determined that existing protective systems were inadequate, prompting tighter safety regulations.

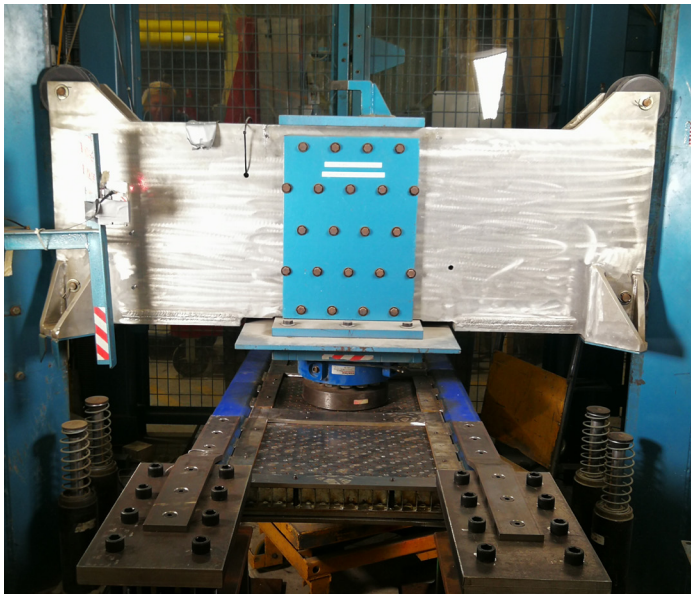
'We wanted to design a new protective system that could be installed on continuous miners as the last line of defence after all other mitigating measures fail,' explains Associate Professor Ren. 'Our aim was to protect people working on these machines against the hazard of coal bursts while building roadways in highly stressed coal seams.'

The researchers modelled the impact of ejected coal fragments and devised formulas to predict the dynamic load and kinetic energy of flying coal and the resulting impact on continuous miners. They then developed a prototype protective system which could be readily assembled underground.

The system they developed contained a number of energy-absorbing honeycomb panels made of very thin steel, with a height of 1.5 metres to protect the full body of a miner. A cover plate is robotically attached to the honeycomb core with several hundred welds.

Through dynamic impact testing, the team assessed the energy-absorbing capacity of the panels and found that, even with 600 kg of coal dropped from a 5-metre height at a velocity of 9 m/s, the panels could absorb a significant amount of energy without disintegration.

Having demonstrated the effectiveness of the system, the researchers are now in discussion with coal industry operators and coal industry equipment designers to generate interest in its further development and applications.



(Above) Dynamic impact testing of the CM protective panel with a drop hammer system. Credit: Dr Xiaohan Yang.

(Right) Credit: iStock.com/SIYAMA9.

THE RESEARCHERS HAVE COLLABORATED WITH INDUSTRY PARTNER PETER HOLT OF IRONCLAD MINING MACHINERY TO DEVELOP A SYSTEM OF ENERGY ABSORBING PANELS THAT CAN BE READILY ASSEMBLED UNDERGROUND TO PROTECT CONTINUOUS MINERS FROM DANGEROUS COAL BURSTS. THE SYSTEM WAS SHOWCASED AT THE 2021 RESOURCE OPERATORS CONFERENCE AND GENERATED SIGNIFICANT INTEREST IN ITS APPLICATIONS.

INTERVIEWS WITH LEADING FIGURES FROM ACROSS BUSINESS, GOVERNMENT ADMINISTRATION AND CREATIVE SECTORS ARE PROVIDING FIRST-HAND, INDUSTRY-SPECIFIC ACCOUNTS OF WHAT EMPLOYERS WANT FROM HUMANITIES GRADUATES, THE NEED FOR SKILLS-MIXING, ETHICAL AND CRITICAL THINKING, AND HOW THE HUMANITIES CREATE LEADERS WITH THE CAPACITY FOR EFFECTIVE COMMUNICATION, INSPIRATION, AND EMPATHY.

Credit: iStock.com/demaerre.

THE FUTURE HUMANITIES WORKFORCE

How can we best support the next generation of humanities researchers? What are the future knowledges and skills sets needed for Australia's humanities workforce, within and beyond the university sector? Is this workforce diverse enough to cater for the future needs of our political, legal, economic and educational sectors?

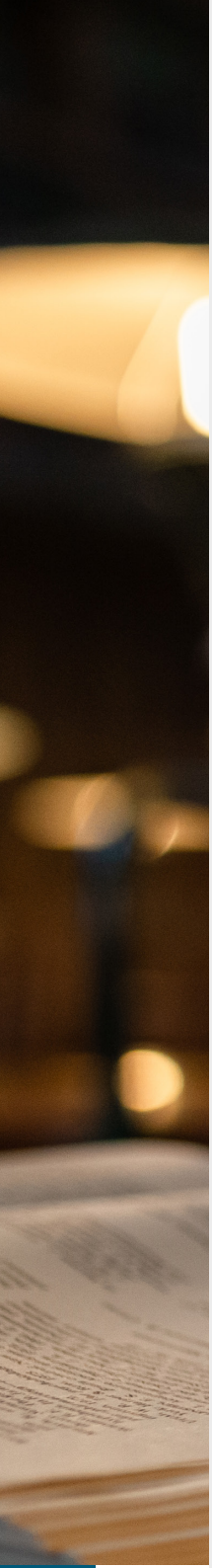
Research being undertaken by the Australian Academy of the Humanities' *Future Humanities Workforce project*, funded by the ARC's *Learned Academies Special Projects* scheme, is tackling these questions as it develops a new and comprehensive account of Australia's humanities workforce and a plan for its future.

The COVID-19 pandemic has had a profound impact on the university sector and wider industries and workplaces. It has never been more essential to take stock of our graduates' preparedness to adapt to changing research environments, digital disruption, increased interdisciplinary and cross-sector collaboration.

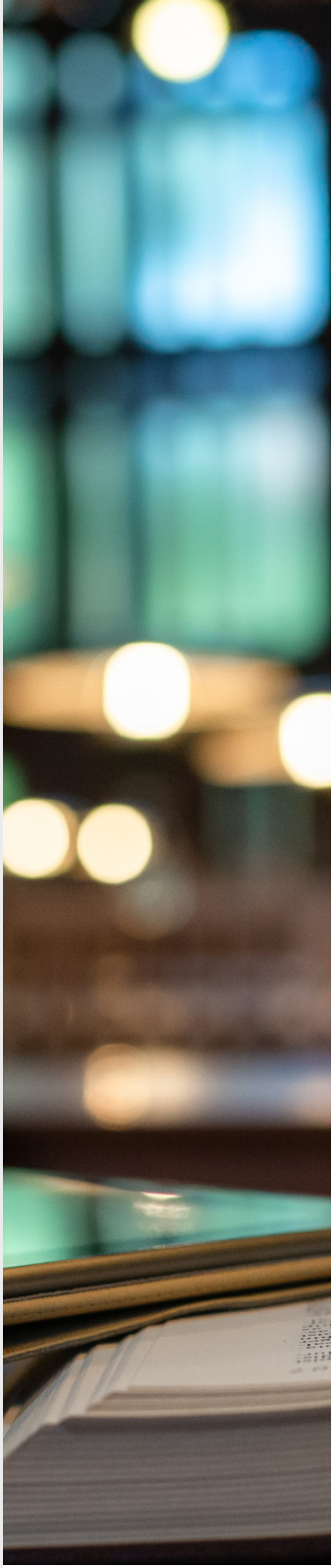
Led by the Academy's Immediate Past President and ARC Laureate Fellow, Professor Joy Damousi, (Australian Catholic University), the project's team includes Professor Jane Lydon (The University of Western Australia), Professor Graham Oppy (Monash University), the Academy's Director, Policy and Research, Dr Kylie Brass, and Project Researcher, Dr Iva Glisic.

To date, the project's consultations have identified priorities for gender and workforce diversity and practical solutions to future-proofing Australia's humanities-trained workforce.

The project will publish its findings in late 2021, providing a springboard for further conversations about how we build both timely and timeless skills to strengthen the working lives and livelihoods of Australians and Australia.



ADVANCING SOCIAL AND CULTURAL OUTCOMES



Credit: iStock.com/ Tashi-Delek.

USING FILM TO TELL THE STORY OF OUR NATIONAL HISTORY

Associate Professor Tom Murray is an academic and film producer based at Macquarie University, whose screen production research has been supported since 2014 by a Discovery Early Career Researcher Award (DECRA). A major outcome of the project is a feature-film documentary, which made its debut at the 2020 Sydney Film Festival.

The Skin of Others is a story told through the extraordinary lives of two remarkable men: Aboriginal WW1 soldier Douglas Grant (c.1885-1951) and acclaimed Indigenous actor Balang Tom E. Lewis from the Murrungun people, who plays Grant in the film.

The film movingly interweaves Grant's experiences during two major conflicts of Australian and world history: the Frontier Wars that remade sovereign Aboriginal nation-territories into the Commonwealth of Australia; and WW1, a conflict that has provided Australian histories with a foundational narrative of tragic heroism and national pride in the ANZAC story. Within this broad narrative Balang Tom E. Lewis demonstrates his incomparable ability to inhabit the skin of others, portraying Grant's heroic actions in war and peace in a lead performance full of empathy and understanding.

'This is also the story of Australia, its violent past and its future potential,' says Dr Murray. 'It recounts a tragic national history of Australian colonial relations with First Nations people, explores the ways we tell the story of our nation, and ultimately dreams of a more reconciled and inclusive Australian future.'

Dr Murray has been awarded an ARC Future Fellowship for work on a new documentary-film history project *The Mangatharra Road*, which aims to demystify Australian pre-colonial isolation by demonstrating Indigenous Australia's connection to South-East Asian cultural and trading networks.

A SONG THAT DR MURRAY CO-WROTE WITH DAVID BRIDIE FOR THE DOCUMENTARY, CALLED '*THE BALLAD OF THE BRIDGE BUILDERS*', WAS VOTED 'BEST ORIGINAL SONG COMPOSED FOR THE SCREEN' AT THE 2020 APRA SCREEN MUSIC AWARDS.

(Above) Actor Balang Tom E. Lewis as Douglas Grant in The Skin of Others. *Credit: Tarpaulin Productions.*

(Right) Director and ARC DECRA recipient Associate Professor Tom Murray with actor Balang Tom E. Lewis in 2018. Credit: Tarpaulin Productions.

KICKING CAFFEINE

Energy drink consumption has been associated with physical and mental health problems, and yet is increasing worldwide – especially among young adults who account for about two-thirds of the market. While consuming the occasional energy drink is not problematic, some individuals may consume several every day, leading to the development of intolerance and serious withdrawal symptoms upon cessation. ARC-funded researchers have looked at ways to reduce or combat such problematic over consumption of energy drinks.

Through an ARC Discovery Project, Psychologist Professor Eva Kemps and her research team at Flinders University have used cognitive bias retraining – a form of computer-based training aimed at reducing decision-making biases in consuming energy drinks – to test the effect on the decision making of regular consumers of energy drinks.

More than 200 participants aged between 18 and 25 underwent a cognitive bias modification protocol aimed at reducing energy drink consumption by either decreasing the extent to which energy drink cans capture the attention of regular energy drink consumers (attentional bias) or reducing the tendency for these consumers to approach energy drinks (approach bias).

'By giving participants some simple techniques, we examined whether they were able to moderate their bias toward choosing energy drinks over soft drinks and more healthy options, and perhaps reduce consumption before they become addicted,' says Professor Kemps.

There is some evidence that a reduction in bias can produce a corresponding reduction in consumption in terms of lower intake. However, so far neither attentional nor approach bias modification has been shown to translate into a significantly reduced energy drink intake.

Professor Kemps says that these trial methods will now be expanded to examine how to combat the attentional and approach biases of consumers towards energy drinks.

> **SIDE-EFFECTS OF EXCESSIVE INTAKE OF THE HIGH CAFFEINE DRINKS, WITH OTHER STIMULANTS TAURINE, GUARANA AND GINSENG, CAN LEAD TO A RANGE OF NEGATIVE PHYSICAL AND MENTAL HEALTH CONSEQUENCES, INCLUDING ANXIETY, DEPRESSION, OR EVEN STRESS, PTSD AND SUBSTANCE ABUSE.**

Flinders University Professor of Psychology Eva Kemps researches mind, body and cognition. Credit: Flinders University.


Coca-Cola
CLASSIC 1886
Coca-Cola

TEEN MENTAL HEALTH STUDY

A global mental health study led by ARC-supported researchers at the *ARC Centre of Excellence for Children and Families over the Life Course* (Life Course Centre), administered by The University of Queensland, has found approximately one in five teenagers experience thoughts of suicide or anxiety.

The study investigated data collected from more than 275,000 adolescents aged between 12-17 years across 82 low, middle and high income countries. It found 14 per cent of adolescents had suicidal thoughts and 9 per cent had anxiety over a 12-month period.

The study, led by Life Course Centre PhD student (now Research Fellow), Tuhin Biswas, showed that in every country, teens with fewer peer and parental supports and higher levels of parental control were more likely to report thoughts of suicide and anxiety. The risks were also higher for teens who had experienced peer conflict, victimisation, isolation and loneliness.

'Our study shows many adolescents around the world, irrespective of their country's income status, experience suicidal thoughts and anxiety, but there is high variation across countries and different continental regions,' says Tuhin Biswas.

Co-authors on the study included Life Course Centre Chief Investigator Associate Professor Abdullah Mamun and Life Course Centre Director Professor Janeen Baxter.

Associate Professor Abdullah Mamun said mental health remained under-reported in many low-to-middle income countries due to social stigma, religious or cultural taboos, and inadequate mental health resources. Of the 82 countries in this study, 36 had no specific mental health policy.

Professor Baxter says the study provides the evidence base to help identify protective factors against adolescent suicidal ideation and anxiety, and to inform targeted responses in policy and practice.

'These could include peer-based programs to enhance social connectedness and parent skills training to improve parent-child relationships. Family environments and peer relationships have a critical role to play in adolescent mental health. It is also important to tailor protective strategies in line with regional, socioeconomic and cultural circumstances.'

The study is based on data collected in the World Health Organization Global School-based Health Surveys between 2003 and 2015. Participants were asked if they had seriously considered attempting suicide during the past 12 months, and if they had been so worried about something they could not sleep at night.

> 'ADOLESCENCE IS A PIVOTAL DEVELOPMENTAL STAGE THAT EXERTS LIFE-LONG INFLUENCE ON HEALTH AND WELLBEING. MENTAL HEALTH ISSUES COME WITH ENORMOUS PERSONAL, SOCIAL AND ECONOMIC COSTS IN LOST OPPORTUNITIES AND REQUIRES STRATEGIC EARLY INTERVENTION.' PROFESSOR JANEEN BAXTER, DIRECTOR OF THE LIFE COURSE CENTRE.

Credit: Wikimedia Commons (Public Domain).

RESEARCH EXPLORES THE STRESS OF UNAFFORDABLE HOUSING MARKET ON OLDER RENTERS

Research by an ARC Discovery Early Career Researcher Award (DECRA) recipient, Dr Emma Power, has found that older women are struggling in an insecure and unaffordable rental housing market. A combination of high housing costs and low incomes leaves many living in substandard housing and unable to afford necessities like food and energy bills.

The research was conducted in three stages: a policy review of age-connected housing strategy in Australia; interviews with stakeholders in the ageing and housing sectors; and in-depth interviews recording the housing biographies and experiences of older women living across diverse housing contexts including private and social rental, shared housing, transitional and emergency housing, and homelessness.

Dr Emma Power, based at Western Sydney University's School of Social Sciences and Institute for Culture and Society, says that older women's experiences are a warning of the risks the current housing crisis poses to Australia's growing group of older renters.

'Single older women, aged 55 and over, are overrepresented amongst the asset poor in Australia. They are also one of the fastest growing groups of homeless people nationally,' says Dr Power.

'Many of the women in my research lived in degraded and low-quality housing or paid high housing costs which stretched their budgets, leaving them unable to buy nutritious food and manage utility bills.'

Dr Power says that while affordability and security are concerns for all renters, they are especially vital for older renters on low, fixed incomes facing uncertain futures in the private rental market. The number of older Australians who rent is also projected to increase over the next decade.

