Acoustics / Criminology / Super-materials / Ancient DNA / Musicology / Parasites

THE AUSTRALIAN

RESEARCH

SEPTEMBER 26, 2018

Luca Cocchi
Neuroscientist

Nicole Kessissoglou
Mechanical engineer

THE STARS OF 2018

Peta Neale
Environmental scientist

Andrew Fairbairn
Archeobotanist

THE RIGHT PARTNER CAN TAKE YOUR COMMERCIAL INNOVATION TO NEW HEIGHTS

Innovation really can change the world. But to do so often requires two crucial components – commercial opportunity and ground-breaking research. For this reason, so much recent success has drawn on the partnership between enterprise and science.

Researchers at The University of Queensland (UQ) continue to lead world-changing projects. Six of our researchers were recently awarded a 2018 Australian Laureate Fellowship – more than any other university in Australia.

New heights in hypersonics

Hypersonic flight has the potential to revolutionise global air travel and small satellite launch. UQ researchers, in partnership with the Defence Science and Technology Group of Australia, the US Air Force Research Laboratory, and Boeing, successfully launched a hypersonic test flight from Woomera in South Australia. The HiFiRE 5B rocket hit target speeds of 9200km/h and reached a height of 278km.

UQ's Professor Michael Smart said, "The knowledge gained from these experiments will be applied to develop future flight vehicles and advanced air-breathing hypersonic propulsion engines, like scramjets".

Contents

In this year's *Research* magazine, we highlight the excellence of Australian researchers, universities and other research institutions, and we are doing it in a way that until recently was not possible. We used the power of data analysis and applied it to the huge volume of information available online to create a view of Australia's best researchers and research organisations – a methodology that offers more detail than is presented by traditional university rankings.

It's a product of the journalistic skills of *The Australian* coupled with the data skills of talent discovery and research analytics firm League of Scholars, which has pioneered the use of big data techniques to produce research metrics.

The result is a list of leading researchers and research institutions across more than 250 fields of research. It's not a high-level, remote picture; it's a highly granular view that delves deep.

As a result, we recognise the highly worthwhile achievements of people who are not otherwise acknowledged, apart from by their peers. People such as Griffith University environmental scientist Peta Neale, who is developing new and better ways to test for chemicals in water and their impact on human and animal life. Or neuroscientist Luca Cocchi at the QIMR Berghofer Medical Research Institute, who is looking for cures for psychiatric disorders.

In this edition you will find proof that Australia's traditional research-intensive universities continue to dominate and excel in so many fields of research. You will also discover that some universities often overlooked in the research domain are nevertheless leaders in small, but very important, fields.

The magazine finishes with a reflective essay by former Australian chief scientist Robin Batterham who points out that, as a nation, we boost the already considerable impact of our research when we concentrate on excellence.

We trust you will enjoy this new tour of Australia's research output.

Tim Dodd
Higher education editor, The Australian

Paul McCarthy
CEO and co-founder, League of Scholars

Institution abbreviations

Alfred Hospital Alfred
Austin Health Austin
Australian Catholic University ACU
Australian Museum Aust Mus
Australian National University ANU
Australian Nuclear Science and Technology Organisation ANSTO
Bond University Bond
Bureau of Meteorology BOM
Central Queensland University Central Qld Uni
Charles Darwin University Charles Darwin
Charles Sturt University Charles Sturt
Commonwealth Scientific and Industrial Research Organisation CSIRO
Curtin University Curtin
Deakin University Deakin
Edith Cowan University Edith Cowan
Flinders University Flinders
George Institute for Global Health George Inst
Griffith University Griffith
James Cook University James Cook
La Trobe University La Trobe
Macquarie University Macquarie
Menzies School of Health Research Menzies
Monash University Monash
Murdoch Children's Research Institute MCRI
Murdoch University Murdoch Uni
Neuroscience Health Research Australia NHRA
New South Wales Government NSW Govt
QIMR Berghofer Medical Research Institute QIMR Berghofer
Queensland University of Technology QUT
RMIT University, Melbourne RMIT
Swinburne University of Technology Swinburne
Telethon Kids Institute Telethon Kids
University of Adelaide Uni of Adelaide
University of Canberra Uni of Canberra
University of Melbourne Uni of Melb
University of Newcastle Uni of Newcastle
University of New England UNE
University of New South Wales UNSW
University of Queensland Uni of Qld
University of Sydney Uni of Sydney
University of Tasmania Uni of Tasmania
University of Technology Sydney UTS
University of Western Australia UWA
University of Wollongong Uni of Wollongong
Walter and Eliza Hall Institute of Medical Research WEHI
Western Sydney University WSU

THE AUSTRALIAN
RESEARCH

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Distinguished Professor Matthew Bailes, Director of OzGrav watches as Swinburne's new $4 million, petabyte-crunching supercomputer is adorned with images of gas swirling around black holes.

SWINBURNE UNIVERSITY OF TECHNOLOGY

Pushing the boundaries of possibility

That's exactly what