Dr Power's research findings present women's experiences of housing insecurity and calls for urgent action to address rental affordability and security on a national scale. The report outlines five policy recommendations made with the intention of enabling single older women to achieve a reasonable standard of life, with basic housing and income security.

> **'A FAILURE TO ENSURE SECURE HOUSING FOR ALL BRINGS RISK TO THE COMMUNITY AS A WHOLE,' SAYS DR POWER.**

(Above) Dr Emma Power. Credit: Western Sydney University.
(Left) Credit: iStock.com/fizkes.

'IT IS NO SURPRISE THE SITE SEES SIGNIFICANT EVIDENCE FOR FISHING... NOT JUST THE BONES OF A WIDE VARIETY OF FISH AND SHARK SPECIES, BUT ALSO IN THE FORM OF SHELL FISHHOOKS IN DIFFERENT SHAPES AND SIZES,' SAYS ARC AUSTRALIAN LAUREATE FELLOW, PROFESSOR SUE O'CONNOR.

Dr Kealy in the field. Credit: ANU media.

SHELLS, BONES AND FISHHOOKS TELL A STORY OF SEA LEVEL CHANGE

ARC-supported researchers from The Australian National University (ANU) have led the excavation of a cave – called Makpan – on the Indonesian island of Alor, making an exciting discovery. Shells, fish bones and fishhooks found in the cave show how people once lived and were rapidly adapting to climate change as they made their way towards Australia tens of thousands of years ago.

Makpan witnessed a series of massive sea level highs and lows during its 43,000 years of human occupation, largely due to the climactic extremes of the last Ice Age. According to Dr Shimona Kealy from ANU, analysis of artefacts found at Makpan show how inventive and adaptive its early residents were.

'When people first arrived at Makpan, they came in low numbers,' Dr Kealy says. 'At this time, the cave was close to the coast – as it is today – and this early community lived on a diet of shellfish, barnacles and sea urchin, with sea urchins in particular eaten in large numbers.'

Shortly after their initial arrival, sea levels began to fall. This increased the distance from the site of Makpan to the coast, and likely encouraged people to broaden their diet to include a variety of land-based fruits and vegetables. As the last Ice Age began to wane about 14,000 years ago, Makpan was once again within 1 km of the coast.

The team, led by ARC Australian Laureate Fellow, Professor Sue O'Connor, used radiocarbon dating of preserved charcoal and marine shells to establish the times when people were occupying the cave.

The findings show that Alor was occupied around the same time as Flores to the west, and Timor to the east – confirming Alor's position as a 'stepping-stone' between these two larger islands.

The study was supported by the *ARC Centre of Excellence for Australian Biodiversity and Heritage* (CABAH), which is administered by The University of Wollongong.

> 'INTERNET-DISTRIBUTED VIDEO SERVICES SUCH AS NETFLIX, HAVE COMPLETELY TRANSFORMED THE ENTERTAINMENT LANDSCAPE AND THE COMPETITIVE FIELD IN WHICH FREE-TO-AIR TELEVISION OPERATES, AS WELL AS TURNED THE DEFINITION OF 'PAY TV' ON ITS HEAD,' SAYS PROFESSOR LOTZ.

Credit: Netflix.

NETFLIX: AN ENTERTAINMENT GAMECHANGER

A team of researchers from RMIT and Queensland University of Technology's Digital Media Research Centre are collaborating on an ARC Discovery Project exploring the impact of global subscription video-on-demand platforms on national television markets –providing a research basis for media regulators to set a new media policy environment.

Internet-distributed service Netflix is often portrayed as an entertainment behemoth crushing all competition and diminishing local content, but the research team has found that's a simplistic view. Unlike old industry heavyweights in Hollywood, Netflix fosters local content for a global audience, and has produced content for more than 167 million subscribers worldwide.

'Few recognize the extent to which Netflix has metamorphosed into a global television service. Unlike services that distribute only US-produced content, Netflix has funded the development of a growing library of series produced in more than 27 countries, across six continents, including Australia,' says researcher Professor Amanda Lotz.

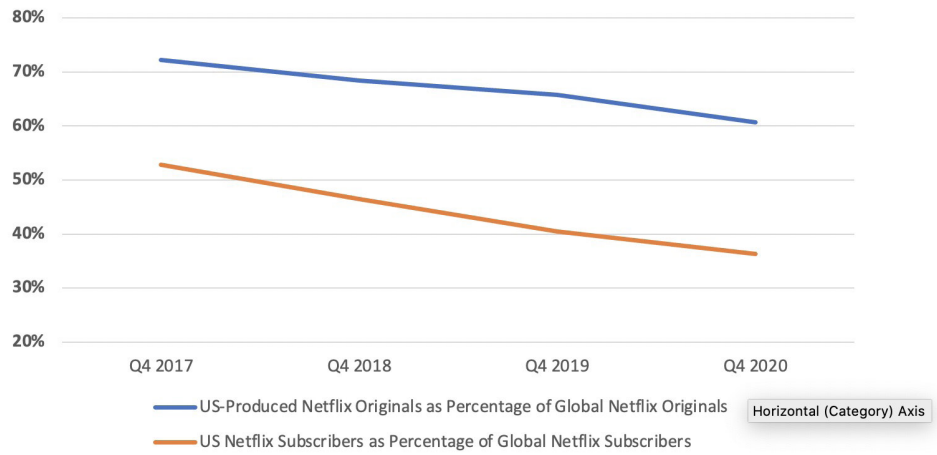
The research team analysed the libraries Netflix makes available in different countries and found differences that distinguish it from services such as Disney+ and others launching from Hollywood studios. As Netflix's non-US subscribers have grown, so too has commissioning of movies and series from outside the US.

The researchers explored how Netflix operates as a supplement rather than a replacement for national providers, especially public service broadcasters central to cultural storytelling. The team has also been tracking national policy approaches to streaming services and their implications.

'It is difficult to appreciate whether some of Netflix's peculiarity results from its global reach, business model, or distribution technology, but these are crucial questions to ask. And do these characteristics lead to the availability of stories, characters and places not readily available? If so, this is a notable benefit to audiences,' says Professor Lotz.

'We should also ask how these characteristics affect opportunities available for writers, producers, and actors who might be rethinking the kind of stories that must be told to sell internationally.'

Percentage of Netflix US Subscribers and Percentage of US Commissions, 2017–2020



Credit: Shutterstock/sdecoret.

INTERNET OF THINGS IMPROVING AUSTRALIAN LIVES

The Australian Council of Learned Academies (ACOLA), funded in part by the ARC *Linkage Learned Academies Special Projects* (LASP), has released a report highlighting the significant benefit Australia can derive from the Internet of Things (IoT).

The IoT describes the network of physical objects – 'things' – that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. Examples of these include home devices, health wearables, agricultural sensors, and autonomous factories and mines.

It is estimated that there were 16 million IoT devices in Australia in 2018, and that by 2022 there will be 29 billion connected devices in the world, of which around 18 billion will be related to IoT.

The ARC-supported study explores a range of applications across Australian cities and regions; to create an on-demand manufacturing sector, monitor carbon emissions in our supply chains, track energy usage in our homes, enhance telehealth to tailor patient care and support the monitoring and treatment of COVID-19 patients in their own homes. The report provides critical evidence of the IoT's potential opportunities and challenges, and outlines practical measures for governments, industry and community.

Australia's former Chief Scientist, Dr Alan Finkel, who commissioned the report on behalf of the National Science and Technology Council, says the research examines how we can improve the way we live through using technology. It also shows how industries can grow by facilitating better processes and automation.

'The Internet of Things could help us monitor environmental disasters, support pandemic management and enhance the delivery of services to regional and remote populations. It can also be useful to track and demonstrate sustainability in supply chains, such as low emissions products, and will assist industry to create a greater trust in data,' says Dr Finkel.

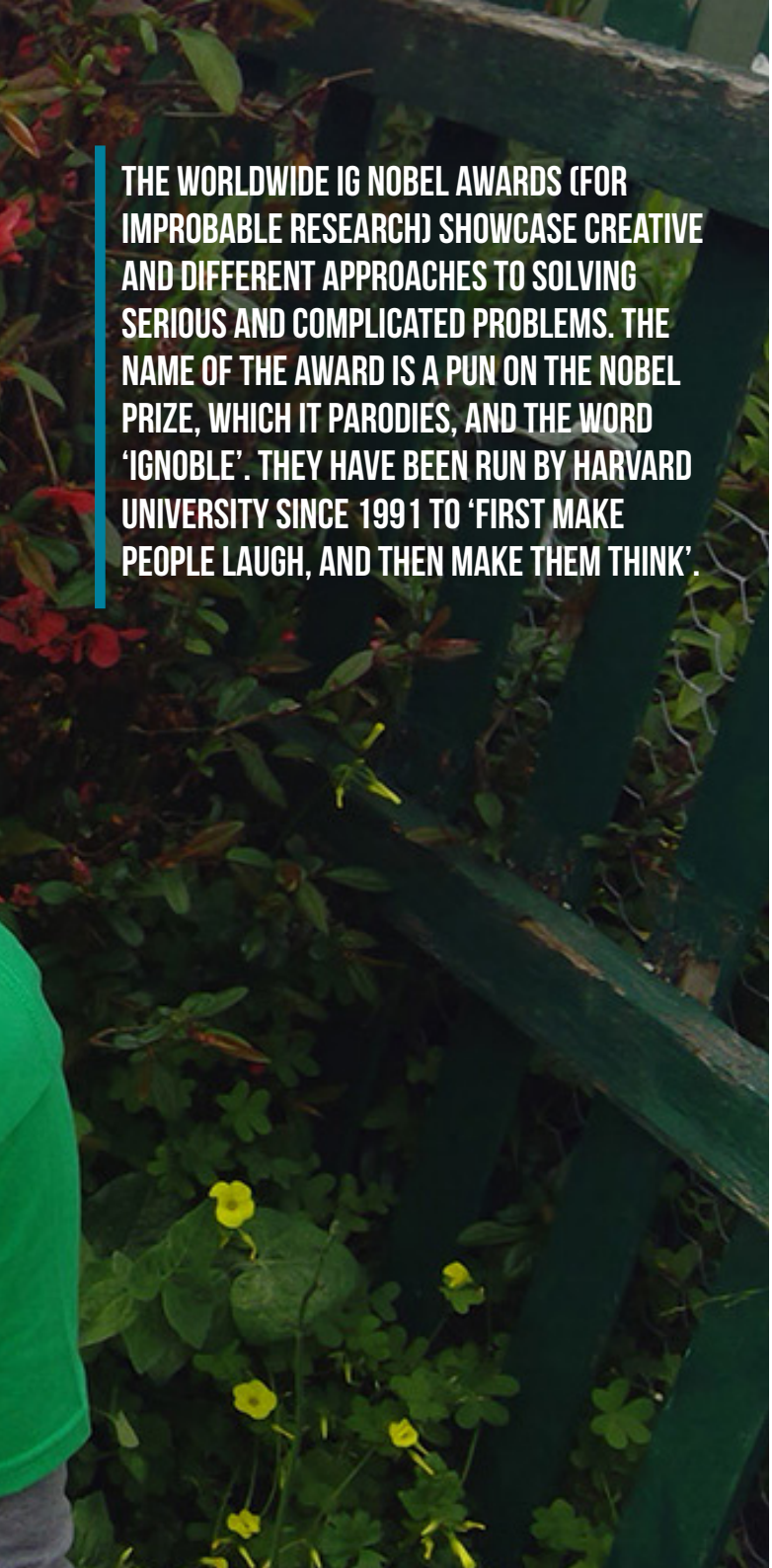
The Chair of the study's expert group, Professor Bronwyn Fox, says 'Australians have wholeheartedly embraced digital transformation across a range of sectors such as manufacturing, mining, food and agriculture. To maintain our competitive advantage, it is vital that policy makers, industry and community work together to ensure we can continue to evolve and use IoT for the benefit of businesses and individuals in cities and regional Australia.'

> **'REFLECTING ON THE CHALLENGES OF 2020, IOT COULD HELP US MONITOR ENVIRONMENTAL DISASTERS, SUPPORT PANDEMIC MANAGEMENT AND ENHANCE THE DELIVERY OF SERVICES TO REGIONAL AND REMOTE POPULATIONS,' SAYS DR ALAN FINKEL.**

Credit: iStock.com/bjdlzx.

DISCOVERY AND FUNDAMENTAL RESEARCH

Dr Ivan Maksymov's worm research may benefit neuroscience and robotics. Credit: Swinburne University of Technology.



THE WORLDWIDE IG NOBEL AWARDS (FOR IMPROBABLE RESEARCH) SHOWCASE CREATIVE AND DIFFERENT APPROACHES TO SOLVING SERIOUS AND COMPLICATED PROBLEMS. THE NAME OF THE AWARD IS A PUN ON THE NOBEL PRIZE, WHICH IT PARODIES, AND THE WORD 'IGNOBLE'. THEY HAVE BEEN RUN BY HARVARD UNIVERSITY SINCE 1991 TO 'FIRST MAKE PEOPLE LAUGH, AND THEN MAKE THEM THINK'.

IG NOBLE PRIZE FOR RESEARCH USING INTOXICATED WORMS

Vibrating a slightly intoxicated earthworm on a sub-woofer speaker in a rural Victorian backyard shed – where experiments were conducted because of the COVID situation – has earned ARC Future Fellow, Dr Ivan Maksymov, and Dr Andrey Pototsky, both from the Swinburne University of Technology, the Ig Nobel award in Physics.

Dr Maksymov is a physicist and an associate investigator with the *ARC Centre of Excellence for Nanoscale BioPhotonics* (CNBP), while Dr Pototsky is a Senior Lecturer in Applied Mathematics. Their esoteric experiment was recognised with the award of an 'Ig Nobel' prize, one of just ten presented internationally in 2020 to researchers that showcase creative and different approaches to solving serious and complicated problems.

Their work was designed to investigate a hypothesis that the brain not only functions using nerve-based electric pulses, but also through acousto-mechanical signals (sound waves). Earthworms are ideal for such experiments because they are inexpensive, their axons (nerve fibres) are somewhat similar to human nerve fibres, and using worms does not require special ethics approval. Also, Dr Maksymov says: 'One can easily anaesthetise a worm using vodka.'

'We used a laser to illuminate the worm and a photodetector to collect the reflected light. The intensity of the reflected light was periodically changed due to the ripples on the surface of the worm, which allowed us to investigate their frequency, amplitude and other parameters that physicists usually want to know.'

As a result of the vibrating worm experiment in the backyard shed, the researchers say that exciting new developments in soft-bodied robotics and mechatronics could be explored.

'Significantly,' adds Dr Maksymov, 'the earthworms recovered after our experiments and were released into a worm farm.'

RARE RING GALAXY CAPTURED 11 BILLION LIGHT-YEARS AWAY

Astronomers from the *ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions* (ASTRO 3D) have captured an image of a super-rare type of galaxy, described as a 'cosmic ring of fire', as it existed 11 billion years ago, just a few billion years after the big bang.

The galaxy, which has roughly the mass of the Milky Way, is circular with a hole in the middle, rather like a very, very big doughnut. Its discovery is set to shake up theories about the earliest formation of galactic structures and how they evolve.

'It is a very curious object that we've never seen before,' says lead researcher, Dr Tiantian Yuan, from ASTRO 3D and based at the Centre for Astrophysics and Supercomputing at Swinburne University of Technology. 'It looks strange and familiar at the same time.'

The galaxy, named R5519, is 11 billion light-years from the Solar System. The massive hole at its centre has a diameter two billion times longer than the distance between the Earth and the Sun, and three million times bigger than the supermassive black hole in the galaxy Messier 87, which was the first ever to be directly imaged in 2019.

The evidence suggests it is a type known as a 'collisional ring galaxy', formed by immense and violent encounters with other galaxies. Extremely rare in the local universe, R5519 is the first of its kind ever to be located in the early Universe.

Working with colleagues from around Australia, US, Canada, Belgium and Denmark, Dr Yuan used spectroscopic data gathered by the WM Keck Observatory in Hawaii and images recorded by NASA's Hubble Space Telescope to identify the unusual structure.

The *ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions* is administered by The Australian National University.

> DR YUAN SAYS THAT THE UNUSUAL GALAXY IS MAKING STARS AT A RATE 50 TIMES GREATER THAN THE MILKY WAY. 'MOST OF THAT ACTIVITY IS TAKING PLACE ON ITS RING – SO IT TRULY IS A RING OF FIRE.'

Keck observatory on Mauna Kea, Hawaii.
Credit: iStock.com/EduardMoldoveanuPhotography.

STUDY OF RAT SKULLS REVEALS AN UNEXPECTEDLY SIMPLE RECIPE FOR ADAPTIVE SUCCESS

An ARC-supported study, co-led by scientists from Flinders University and The University of Queensland, has revealed that the skulls of rodents resemble each other in any given size, meaning little adaptation seems to be necessary for a rodent to survive in a variety of habitats.

Flinders University Associate Professor Vera Weisbecker, an ARC Future Fellow who supervised the study, says everyone knows rodents all look similar, but the researchers expected far more variety in the details of their skull shape than what they found.

Dr Ariel Marcy, from The University of Queensland, says rodents first entered Australia around four million years ago, and quickly adapted to the diversity of habitats available on our continent.

'Because well-adapted skulls are key to the survival of mammals, we expected to find a lot of locally adapted skull shapes.'

To understand the patterns of adaptation they expected to see, the team scanned hundreds of rodent skulls of 38 species from museums using 3D surface scanners, and analysed their shape using a statistical procedure called geometric morphometrics.

What the researchers found was the opposite of what they expected: there was low variation in the skull shape of rodents, which could be explained mostly by body size.

The researchers think this astonishing conservatism of shape may have to do with the very successful specialisation of rodent jaws, allowing their skulls to be a true multi-purpose tool. Professor Weisbecker notes that the results make an important point in one of the biggest questions in evolutionary biology – why some groups of animals are more diverse than others.

'IT SEEMS INTUITIVE THAT A GROUP OF ANIMALS THAT DISPLAYS A WIDE VARIETY OF SHAPES SHOULD BE MORE SUCCESSFUL IN EVOLUTION. BUT, AUSTRALIAN RODENTS DEMONSTRATE THAT SHAPE DIVERSITY DOESN'T ALWAYS MEAN EVOLUTIONARY SUCCESS. SO FOR AUSTRALIAN RODENTS, IF THE SKULL AIN'T BROKE, DON'T FIX IT!' SAYS PROFESSOR WEISBECKER.

Illustration: Australia's smallest rodent, the molinipi (Pseudomys delicatulus), considers one of Australia's largest rodents, the otter-like rakali (Hydromys chrysogaster). They share a skull shape gradient that goes back further than either species' arrival to their shared continent. Illustration by Alison K. Carlisle (aka Papadore Illustrations).

THE SITE'S ARCHAEOLOGY REVEALS THAT FISHING AND SHELL FISHING WERE IMPORTANT COMPONENTS OF THE NEANDERTHAL SUBSISTENCE ECONOMY, AND RESEARCHERS SUGGEST THAT IF HABITUAL CONSUMPTION OF SEAFOOD PLAYED AN IMPORTANT ROLE IN THE DEVELOPMENT OF COGNITIVE ABILITIES, THEN THIS APPLIES TO NEANDERTHALS AS WELL.

(Above) Stone tools recovered from Neanderthal occupation layers of Figueira Brava cave. Credit: J. P. Ruas.

The Figueira Brava cave on the Portuguese coast was used as a shelter by Neanderthal populations over the course of twenty millennia. Credit: Pedro Souto.

NEANDERTHALS WERE AS FAMILIAR WITH THE SEA AS MODERN HUMANS

ARC-supported researchers at The University of Adelaide are part of a research team that has uncovered new evidence about how our closest extinct human relatives, Neanderthals, consumed seafood.

Their study, which follows excavations and dating research undertaken at the Portuguese archaeological cave site of Figueira Brava, on the Atlantic coast near Lisbon, reveals that familiarity with the sea and its resources is much older and more widespread than previously thought.

The Australian researchers were focused on dating sediments contained within the site, using a technique known as optically stimulated luminescence (OSL) dating, which can determine when individual grains of quartz were last exposed to daylight.

'This technique allows us to provide reliable ages for archaeological remains that are too old to be dated using radiocarbon,' says Associate Professor Lee Arnold from The University of Adelaide's School of Physical Sciences.

ARC Discovery Early Career Researcher Award (DECRA) recipient involved in the research, Dr Martina Demuro, said they were able to independently compare the OSL ages with a second set of ages obtained using a technique known as uranium-series dating, which is applicable to cave formations such as stalactites and stalagmites.

'The two sets of results were in perfect agreement, providing strong evidence that Neanderthals occupied the cave during the Last Interglacial (between 86,000 and 106,000 years ago), when the Earth's climate was similar to today,' Dr Demuro says.

The Neanderthal occupants left abundant archaeological remains, including indicators of intensive fire use, quartz and flint tools, and food remains. The nature of the materials found has drawn into question the behavioural gap that had been thought to separate Neanderthals from contemporaneous Homo sapiens.

HUGE NEW DATASET REVEALS CHEMICAL DATA ON 600,000 STARS

Researchers are excited by the astronomical questions that can now be answered following the release of 'GALAH DR3', the largest set of stellar chemical data ever compiled.

The data, based on over 30 million individual measurements taken over several years, was gathered by an Australian-led team of astronomers, including researchers from The University of New South Wales (UNSW Sydney) and the *ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions* (ASTRO 3D), using the Anglo Australian Telescope (AAT) at Siding Spring Observatory in rural New South Wales.

The release is the third from the Galactic Archaeology with HERMES (GALAH) project, which aims to investigate this history of star formation, chemical enrichment and galaxy mergers in the Milky Way. The new data measures 29 chemical elements in 600,000 stars and takes the project closer to meeting its goal of surveying one million.

'Making large datasets like GALAH DR3 widely available is really important for astronomical research,' explains Associate Professor Sarah Martell, who is a former ARC Discovery Early Career Researcher Award (DECRA) recipient from UNSW and an affiliate member of ASTRO 3D.

'Since the start of the GALAH project, we have focused on building a dataset that can answer our questions about the history of the Milky Way, and also many others. I'm excited to see what our international colleagues will do with GALAH DR3.'

The GALAH project's previous data release – known as DR2 – took place in 2018. It has fuelled a raft of significant discoveries regarding the evolution of the Milky Way, the properties of exo-planets, and hidden star clusters.

The *ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions* is administered by The Australian National University.

MORE THAN 100 SCIENTISTS ARE COLLABORATING ON THE GALAH PROJECT, BASED AT UNIVERSITIES IN AUSTRALIA, NEW ZEALAND, ITALY, UK, SLOVENIA, US, HUNGARY, SWEDEN, THE NETHERLANDS, AND GERMANY.

Day and night at the Anglo Australian Telescope, used to conduct the star survey at Siding Spring in rural New South Wales. Credit: Dr Ángel R. López-Sánchez/Australian Astronomical Optics/ Macquarie University/ASTRO 3D.

UNLOCKING MACQUARIE ISLAND'S GEOLOGICAL SECRETS

A team of ARC-supported researchers embarked on a landmark voyage to shed new light on Macquarie Island's underlying structure and geological evolution, and also to help with the monitoring of future earthquakes and tsunamis that could affect Australia and New Zealand.

The voyage had a two-fold purpose: to deploy 29 seismometers around the island and produce the first high resolution maps of the seafloor surrounding the island.

Macquarie Island is a UNESCO World Heritage Site and is the only island in the world composed entirely of oceanic crust and rocks from the mantle. The island is a part of the 40,000km-long Ring of Fire – responsible for 90% of the world's earthquakes – and is the boundary between the Australian and Pacific tectonic plates.

As part of a 2020 ARC Discovery Project, Professor Hrvoje Tkalčić and Dr Caroline Eakin led a team of Australian National University scientists to investigate the region's crustal and mantle structure as well as its seismicity by deploying seismometers around the island.

Professor Tkalčić said the seismometers would be recovered in late 2021, returning critical data. In the meantime, five seismometers are being deployed on Macquarie Island as part of the project, supported by Geoscience Australia, the Australian Antarctic Division and Tasmania Parks and Wildlife Service, and assisted by their personnel.

'Our research aims to image Earth structure by using state-of-the-art seismological techniques together with a carefully designed configuration of ocean bottom seismometers pointing towards the Earth's centre like a giant antenna; and also to shed more light about the physics of the world's largest underwater earthquakes that are not associated with active subduction.'

At the same time, scientists from the University of Tasmania led by Professor Mike Coffin conducted research to produce the first high-resolution maps of the seafloor surrounding Macquarie Island.

'The creation of seafloor maps that identify faults, fracture zones, and seafloor spreading centres will give us new insights into the structure, behaviour, and history of this important plate boundary, which presents significant tsunami hazards for both sides of the Tasman Sea,' Professor Coffin says.

MACQUARIE ISLAND SITS ON THE HIGHLY ACTIVE TECTONIC PLATE BOUNDARY BETWEEN THE AUSTRALIAN AND PACIFIC PLATES AND GENERATES SOME OF THE LARGEST INTRA-OCEANIC EARTHQUAKES AWAY FROM SUBDUCTION ZONES.

The research team after their return to Hobart. Credit: Professor Hrvoje Tkalčić.

WHAT OPAL FOSSILS TELL US ABOUT GIANT AUSTRALIAN DINOSAURS

ARC Discovery Early Career Researcher Award (DECRA) recipients, Dr Nicolás Campione and Dr Phil Bell, and PhD candidate Timothy Frauenfelder, from the University of New England, have been studying opalised dinosaur teeth to help paint a picture of the eating habits and lifestyles of the largest land animals to ever roam the planet: sauropods.

The teeth were found near the town of Lightning Ridge and are ~100 million years old. Confident in the knowledge that sauropod tooth fossils with different shapes came from different species, this research identified 5 'morphotypes' or tooth-shape categories from the 25 teeth that were studied. By comparing these teeth with the teeth of better-known sauropods, the researchers identified at least three distinct species that would have cohabited the area.

The researchers also studied microscopic scratches and pits, known as 'microwear', on the surfaces of each tooth that formed when the animal was biting into its food. By analysing these marks, the researchers could identify the grittiness or smoothness of the dinosaur's diet, which indicated that they coexisted by eating different things; one species likely fed on soft vegetation between 1 to 10 m above the ground, whereas another ate coarser vegetation less than 1 m above the ground.

'While we couldn't assign the 25 tooth fossils to specific species (as we'd need more than just teeth to identify a dinosaur species), we do know all the teeth belonged to a large group of sauropods known as *Titanosauriformes*,' Mr Frauenfelder says.

This discovery contributes significantly to the very limited understanding of the sauropods that once inhabited New South Wales.

> **'OUR RESEARCH MAY HAVE BEEN LIMITED TO TEETH, BUT IT DEMONSTRATES EVEN INCOMPLETE FOSSILS CAN PROVIDE KEY INSIGHTS INTO THE LIVES OF LONG-EXTINCT CREATURES'. MR TIMOTHY FRAUENFELDER.**

Five sauropod teeth fossils (not to scale) showing the diversity of tooth shapes found at Lightning Ridge. The fossils have different colours since they're all made out of opal.

HOW THE HUMAN BRAIN PROCESSES VISUAL INFORMATION

A team of researchers at the *ARC Centre of Excellence for Integrative Brain Function*, with lead researchers Dr Ali Almasi from the National Vision Research Institute of Australia and Associate Professor Hamish Meffin from The University of Melbourne, has studied brain cells in the primary visual cortex (V1) to determine how they respond to specific features that are important to a visual object's identity.

The human brain has a remarkable ability to recognise specific objects, even when those objects change in appearance. For example, we can tell that a hand is a hand regardless of its colour, size, location or orientation. When processing visual information, brain cells display 'feature selectivity', ignoring features that are not important, meaning that they are 'invariant' to feature manipulation.

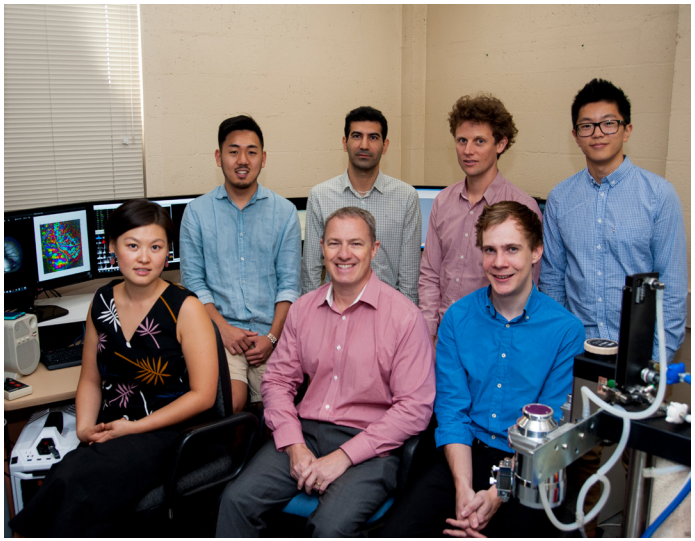
To determine how these cells combine their qualities of selectivity and invariance, the researchers measured how the activity of cells in V1 changed when the cells received visual information about 'white noise', using random combinations of black and white pixels arranged in a square grid.

Because the white noise images are random, patterns can emerge in the pixels, which occasionally match the image characteristics to which the recorded neurons are tuned. The researchers used the brain activity data to map how the cells responded to different combinations of patterns and built a computer model to estimate the cells' selectivity and invariance to particular features of the different patterns, such as their orientation, spatial scale and position.

The model revealed that most cells had a high degree of selectivity and a low degree of invariance for both the orientation and spatial scale of the patterns. However, the cells varied in their response to the position of the pattern; some cells were highly selective, but others were completely invariant. Returning to the example of the hand, this means that some cells would only respond when the hand was in a certain position, while others were completely invariant to hand location as long as it was a hand. This shows that even at an early stage of visual processing, the brain forms an elaborate set of sensitivities to generic features, which form the basis of more sophisticated processing in other visual areas of the brain.

The *ARC Centre of Excellence for Integrative Brain Function* is administered by Monash University.

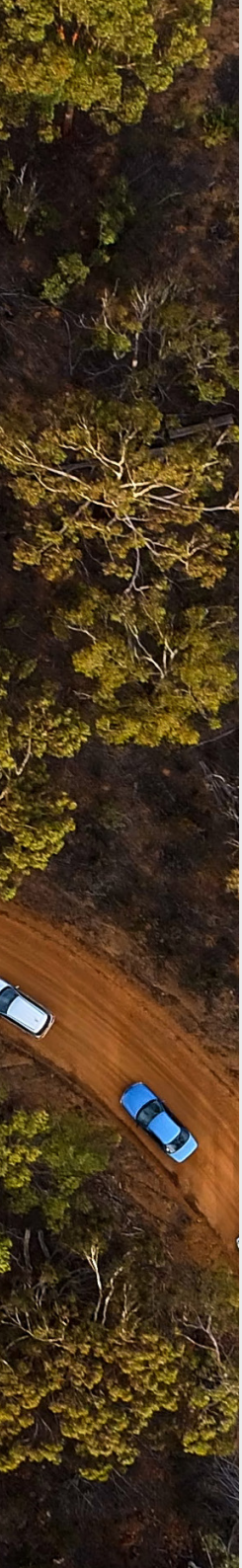
> **IN THE EARLIEST STAGES OF VISUAL PROCESSING, THE BRAIN DETECTS AND PROCESSES SPECIFIC VISUAL FEATURES BY RECOGNISING A SIMPLE SET OF PATTERNS.**



(Above) The research team:Top row from left: Jason Jung, Ali Almasi (joint 1st author), Hamish Meffin (joint 1st author), Scott Sun. Bottom row: Molis Yunzab, Michael Ibbotson (Lab Head), Mitchell Crawford (lab technician). Credit: ARC Centre of Excellence for Integrative Brain Function.

(Right) Credit: iStock.com/metamorworks.

Credit: Curtin University.



FIRST AUSTRALIANS' COLLABORATIONS AND KNOWLEDGES

ANCIENT FOOD DEBRIS TELLS THE STORY OF 65,000 YEARS

Australia's oldest known plant foods, eaten by early communities 65,000 years ago, have been discovered by researchers working at a remote rockshelter in the Kakadu region. Preserved as pieces of charcoal, the morsels were recovered from the debris of ancient cooking hearths at Madjedbebe, an archaeological site on Mirarr country in northern Australia.

University of Queensland archaeobotanist, Dr Anna Florin, says that a team of archaeologists and Traditional Owners identified 10 plant foods, including several types of fruits and nuts, underground storage organs ('roots and tubers'), and palm stem.

'By working with Elders and co-authors May Nango and Djaykuk Djandjomerr, we were also able to explain how the plants were used at Madjedbebe. This included multi-step cooking techniques still practiced today,' Dr Florin says.

Madjedbebe is Australia's oldest documented site of human habitation. Dr Florin said the plant foods found not only gave insight into how the First Australians were living 65,000 years ago, but also allowed researchers to tell a localised story of climate change.

'We used the nutshell from one of these foods, anyakngarra (Pandanus spiralis), to look at past rainfall. What emerged was an amazing story detailing how communities living in the Kakadu region thrived in a changing environment over 65,000 years,' says Dr Florin.

Gundjeihmi Aboriginal Corporation CEO, Justin O'Brien said, 'The depth of knowledge being gained from Madjedbebe demonstrates the extraordinary value of the place and reaffirms the importance of its long-term protection.'

One of the most significant findings of the climate study was that Kakadu is currently experiencing its driest time in human history. 'The region's plants and animals are experiencing extreme hardships. Feral animals, loss of biodiversity and disruptions to cultural landscape management, including vegetation burning, all pose increased threats to the health and wellbeing of the landscape and its Traditional Owners,' says Dr Florin.

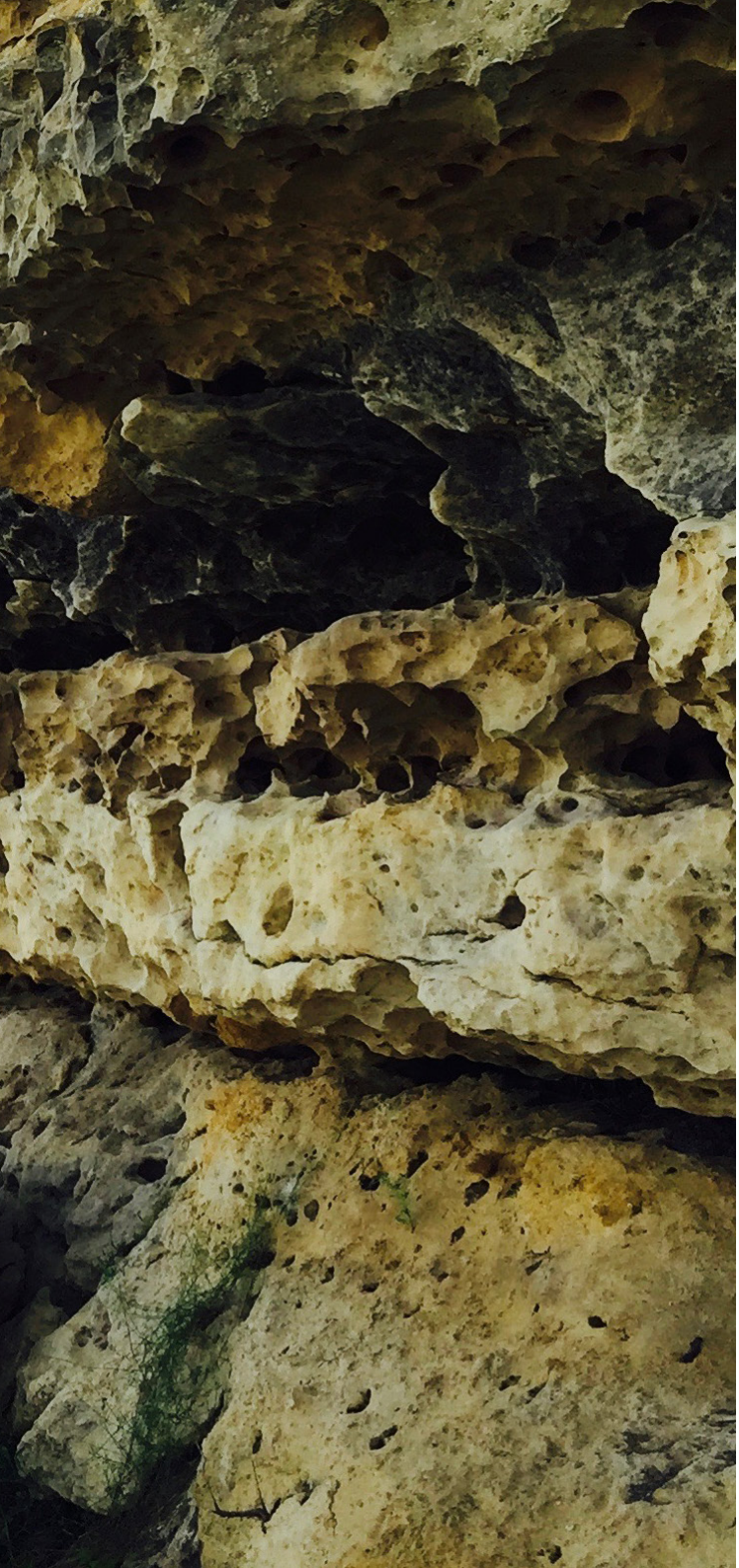
The excavation at Madjedbebe was funded by an ARC Discovery Project led by researchers supported by the *ARC Centre of Excellence for Australian Biodiversity and Heritage* (CABAH), administered by The University of Wollongong.

> **AS WELL AS HOLDING AUSTRALIA'S EARLIEST FOOD SCRAPS, MADJEDBEBE ROCKSHELTER ALSO CONTAINS EVIDENCE FOR THE OLDEST EDGE GROUND STONE AXES IN THE WORLD, THE EARLIEST GRINDSTONE TECHNOLOGY OUTSIDE AFRICA, THE EARLY SHAPING OF STONE SPEARHEADS, MANY KILOGRAMS OF GROUND OCHRE, AND THE FIRST RECORDED USE OF REFLECTIVE PIGMENTS IN THE WORLD.**

May Nango, Dr Florin and Djaykuk Djandjomerr collecting plants in Kakadu. Credit: Elspeth Hayes, with permission of the Gundjeihmi Aboriginal Corporation.

THE ENGRAVINGS REVEAL THE DEEP ABORIGINAL SIGNIFICANCE OF THE ROCKSHELTER, THE TRAUMATIC PERIOD OF EUROPEAN INVASION AND FRONTIER CONFLICT AS WELL AS ONGOING IMPACTS OF COLONIAL SETTLEMENT, SAYS PROFESSOR AMY ROBERTS, WHO IS WORKING IN COLLABORATION WITH MEMBERS OF THE LOCAL ABORIGINAL COMMUNITY.

Western cavity, Pudjinuk Rockshelter. Credit: Amy Roberts, Flinders University.



GRAFFITI RECORDS THE STORIES OF CONFLICT

Archaeologists from Flinders University have analysed 188 engravings in a remote South Australian rockshelter, which depict symbols of conflict and stand as a record of frontier disputes and the strife brewing in Europe ahead of World War Two.

The 'graffiti' was engraved over or adjacent to Aboriginal rock art at a culturally-significant rockshelter in limestone cliffs of the Murray River near Waikerie in South Australia.

'Of the 188 motifs identified, only one engraving remained that could be positively identified as a pre-European Aboriginal design – a 'treelike' motif,' says Professor Amy Roberts, the leader of the research. 'The rest of the identifiable historical inscriptions were the work of members of frontier conflict/punitive expeditions, local European settlers and a non-local Aboriginal man. Of the motifs that can be confidently identified, one incorporates a swastika, engraved in 1932.'

The first European historical inscriptions were engraved by members of volunteer police parties on punitive expeditions and were part of a historical trajectory that later culminated in the Rufus River Massacre.

Fiona Giles, of the River Murray and Mallee Aboriginal Corporation, says: 'We need to tell these stories to protect our history and heritage so that our culture is respected and not lost. For us, as traditional owners, this rockshelter is a highly significant and special place. It tells the stories of our ancestors and shows our deep connection to the river and reminds us of how our people lived before Europeans invaded our world.'

The published research forms part of am ARC Linkage Project grant led by Professor Roberts, which is creating the first comprehensive study of the colonial frontier in South Australia's Riverland. By coalescing archaeological, anthropological and oral history evidence, meaningful narratives and new understandings are being created for and with Aboriginal descendants.

RECORDING THE STORIES CARVED IN ANCIENT BOAB TREES

Research leaders from four Australian universities, supported through one of the first *ARC Special Research Initiative for Australian Society, History and Culture* grants, are working with Aboriginal communities in the Kimberley to develop the first ever systematic archive of carved boab trees.

Australian boab trees record the stories of Indigenous and non-Indigenous people in the region, including from the time of the first European contact. The project will create the archive using state-of-the-art technology to capture accurate 3D records of the markings.

With a lifespan of centuries (some individuals are over 1,500 years old, making them amongst the oldest living trees in Australia), the boab lacks foliage for much of the year, becoming dormant in the winter dry season, before its large fragrant flowers emerge and open in the spring evenings.

Local Aboriginal people have used the boab in multiple ways, as food, medicine, shelter, and even for creating intricate artwork both on the boab nuts and the trunk of the tree itself, and it is the latter that interests this group of researchers.

The research team – Dr Melissa Marshall (University of Notre Dame Australia), Professor Sue O'Connor (The Australian National University), Professor Jane Balme (The University of Western Australia), and Dr Ursula Frederick (University of Canberra) – bring together a wide breadth of expertise, including local knowledge and the latest photogrammetry and scanning techniques.

The researchers are recording both Indigenous and non-Indigenous carvings on the boab trees, to learn about the little-known traditional Indigenous cultural and artistic practice, as well as piece together more information about the daily lives of people living on missions and pastoral properties prior to and immediately following European contact.

The team is also examining unpublished manuscripts, diaries, letters, mission records, newspapers and published historical and anthropological literature for the Kimberley, to contextualise the carvings as they are recorded. The final outcomes will be made available digitally, for future generations to see.

> **MANY OF THE CARVED TREES ARE ALREADY HUNDREDS OF YEARS OLD, INCREASING THE URGENCY OF CAPTURING HIGH-QUALITY RECORDINGS BEFORE THESE REMARKABLE HERITAGE TREES DIE.**

One of the iconic boab trees with a carving in the Kimberley, WA. Credit: Jane Balme.

‘AS A NYUNGAR MAN WHO GREW UP NEAR THE DRYANDRA WOODLANDS, NEAR NARROGIN, THIS VALUABLE NATURE CONSERVATION AREA HOLDS CULTURAL SIGNIFICANCE TO INDIGENOUS PEOPLE AND I AM GRATEFUL TO THE WIILMAN ELDERS FOR THEIR ROLE IN THIS PROJECT, WHICH SEEKS TO ADVANCE RECONCILIATION BY HEALING LAND AND PEOPLE,’ SAYS DISCOVERY INDIGENOUS RESEARCHER, DARRYL KICKETT.

Darryl Kickett (centre) with Narrogin-based Research Assistant and Dryandra Wilman Elder Travis Abraham (left) and Wilman Elder Clive Abraham (right). Credit: Curtin University.

HEALING LAND AND PEOPLE WITH BIODIVERSITY RESEARCH

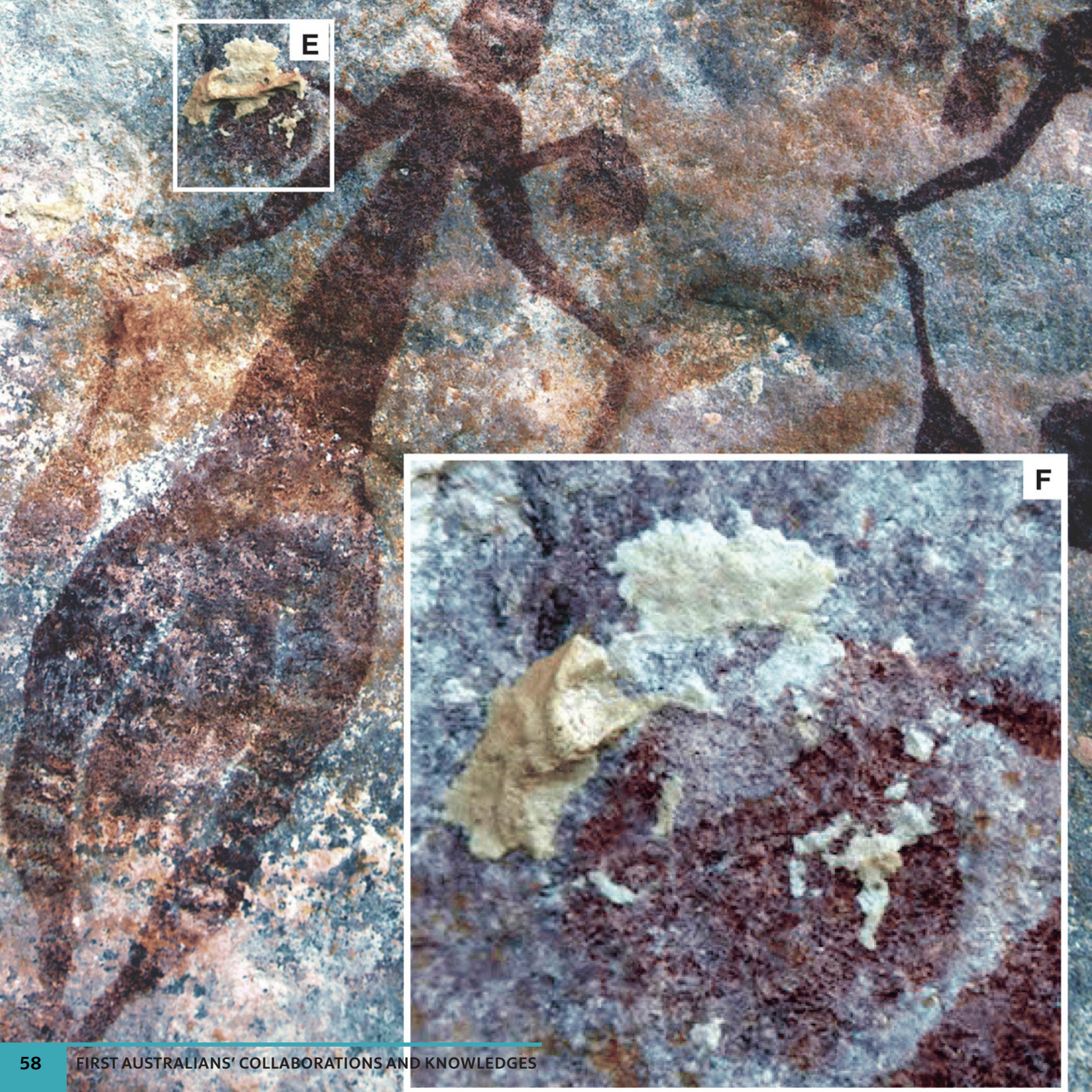
A Discovery Indigenous research project led by Mr Darryl Kickett from Curtin University's School of Media, Creative Arts and Social Inquiry is advancing reconciliation in Australia by bringing together scientific expertise, history and Indigenous cultural knowledge to conserve the country's precious biodiversity.

The project titled *Healing Land, Healing People: Novel Nyungar Perspectives* includes fellow Curtin researchers Professor Anna Haebich and Dr Carol Dowling, as well as Professor Stephen Hopper from The University of Western Australia and Dr Tiffany Shellam from Deakin University.

The unique research project combines expertise in cultural healing, cross-cultural knowledge of biodiversity on old and young landscapes, archival collections-based historical studies, and oral histories explored on country with Nyungar people and along songlines in southwest Australia.

Darryl Kickett has been instigating opportunities for Aboriginal leaders, communities, and governments to work together for many years while based at Curtin University's Centre for Aboriginal Studies. In this project Nyungar Elders and family groups are contributing historical knowledge about how the study area, the Dryandra Woodlands, south of Perth, has been used for thousands of years. By combining this knowledge with scientific assessments, the research team is working to heal the land, by slowing the decline in biodiversity in the woodlands and the surrounding area.

The collaboration also provides a model opportunity to embrace Indigenous Elders as a solution to protecting biodiversity, and to advance the progress of reconciliation between Nyungar people, non-Indigenous community members and land.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DATING GWION GWION ROCK ART FIGURES IN THE KIMBERLEY

A team of ARC-supported archaeologists has been able to accurately date a significant number of the Kimberley's most remarkable ancient rock art to more than 10,000 years ago.

The dates have been produced as part of the ARC Linkage Project, '*Dating the Aboriginal rock art sequence of the Kimberley in NW Australia*', led by The University of Melbourne and working in partnership with Balanggarra and other Aboriginal Corporations.

Professor Peter Veth, from The University of Western Australia, and one of the project's Chief Investigators, said the Kimberley region of Western Australia hosted thousands of rock art sites with some earlier depictions in an exceptionally good state of preservation.

'They provide a window into how Aboriginal people thought and lived in a socially and environmentally dynamic world and are of great significance to Kimberley Traditional Owners today,' Professor Veth says.

'One of the best known styles showing human figures with complex headdress and body ornaments is the Gwion Gwion. Their extraordinary detail challenged European observers leading to more than a century of speculation about their age and authorship. They are clearly of Aboriginal origin forming part of a long tradition of signalling places of importance within the wider landscape.

As with other rock art worldwide, the older styles have proven notoriously difficult to date quantitatively, requiring new scientific approaches. The research team's method of dating carbon found in mud wasp nests under and overlying Gwion Gwion images has produced a remarkably consistent suite of dates clustering around 12,000 years ago (11,500 to 12,700 years ago) with one motif, however, dating to approximately 17,000 years.

The research team worked with partners including the Aboriginal Traditional Owners and Corporations, the University of Wollongong, the Australian Nuclear Science and Technology Organisation (ANSTO), the Department of Biodiversity, Conservation and Attractions, Dunkeld Pastoral and with ongoing support from Rock Art Australia.

> 'MORE EXCITING DATING WORK AWAITS, WITH GWION GWION IMAGERY KNOWN TO OCCUPY THE MIDDLE PART OF A VERY LONG CHRONOLOGY OF MAKING ROCK ART IN THE KIMBERLEY THAT CONTINUES TO THIS DAY,' SAYS DR SVEN OUZMAN, A CHIEF INVESTIGATOR ON THE PROJECT FROM THE UNIVERSITY OF WESTERN AUSTRALIA'S CENTRE FOR ROCK ART RESEARCH AND MANAGEMENT.

Mud wasp nest samples and their development sequence. Credit: Damien Finch

> ‘OUR RESULTS REPRESENT THE FIRST STEP IN A JOURNEY OF DISCOVERY TO EXPLORE THE POTENTIAL OF ARCHAEOLOGY ON THE CONTINENTAL SHELVES WHICH CAN FILL A MAJOR GAP IN THE HUMAN HISTORY OF THE CONTINENT,’ SAYS ASSOCIATE PROFESSOR JONATHAN BENJAMIN, FROM FLINDERS UNIVERSITY.

Westward facing aerial view of Cape Bruguieres Channel at high tide. Credit: J. Leach.

FIRST UNDERWATER INDIGENOUS SITES FOUND ON AUSTRALIAN SEABED

An international team of archaeologists from Flinders University, The University of Western Australia, James Cook University, Airborne Research Australia and the University of York (United Kingdom), in partnership with the Murujuga Aboriginal Corporation, has located Australia's oldest known underwater Aboriginal archaeological sites.

The sites were discovered off the Pilbara coast in Western Australia during a series of archaeological and geophysical surveys conducted in the Dampier Archipelago, as part of the *Deep History of Sea Country* project, which is funded through the ARC's *Discovery Projects* scheme.

The ancient underwater sites, at Cape Bruguieres and Flying Foam Passage, provide new evidence of Aboriginal ways of life from when the seabed was dry land, due to lower sea levels, thousands of years ago.

At Cape Bruguieres, the dive team mapped 269 artefacts in shallow water. Radiocarbon dating and analysis of sea-level changes show the site is at least 7,000 years old.

The second site at Flying Foam Passage includes an underwater freshwater spring 14 metres below sea level. This site is estimated to be at least 8,500 years old.

The team of archaeologists and geoscientists employed predictive modelling and various underwater and remote sensing techniques, including scientific diving methods, to confirm the location of sites and presence of artefacts.

The submerged cultural landscapes are known today as Sea Country to many Indigenous Australians, who have a deep cultural, spiritual and historical connection to these underwater sites. Researchers say that the discovery emphasises the need for stronger federal legislation to protect and manage underwater heritage sites in Australia.

Artist impression. iStock.com /inkoly

RESPONDING TO COVID-19

THE CHANGING WORKFORCE UNDER COVID-19

Professor Sharon Parker is an ARC Kathleen Fitzpatrick Australian Laureate Fellow at Curtin University, who has established the Centre for Transformative Work Design, conducting high quality, independent and innovative research to understand the role of work design in generating healthy and productive work.

However, during 2020 the research program of the Centre suddenly turned its attention to the unfolding COVID-19 crisis, and the subsequent shift of much of the workforce to working from home. Some of the Centre's own research programs had to be suspended, but the opportunities and challenges of studying this unprecedented situation have since occupied Professor Parker's team in new ways.

'Although research already existed on working from home, the COVID situation was entirely new,' says Professor Parker.

'Previously, working from home was usually a choice, given to those trusted by their manager to work more independently. But during COVID, many people worked at home, irrespective of preference, experience, or even if their job was suited for remote work.

In April 2020, during the early stages of lockdown, the research team began to survey approximately 1000 workers from all around the world, asking them about their experience of working from home.

'We found that the levels of psychological distress were high,' says Professor Parker. 'During normal times, about 13% of workers report high or very high distress, but these levels at least doubled during the early phase of lockdown'.

The research team then continued tracking several hundred of the survey participants, once per week for the first 4 weeks, then once a month, as respondents began to return to their offices.

'We found that some people's distress reduced over time as they adapted to the situation. But others got more distressed as COVID progressed. The question we then investigated is why – what are the factors that explained these people's worsening mental health?'

The research team found that people in jobs that were insufficiently stimulating or, conversely, overly demanding, as well as people who felt micromanaged by their bosses, suffered from declining mental health.

Overall, Professor Parker says that the COVID crisis has made us all aware of just how much we do value having work, and that well-designed jobs, apart from the financial security, are a significant part of our mental health and wellbeing.

(Above.) Professor Sharon Parker. Credit: Centre for Transformative Work Design.

(Right) Credit: iStock.com/AleksandarNakic.

‘IT’S NOT JUST ABOUT HAVING WORK, IT’S ABOUT HAVING QUALITY WORK WHERE YOU’RE SUPPORTED, WHERE YOU ENGAGE IN TASKS THAT FEEL MEANINGFUL, WHERE YOU’RE AUTONOMOUS. THAT HAS BECOME REALLY CLEAR TO PEOPLE, WHEREAS PERHAPS BEFORE COVID IT WAS A BIT MORE UNDER THE SURFACE,’ SAYS PROFESSOR PARKER.

ECONOMIC MODELLING OF COVID-19 SCENARIOS

Early in the pandemic, in March 2020, researchers Professor Warwick McKibbin and Roshen Fernando in the *ARC Centre of Excellence in Population Ageing Research* (CEPAR), based at The Australian National University, produced the first wide-ranging global economic assessment of the effects of Coronavirus disease. Their goal was to help policymakers prepare a coordinated response to the economic costs of a pandemic as the virus rapidly evolved.

The research modelled seven scenarios of the impact of the coronavirus on the world economy. The scenarios ranged from containing COVID-19 in mid-2020 to ongoing waves of the virus over several years.

The researchers estimated the global economy could lose up to $US21.8 trillion dollars in 2020 alone due to COVID-19. Professor McKibbin said even under the best-case scenario the global economy would lose up to $US14.7 trillion dollars.

To display their results, the researchers created an online dashboard, the *COVID-19 Macroeconomic Modelling Results Dashboard*. It also examines other key economic impacts of COVID-19 including the impact on government spending, wage subsidies and household transfers, country risk assessments and potential rates for mortality (the proportion of total population who dies) and morbidity (people incapacitated or caring for the incapacitated and unable to work).

This research was updated in July and August 2020 as more data on the pandemic became available.

Throughout 2020, and up to the present, researchers at CEPAR, which is administered by The University of New South Wales, have continued to release modelling and conduct research into how the pandemic has been affecting Australia and the world, and in particular older people.

THE *ARC CENTRE OF EXCELLENCE IN POPULATION AGEING RESEARCH* HAS BEEN BRINGING TOGETHER ACADEMICS, GOVERNMENT AND INDUSTRY REPRESENTATIVES TO DISCUSS THE IMPLICATIONS FOR PENSIONS, SUPERANNUATION AND RETIREMENT IN A POST-COVID-19 WORLD.

Credit: iStock.com/Mark Kriedemann.

ROLLING OUT A PAPER-BASED MEDICAL GOWN

As mass shortages, poorly manufactured and misused personal protective equipment (PPE) continues to plague many countries in their fight against COVID-19, Australian researchers have come up with a simple, cost-effective and industrially scalable solution to keep health workers and patients safe.

The researchers based at Monash University's Bioresource Processing Institute of Australia (BioPRIA), and the *ARC Industrial Transformation Hub for Processing Lignocellulosic into High Value Products* (PALS), have created medical gowns for health care workers and first responders using paper laminated with a coating of polyethylene – a lightweight thermoplastic.

This is the first time that paper has been successfully used to produce medical gowns with viral protection. The researchers say that paper could be the missing element in creating affordable alternative materials for PPE to reduce the spread of COVID-19, and as it is easily available, it could enable a mass rollout of high-quality PPE to vulnerable communities across the world.

'The global pandemic, spike in demand, and shortage of traditional PPE materials suitable for viral transmission protection has driven researchers, virologists and biomedical experts to collaborate and explore low-cost alternative materials for medical gowns and other PPE,' says Professor Gil Garnier, Director of the ARC PALS Hub.

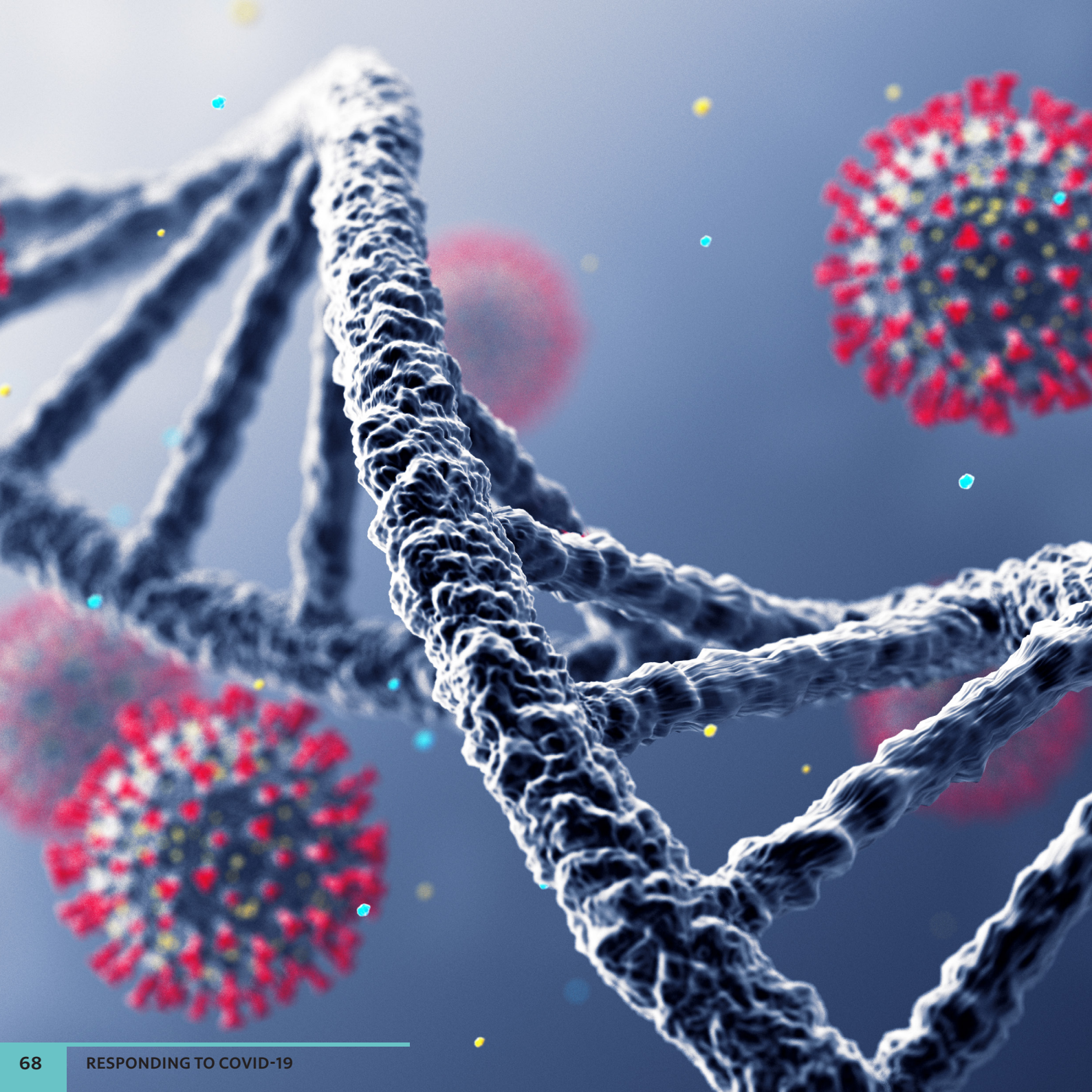
'In the absence of genuine and appropriate PPE, many workers have adopted makeshift solutions, such as wearing plastic garbage bags as gowns, which fail to provide any protection and contribute to the spread of COVID-19.'

Working with their industrial partners, the research team engineered virus safe medical gowns using bleached Kraft paper and newsprint paper as the base materials, coated with layers of polyethylene.

By testing different formulations for viral protection using a fluorescent DNA virus, they identified an ideal combination of paper and polyethylene that has high tensile and seam strength and low water vapour transmission rate, while hindering viral penetration.

Professor Gil Garnier, Dr Joanne Tanner, Professor Mark Banaszak Holl, Laila Hossain, Ruth Barajas Ledesma and Maisha Maliha in the novel gown. Credit: Monash University.

IN PARTNERSHIP WITH AN INDUSTRIAL CONSORTIUM, THE RESEARCH TEAM HAS DESIGNED A SIMPLE, COST-EFFECTIVE AND SCALABLE PAPER-BASED MEDICAL GOWN THAT CAN BE DISTRIBUTED GLOBALLY IN THE BATTLE AGAINST COVID-19.



PROFESSOR HOLMES WAS NAMED 2020 NEW SOUTH WALES SCIENTIST OF THE YEAR IN RECOGNITION OF HIS RESEARCH INTO EMERGING VIRUSES, INCLUDING SARS-COV-2, THE VIRUS THAT CAUSES COVID-19 IN HUMANS.

ARC-SUPPORTED RESEARCHERS AT THE FOREFRONT OF THE RACE TO UNDERSTAND COVID

ARC Australian Laureate Fellow, Professor Edward Holmes at The University of Sydney, is an expert in the evolution and emergence of infectious viruses including hepatitis C, HIV, influenza, West Nile, dengue, Zika and Ebola. Since the beginning of the COVID-19 pandemic, Professor Holmes' research has been at the forefront of international efforts to understand the origin and spread of SARS-CoV-2.

In January 2020, in the very early days of the pandemic, and following a collaboration with colleagues in Wuhan, China, Professor Holmes was responsible for the very first public release of the full genome sequence of SARS-CoV-2.

This release enabled the international scientific community to commence with the rapid development of diagnostic tests and vaccines for the virus and opened the door to a fuller understanding of the origins of the pathogen.

Professor Holmes has since undertaken fundamental research into the animal origins of the virus and was the first to show that pangolins carry a virus closely related to SARS-CoV-2 and so are a possible intermediate host between bats and humans, from an original natural reservoir of coronaviruses in bats. He has worked to highlight the dangers associated with the illegal trafficking of wildlife for food and medicine.

Professor Holmes is currently also leading a three-year Discovery Project examining the emergence and evolution of viruses in fish, and their impact on Australian aquaculture.

ARC Australian Laureate Fellow, Professor Edward Holmes FRS FAA. Credit: The University of Sydney.

(Background) Artist impression. Credit: iStock.com/BlackJack3D.

OTHER EXAMPLES OF WIDER CONTAGION PHENOMENA WHICH CAN BE MODELLED INCLUDE SOCIAL SEGREGATION, 'INFODEMICS' (WAVES OF MISINFORMATION), AND SOCIAL UNREST.

Credit: iStock.com/Chinnapong.

EFFECTS OF COVID-19 ON GLOBALISATION AND MIGRATION

Theoretical modelling by a group of pandemic researchers has shown that populations typically disperse following major global crises, including contagions.

A team at The University of Sydney led by Professor Mikhail Prokopenko, as part of an ARC Discovery Project, suggested that the COVID-19 pandemic will not spell the end of globalisation and migration.

Disease outbreaks, civil unrest and war often bring about the biggest movements of people. The end of the Second World War saw the largest movement of people in Europe's history, with millions settling in Australia in the decades following 1945.

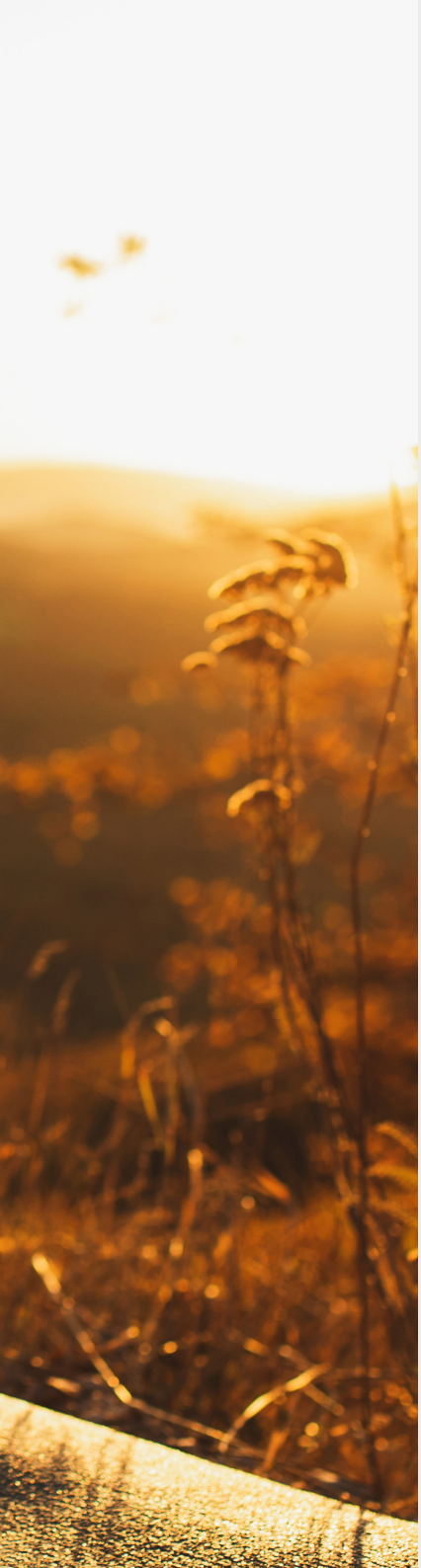
'While many countries' borders have been closed, making migration virtually impossible, a post-pandemic world might look very different,' says Professor Prokopenko, who contributed to the G08 COVID-19 Federal Advisory report, *Roadmap to Recovery.*

'Our theoretical modelling suggested that, when faced with either threat or opportunity, people tend to avoid risks, seek an advantage, or both. One can stretch these scenarios and imagine how attractive a destination Australia may appear if the local transmission of COVID-19 is eliminated in our country.'

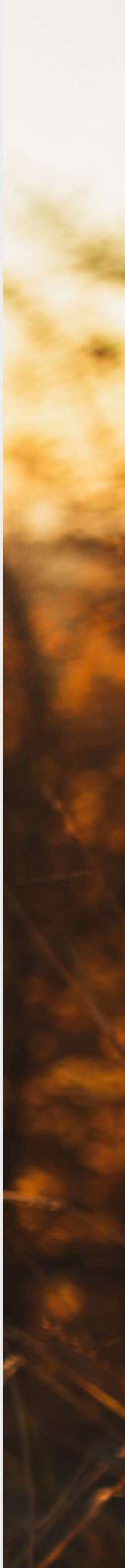
People who have been affected by economic collapse or worsened health conditions may consider short-term or even long-term relocation to safer regions.

The theoretical model worked by tracing a 'contagion' spread in an abstract geographical region, where 'people' make choices to stay or move around. The method looked at how changes in individual preferences affect the behaviour of a large population.

iStock.com/olegbreslavtsev.



IMPROVING HEALTH AND WELLBEING



ARTIFICIAL INTELLIGENCE IMPROVING THE STUDY OF BRAIN DISEASE

A team of Macquarie University neurosurgery and computer science researchers, including ARC Future Fellow, Professor Antonio Di Ieva, is investigating the use of Artificial Intelligence and other computer tools to improve the study of brain disease, with results already indicating far-reaching impact for disease diagnosis and treatment.

The research is taking place at the University's world-first Computational NeuroSurgery (CNS) Laboratory founded by Professor Antonio Di Ieva, who is also a practising neurosurgeon at Macquarie University Hospital. The CNS lab is focused on developing computerised tools to produce more accurate images of the brain and its diseases.

'Our research is to develop new computer methods to identify novel diagnostic, prognostic and therapeutic markers of brain diseases, such as brain tumours and cerebrovascular diseases,' Professor Di Ieva says.

In their latest research, the team used an AI method called Deep Learning to analyse surgical samples of gliomas – the most common primary brain tumours – and to predict patient outcome and treatment.

By using Deep Learning to analyse surgical samples of gliomas, this allows a much faster and cheaper way to predict the presence of an important DNA marker for the disease, improving and speeding up the treatment of patients affected by brain cancer.

Professor Di Ieva and Macquarie Medical Imaging were also the first in Australia to introduce a Magnetic Resonance technique called 2HG-Magnetic Resonance Spectroscopy to predict the status of such a gene even before surgery.

'The long-term goal is to enhance treatment and outcomes for patients.'

Professor Antonio Di Ieva. Credit: Macquarie

A NEW WORLD-FIRST AI-DRIVEN NEUROSURGERY LAB AT MACQUARIE UNIVERSITY HOSPITAL IS USING A MAGNETIC RESONANCE TECHNIQUE TO PRODUCE MORE ACCURATE IMAGES OF THE BRAIN, IMPROVING OUTCOMES FOR PATIENTS.

NEW RESEARCH REVEALS THE DAMAGING ROLE OF A SUPERBUG IN THE GUT

An ARC-supported research collaboration at Monash University's Biomedicine Discovery Institute has revealed that a bacterial superbug can prevent stem cells in the gut from carrying out their vital role of regenerating the inner lining of the intestine. This causes potentially severe disease, particularly in the elderly.

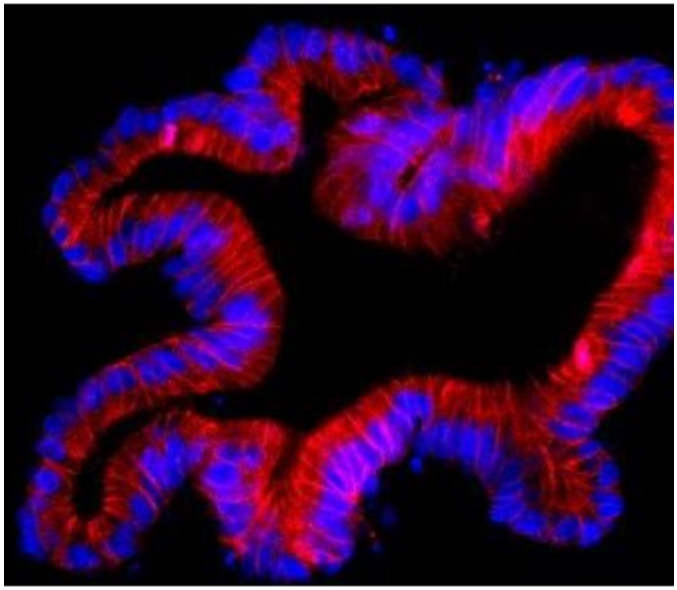
The research team, which included ARC Future Fellow, Professor Dena Lyras, found that *Clostridioides difficile* infection, the most common cause of hospital-acquired diarrhoea, damages colonic stem cells via a toxin called TcdB, impairing tissue repair in the gut and recovery from disease.

It grows after antibiotic treatment is administered to a patient, where it can upset the host-microbial balance in the gut allowing the bacterium to colonise. More than 90% of mortalities resulting from infections are caused by *Clostridioides difficile.*

Professor Helen Abud says the study provides the first direct evidence that a microbial infection alters the functional capacity of gut stem cells.

'It adds a layer of understanding about how the gut repairs after infection and why this superbug can cause the severe damage that it does. The reason it's important to have that understanding is that we're rapidly running out of antibiotics – we need to find other ways to prevent and treat these infections.'

The findings could have wider implications for those going through treatments for cancer such as chemotherapy and radiation therapy that also damage the gut.



BY UNDERSTANDING THIS NEW MECHANISM OF DAMAGE AND REPAIR, THE RESEARCHERS HOPE TO FIND WAYS TO PREVENT THE DAMAGE FROM HAPPENING OR DEVELOP NEW TREATMENTS.

Fuorescent pictures of a human colon organoid stained for E-cadherin in red and DAPI in blue. Credit: Dr Thierry Jarde.

WORLD-FIRST 3D PRINTED CHEST RECONSTRUCTION IMPLANT

A world-first 3D printed chest reconstruction implant is the outcome of years of research led by Professor Dietmar W. Hutmacher, director of the *ARC Industrial Transformation Centre in Additive Biomanufacturing* at the Queensland University of Technology's Centre for Biomedical Technologies.

Professor Hutmacher, who pioneered the use of patient-specific 3D printed scaffolds to repair bone and other tissue, said the implant corrected a birth defect called funnel or sunken chest, whereby the ribs and sternum grow inwards, giving a concave appearance.

The flexible implant was made from porous, biodegradable material. Unlike bone scaffolds, the implant contained no rigid ceramics and was made to fit precisely over the chest deformity to allow the patient's own blood vessels and fat tissue to grow into the implant to create a lasting normal shaped chest.

'The implant had to be flexible as the chest is in constant movement and so it had to have the ability to change shape without breaking,' says Professor Hutmacher.

The ground-breaking surgery to implant the scaffold took place at the Princess Alexandra hospital, performed by Dr Michael Wagels, an Adjunct Professor with QUT, who collaborated closely with Professor Hutmacher for many years.

'An important part of the surgery was injecting the scaffold with the patient's own fat at the time of implant insertion to commence the reconstruction/regeneration of the highly porous scaffold with more than 90 % of her own tissue,' Dr Wagels said.

Professor Hutmacher (R) demonstrating the chest implant with Dr Matthew Cheng (L). Credit: Metro South Health.

THE 3D PRINTED CHEST RECONSTRUCTION IMPLANT HAS CHANGED THE LIFE OF A YOUNG MEDICAL STUDENT RECIPIENT.

TINY TECH GETS TO THE HEART OF DISEASE

A team of researchers at the *ARC Centre of Excellence for Nanoscale BioPhotonics* (CNBP) has developed the world's tiniest endoscope.

Lead researcher Dr Jiawen Li, an associate investigator and Heart Foundation Postdoctoral Fellow at CNBP at The University of Adelaide, says that the endoscope will help clinicians better understand the causes and progression of heart disease.

In Australia, 157 people are hospitalised every day due to heart attacks. Around one in 10 of these people are likely to be readmitted for a second one within a year. The endoscope can help detect and prevent these secondary heart attacks by assessing plaque in the arteries after the initial attack.

At the heart of the endoscope is a tiny 3D-printed lens on the end of an optical fibre less than half a millimetre wide, including a protective catheter sheath. This means it can safely fit inside a narrow artery.

'We used the technology to take 3D scans of atherosclerotic plaques inside blood vessel walls,' Dr Li says. 'These are a common cause of heart attacks.'

'These miniaturised endoscopes, which act like tiny cameras, allow doctors to see how these plaques form and explore new ways to treat them.'

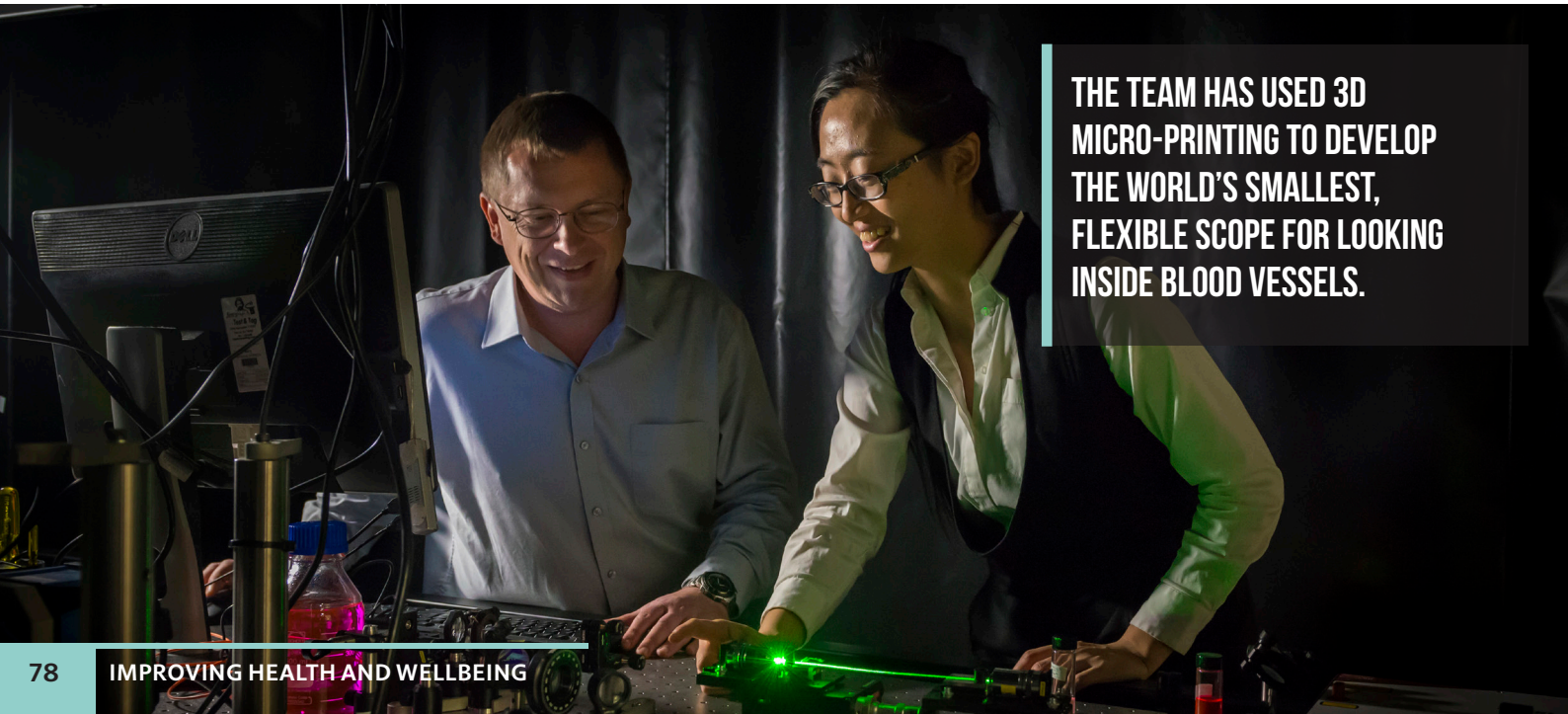
Dr Simon Thiele, Group Leader, Optical Design and Simulation at the University of Stuttgart, was responsible for fabricating the tiny lens.

'Until now, we couldn't make high quality endoscopes this small.'

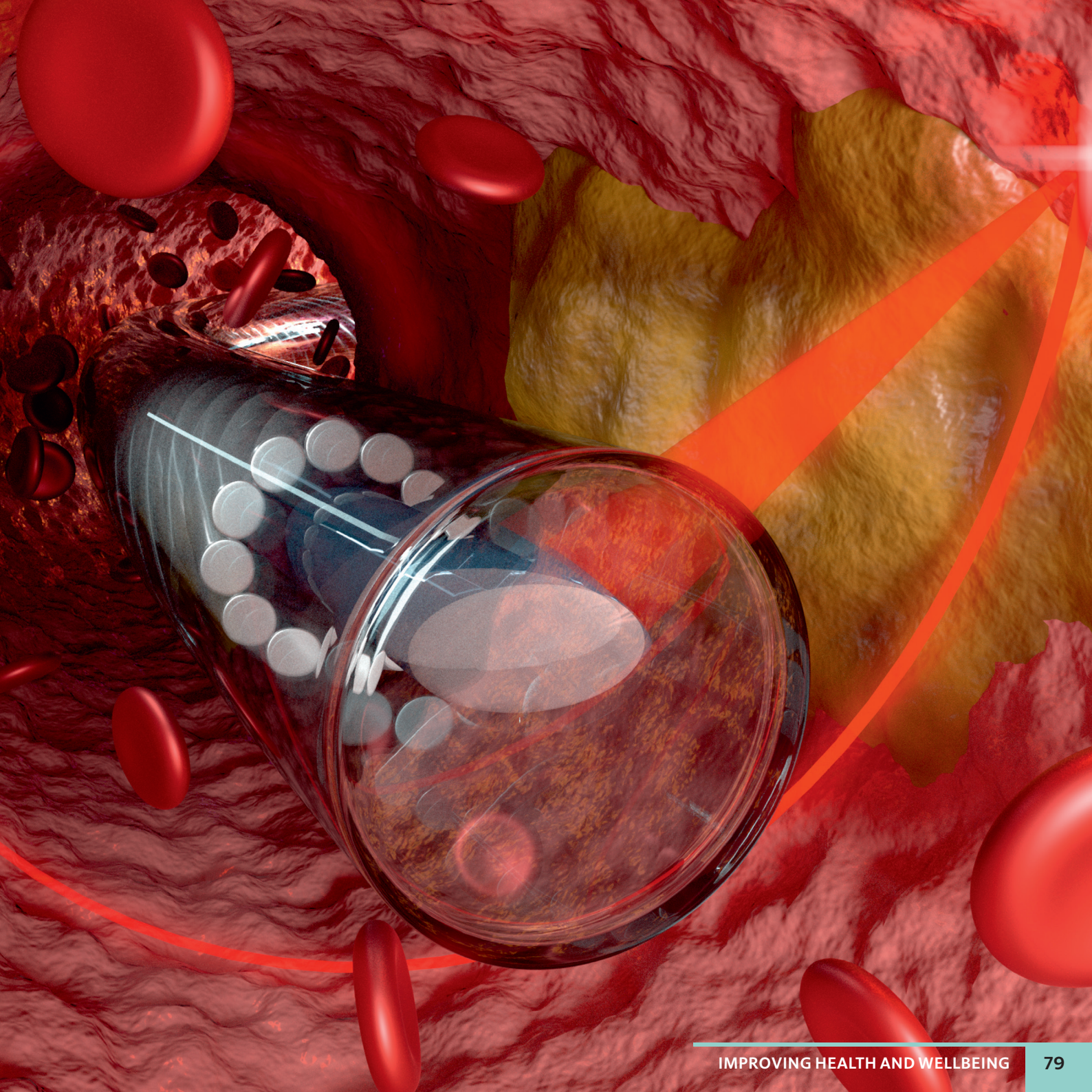
'Using 3D micro-printing, we are able to print complicated lenses that are too small to see with the naked eye,' Dr Thiele said.

(Below) Rodney kirk, Jiawen Li. Credit: University of Adelaide.

(Right) Imaging probe in blood vessel. Credit: Florian Sterl, Sterltech Optics.



THE TEAM HAS USED 3D MICRO-PRINTING TO DEVELOP THE WORLD'S SMALLEST, FLEXIBLE SCOPE FOR LOOKING INSIDE BLOOD VESSELS.



INSECT WINGS MIGHT BE THE NEW WEAPON AGAINST 'SUPERBUGS'

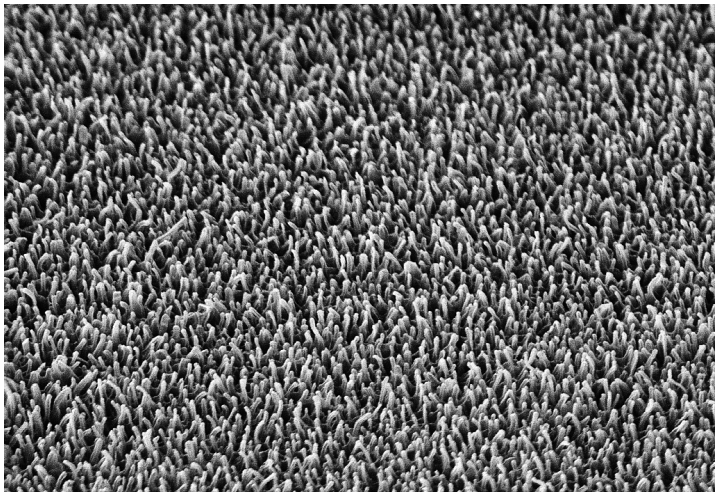
A team of scientists has revealed how nanomaterials inspired by insect wings are able to destroy bacteria on contact, which holds promise for a new era of biomedical antimicrobial nanotechnology.

The wings of cicadas and dragonflies are natural bacteria killers, a phenomenon that has spurred researchers searching for ways to defeat drug-resistant superbugs. New anti-bacterial surfaces are being developed, featuring different nanopatterns that mimic the deadly action of insect wings, which can stretch, slice or tear bacteria apart on contact.

A pioneer in biomimetic antibacterial surfaces, Distinguished Professor Elena Ivanova leads the Mechano-bactericidal Surfaces research group in the School of Science at RMIT University, and is a Chief Investigator at the *ARC Training Centre in Surface Engineering for Advanced Materials* and the *ARC Research Hub for Australian Steel Innovation*.

'Bacterial resistance to antibiotics is one of the greatest threats to global health, and routine treatment of infection is becoming increasingly difficult,' says Professor Ivanova.

'If we can understand exactly how insect-inspired nanopatterns kill bacteria, we can be more precise in engineering these shapes to improve their effectiveness against infections. Our ultimate goal is to develop low-cost and scaleable anti-bacterial surfaces for use in implants and in hospitals, to deliver powerful new weapons in the fight against deadly superbugs.'



'BACTERIAL RESISTANCE TO ANTIBIOTICS IS ONE OF THE GREATEST THREATS TO GLOBAL HEALTH AND ROUTINE TREATMENT OF INFECTION IS BECOMING INCREASINGLY DIFFICULT.' DISTINGUISHED PROFESSOR ELENA IVANOVA.

(Top) Common whitetail dragonfly. Credit: Public domain image by Christopher Johnson (Insects Unlocked, University of Texas at Austin).

(Below) The nanopillars on the surface of a dragonfly wing (magnified 20,000 times). Credit: RMIT University.

'SMART' WOUND DRESSING TECHNOLOGY

ARC-supported scientists have developed a next generation wound dressing that can detect infection and improve healing in burns, skin grafts and chronic wounds.

In research led by RMIT University's Research Fellow Dr Asma Khalid, smart wound dressings made of silk and nanodiamonds could detect early signs of infection, by sensing wound temperature, as well as acting to reduce infection from certain bacteria.

The team turned to diamonds – which are known to detect biologically-relevant temperatures to a highly precise level – to incorporate the heat sensing capability in the dressings.

'The heat sensing capability opens the possibility of contactless wound monitoring. Clinicians would be able to obtain information on the wound's status from the nanodiamond temperature readout,' says Dr Khalid.

Senior researcher, previous ARC Future Fellow Professor Brant Gibson, says it offered a solution to the global challenge of wound care and healing.

'Traditional wound management presents a significant challenge for clinicians, who have to regularly check for infection by looking for signs of redness, heat and swelling,' he said.

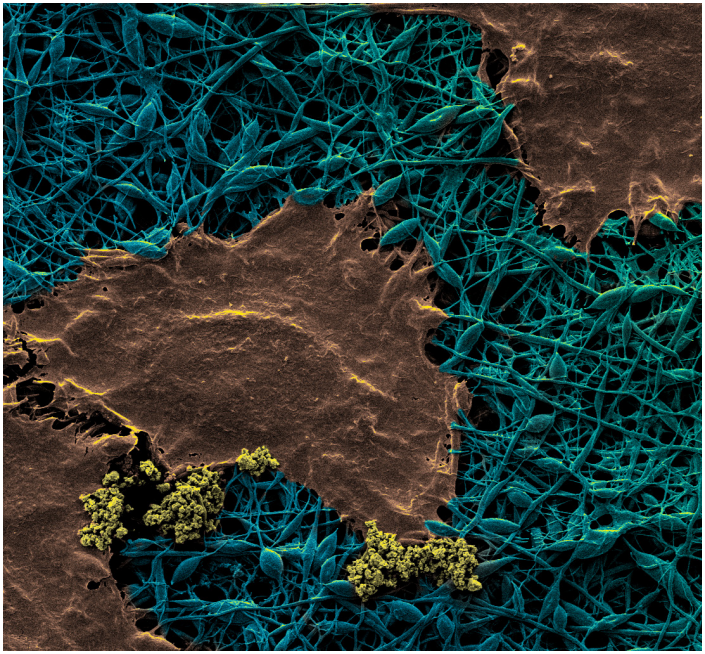
'This new technology would aid clinicians to detect infections earlier and non-invasively without the painful procedure of dressing removal.'

The researchers also tested the technology for resistance to bacteria, the major cause of skin wound infections. The study found that the nanodiamond silk membranes showed an extremely high antibacterial resistance.

The research consortium included scientists from RMIT University, The University of Adelaide and The University of Melbourne, Flinders University, SAHMRI and the *ARC Centre of Excellence for Nanoscale BioPhotonics* (CNBP).

This project has also been awarded an NHMRC Ideas Grant to prototype and validate the smart dressing in preparation for human trials.

> **'BY EMBEDDING NANODIAMONDS INTO SILK FIBRES USING AN ELECTROSPINNING PROCESS, WE'VE BEEN ABLE TO DEVELOP A NATURALLY-DERIVED WOUND DRESSING THAT CAN SENSE INFECTIONS,' SAYS DR ASMA KHALID.**



Diamond silk fibres are electrospun to form porous membranes, shown in bluish green colour, with the golden-brown colour representing the skin cell growth on the membrane. Credit: Colourised by Daniel Oldfield.

UNDERSTANDING THE NATURAL WORLD

Operation Posidonia. *Credit: Richard Woodgett.*

TICK SALIVA PROTEIN COULD ONE DAY HELP TREAT INFLAMMATORY DISEASES

A team of researchers at the *ARC Centre of Excellence for Innovations in Peptide and Protein Science* (CIPPS) has for the first time synthetically produced anti-inflammatory proteins found in tick saliva, a promising step towards new therapeutic treatments.

Evasins, as the proteins are known, act in human blood to suppress a class of transmitter proteins, which is why when bitten, we often don't notice a tick has burrowed into our skin. Scientists now want to see how these proteins can be used for treating human diseases, including potential application for lung inflammation in respiratory illness, such as COVID-19.

'Ticks have a terrible reputation – they are not very nice to look at, need to suck blood to survive and are responsible for transmitting bacteria that cause severe diseases, such as Lyme disease in humans,' said Professor Richard Payne, an ARC Future Fellow and Deputy Director at CIPPS, who is based at The University of Sydney. 'But to a medicinal chemist, ticks are amazing creatures.'

Ticks have evolved an impressive arsenal of biologically active salivary proteins they pump into the bite sites on their hosts. Among these are various pain-killing agents and some of the best blood-thinning molecules known.

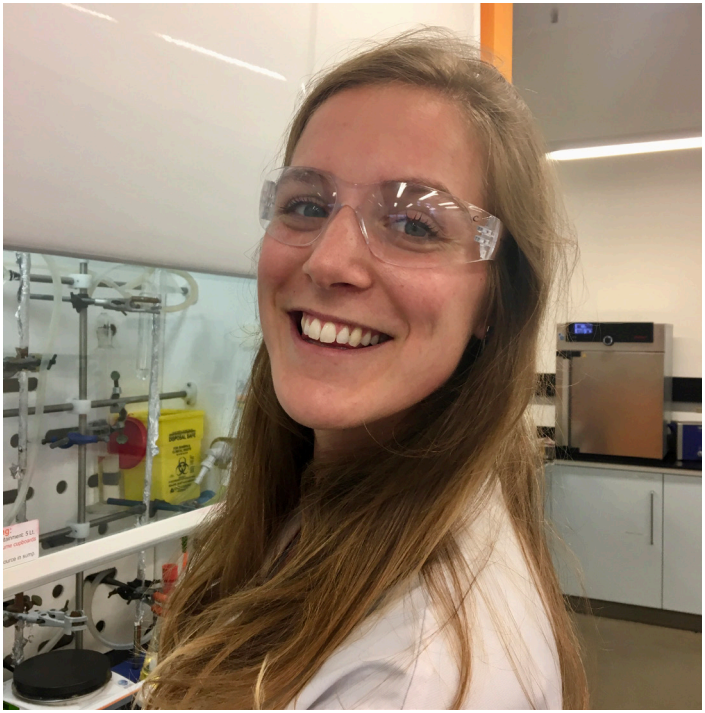
'In order to avoid detection, ticks also produce small protein molecules that suppress the inflammatory response. These proteins are called the 'evasins' because they help the tick evade immune detection. This means they can feed for days without the host knowing they are attached,' Professor Payne says.

In the past, evasins have proven difficult to isolate, so the researchers, led by CIPPS Research Fellow Dr Charlotte Franck, built the proteins from scratch in a feat of synthetic chemistry, something that no one else had ever been able to do. They discovered that sulfate molecules attached to evasins give the proteins a powerful kick.

'Armed with this knowledge, evasins could potentially be repurposed to suppress chemokine-driven inflammation in human disease,' Dr Franck says.

'We are now trying to engineer these sulfated evasin molecules to make them more stable in blood. We can then start to explore how effective they could be for a range of inflammatory conditions in the clinic.'

The findings were part of Dr Franck's doctoral research and was funded by an ARC Discovery Project and NHMRC Project Grant. The CIPPS team will continue to build on this knowledge to try to make the sulfated evasins more effective.



(Above) Dr Charlotte Franck at the School of Chemistry. Credit: The University of Sydney.

(Right) Credit: iStock.com/Risto0.

‘LIFE HAS HAD BILLIONS OF YEARS TO EXQUISITELY FINE-TUNE PROTEINS, SUCH AS EVASINS, FOR PARTICULAR TASKS. WE HAVE AN AMAZING OPPORTUNITY NOW TO UNDERSTAND HOW THEY WORK AND SEEK INNOVATIVE WAYS TO APPLY THEM TO CHALLENGES IN MEDICINE AND OTHER AREAS TO BENEFIT HUMANITY.’ PROFESSOR RICHARD PAYNE.

THE TREE WHOSE STING IS LIKE A SPIDER BITE

The painful toxins wielded by a giant Australian stinging tree are surprisingly similar to the peptides found in spider and cone snail venoms, ARC-supported researchers from The University of Queensland (UQ) have found.

The Gympie-Gympie stinging tree is one of the world's most venomous plants and causes extreme long-lasting pain.

ARC Discovery Project grant recipients, Professor Irina Vetter, Dr Thomas Durek and their teams at UQ's Institute for Molecular Bioscience, found a new family of toxins, which they've named 'gympietides' after the Gympie-Gympie stinging tree.

'Like other stinging plants such as nettles, the giant stinging tree is covered in needle-like appendages called trichomes that are around five millimetres in length – the trichomes look like fine hairs, but actually act like hypodermic needles that inject toxins when they make contact with skin,' says Professor Vetter.

Scientists were already aware of toxins such as histamine, acetylcholine and formic acid in the stinging tree's trichomes, but these alone could not explain the severe and long-lasting pain of the stinging tree. This suggested that an unidentified neurotoxin was still to be found in the plant's venom.

'We were interested in finding out if there were any neurotoxins that could explain these symptoms, and why Gympie-Gympie can cause such long-lasting pain, Professor Vetter says.

After a long search, the researchers uncovered a completely new class of neurotoxins – miniproteins that they named 'Gympietides', after the Indigenous name for the plant.

Although they come from a plant, the gympietides fold into similar 3D molecular structures and target the same pain receptors as many spider and cone snail toxins do.

'This arguably makes the Gympie-Gympie tree a truly 'venomous' plant.'

THE RESEARCH OPENS THE POTENTIAL TO REVEAL THE MECHANISMS OF PAIN SIGNALLING AND FUTURE NEW THERAPEUTIC TARGETS. BY UNDERSTANDING HOW THESE TOXINS WORK, THE RESEARCHERS HOPE TO PROVIDE BETTER TREATMENT TO THOSE WHO HAVE BEEN STUNG BY THE PLANT, TO EASE OR ELIMINATE THE PAIN.

The Gympie-Gympie tree's needle-like trichomes inject toxins. Credit: Darren Brown, Institute for Molecular Bioscience, The University of Queensland.

CELL GATEKEEPERS COULD BE THE KEY TO BETTER CROPS

Research at The Australian National University has shed new light on the network of gatekeepers controlling the 'traffic' of molecules in and out of plant cells, a discovery that could hold the key to developing food crops with increased yields.

A sieve of microscopic pores made of special proteins called aquaporins are gatekeepers that control the flow of molecules across cell membranes needed for plant growth. Aquaporins are found in all Kingdoms of life, from bacteria to humans. In plants, they are vital for numerous processes including water transport, growth and development, stress responses, root nutrient uptake, and photosynthesis.

Led by former PhD student, Dr Annamaria De Rosa and Dr Michael Groszmann from Professor John Evans' research group in the *ARC Centre of Excellence for Translational Photosynthesis* (CoETP), the researchers say that the discovery could also open the door to crops with an improved ability to cope with extreme environments.

'We know that if we are able to manipulate aquaporins, it will enable numerous useful applications for agriculture, including improving crop productivity – but first we need to know more about their diversity, evolutionary history and the many functional roles they have inside the plant,' Dr De Rosa says.

The research has identified all the different types of aquaporins found in tobacco (Nicotiana tabacum), a model plant species closely related to major economic crops such as tomato, potato, eggplant and capsicum. Potential applications for crop improvement include increased photosynthesis, more efficient water and fertiliser use, improved drought tolerance and more effective response to disease infection.

> 'THE FUTURE OF AQUAPORINS IS FULL OF POSSIBILITIES.' DR MICHAEL GROSZMANN.

Michael Groszmann, John Evans and Annamaria De Rosa in the glasshouse with tobacco plants. Credit: Natalia Bateman Vargas.

HEATWAVES AROUND THE WORLD INCREASE

Researchers at the *ARC Centre of Excellence for Climate Extremes*, administered by The University of New South Wales, have conducted the first comprehensive worldwide assessment of heatwaves – revealing that in nearly every part of the world, heatwaves have been increasing in frequency and duration since the 1950s.

The research has also produced a new metric, cumulative heat, which reveals exactly how much heat is packed into individual heatwaves and heatwave seasons. As expected, that number is also on the rise.

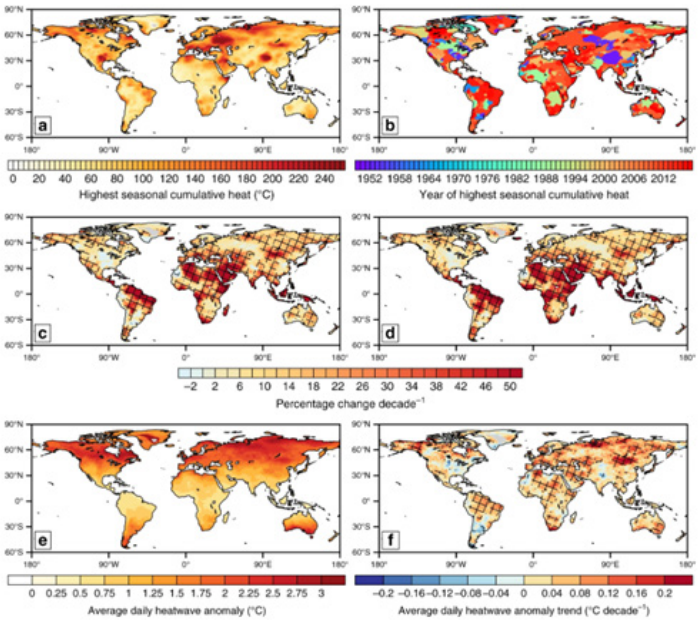
In Australia's worst heatwave season, an additional 80°C of cumulative heat was experienced across the country. In Russia and the Mediterranean, their most extreme seasons baked in an additional 200°C or more.

'Not only have we seen more, and longer, heatwaves worldwide over the past 70 years, but this trend has markedly accelerated,' says ARC Future Fellow, Dr Sarah Perkins-Kirkpatrick. 'Climate scientists have long forecast that a clear sign of global warming would be seen with a change in heatwaves.'

The study also identified that heatwaves are quite sensitive to internal climate variability at regional levels. This variability can overwhelm heatwave trends, so regional trends shorter than a few decades are generally not reliable. To detect robust trend changes, the researchers looked at how the trends had changed over multi-decade intervals between 1950-2017. The changes were stark.

'The dramatic region-by-region change in heatwaves we have witnessed over the past 70 years and the rapid increase in the number of these events, are unequivocal indicators that global warming is now with us and accelerating.'

> THE RESEARCHERS SAY THAT WHETHER OR NOT THESE CHANGES ARE RAPID OR SLOW, IT SEEMS INEVITABLE THAT VULNERABLE NATIONS WITH LESS INFRASTRUCTURE WILL BE HIT HARDEST BY EXTREME HEAT.



Global maps of cumulative heat statistics. Credit: Perkins-Kirkpatrick and Lewis, 2020, Nature Communications.

RESTORING UNDERWATER LEAFY HABITATS

Associate Professor Adriana Vergés is a marine ecologist and multiple ARC grant recipient, based at The University of New South Wales and the Sydney Institute of Marine Science, whose research seeks to reverse the disappearance of the world's seaweed forests, under pressure from human activity and climate change.

The winner of the UNSW Emerging Thought Leader Prize in 2019, Professor Vergés is one of the masterminds behind *Operation Crayweed*, which has restored thriving crayweed forests to the shallow waters off Sydney. This successful restoration project has had a significant impact on the wider community, both in terms of its environmental effect, but also through the innovative science communication that took place around it at public events, to engage and inspire the local community in the protection of seaweeds.

A newer project *Operation Posidonia* seeks to achieve similar aims, with public engagement and funding to restore the endangered Posidonia australis seagrass to estuaries where it once thrived and phase out the use of the block-and-chain boat moorings which destroy it.

Kelp and seagrasses are important for carbon capture and storage. In some regions of Australia, seagrasses can store 20 or 30 times more carbon than rainforests. Kelp and seagrasses also underpin the ecosystems which commercially valuable fisheries, and local tourism industries depend upon.

Associate Professor Vergés says that her ultimate goal is to not only restore lost underwater forests and seagrass meadows but to also climate-proof these habitats as much as possible.

'In the marine environment, we are already seeing the impacts of climate change in a major way. Fishers are now catching species that used to be found in warmer waters, and we also have species and entire habitats that are disappearing,' says Associate Professor Vergés.

'For example, 95% of Tasmania's giant kelp forests have disappeared – and that is because of climate change.'

> **A DISCOVERY PROJECT LED BY ASSOCIATE PROFESSOR ADRIANA VERGÉS IS QUANTIFYING THE IMPACTS OF A CHANGING CLIMATE ON KEY ECOSYSTEM FUNCTIONS OF TEMPERATE REEFS THAT UNDERPIN MAJOR ECOSYSTEM SERVICES, SUCH AS THE PROVISION OF FOOD OR RECREATIONAL FISHING.**

Associate Professor Adriana Vergés measuring crayweed. Credit: John Turnbull.


PELAGIC
MEDIUM

WARMER OCEAN TEMPERATURES AFFECTING BABY SHARKS

Researchers from the *ARC Centre of Excellence for Coral Reef Studies* (Coral CoE), administered by James Cook University (JCU) and working with the University of Massachusetts have found that as climate change causes the world's oceans to warm, baby sharks are born smaller, exhausted, undernourished and into environments that are already difficult for them to survive in.

PhD candidate, Carolyn Wheeler, examined the effects of increased temperatures (up to 31°C) on the growth, development and physiological performance of epaulette sharks – an egg-laying species found only on the Great Barrier Reef (GBR).

'The hotter the conditions, the faster everything happened, which could be a problem for the sharks. The embryos grew faster and rapidly depleted their yolk sac, which is their only source of food whilst developing in the egg.'

Embryos hatched earlier than usual, were smaller, and hatchlings needed to feed almost straight away – while lacking significant energy.

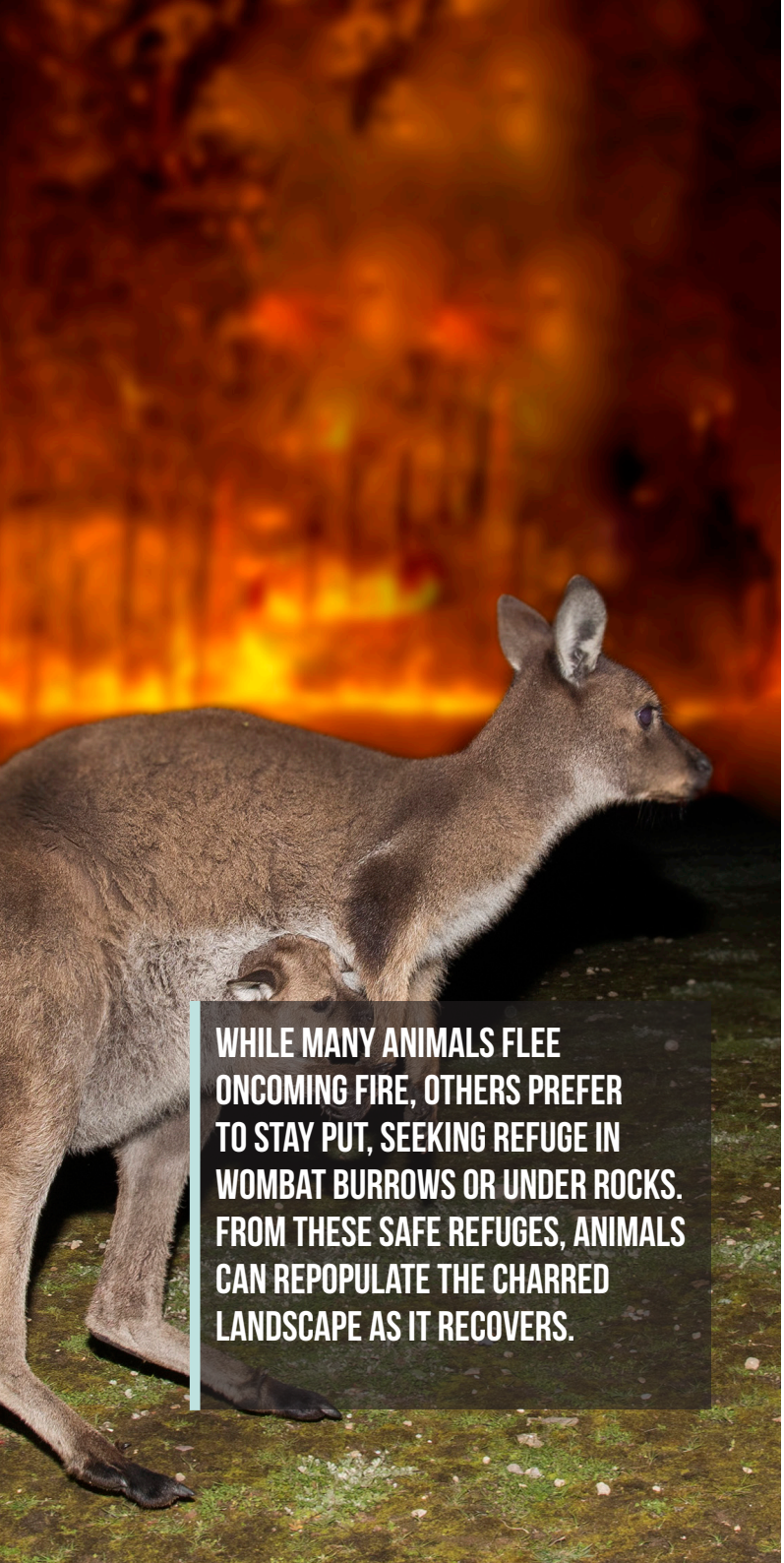
Associate Professor Jodie Rummer, a Discovery Early Career Researcher Award recipient from Coral CoE at JCU, says the waters of the GBR will likely experience summer averages close to or even exceeding 31°C by the end of the century.

'The epaulette shark is known for its resilience to change, even to ocean acidification,' Dr Rummer says. 'So, if this species can't cope with warming waters then how will other, less tolerant species fare?'

The research was a collaborative effort between the Anderson Cabot Center for Ocean Life and the husbandry staff at the New England Aquarium in Boston.

A newly hatched epaulette shark. Credit: Jodie Rummer.

'THE STUDY PRESENTS A WORRYING FUTURE GIVEN THAT SHARKS ARE ALREADY THREATENED. SHARKS ARE IMPORTANT PREDATORS THAT KEEP OCEAN ECOSYSTEMS HEALTHY. WITHOUT PREDATORS, WHOLE ECOSYSTEMS CAN COLLAPSE WHICH IS WHY WE NEED TO KEEP STUDYING AND PROTECTING THESE CREATURES,' SAYS PHD CANDIDATE, CAROLYN WHEELER.



WHILE MANY ANIMALS FLEE ONCOMING FIRE, OTHERS PREFER TO STAY PUT, SEEKING REFUGE IN WOMBAT BURROWS OR UNDER ROCKS. FROM THESE SAFE REFUGES, ANIMALS CAN REPOPULATE THE CHARRED LANDSCAPE AS IT RECOVERS.

ANIMAL RESPONSES TO BUSHFIRE

Research into the movement of animals in fire-prone landscapes is helping to better understand how native species survive and recover from the devastation of bushfire.

The study led by ARC *Discovery Early Career Researcher Award* (DECRA) recipient based at Charles Sturt University, Associate Professor Dale Nimmo, and 27 colleagues from various institutions, considered how fire affects animal movement from daily foraging bouts to infrequent dispersal events, and annual migrations.

The researchers found that different species have a range of abilities to detect a fire including smelling smoke, recognising the sound of fire and sensing fire chemicals, as well as detecting infrared radiation from fires. Once an animal becomes aware of an approaching fire, the decision to stay or flee is not always based on instinct.

In the days and weeks following the passage of a fire, the researchers found that some native animals have learned to minimise movement to avoid predation in the burned landscape, but other species make bad decisions to move when they should stay put.

'As the 2019–20 bushfire season made brutally clear, climate change is increasing the scale and intensity of bushfires. This reduces the number of small refuges such as fallen logs, increases the distance animals must cover to find new habitat, and leaves fewer cues to direct them to safer places,' Associate Professor Dale Nimmo says.

'Filling in the knowledge gaps might lead to new ways of helping wildlife adapt to our rapidly changing world.'

Credit: iStock.com/izanbar.

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.

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 sectors, including from 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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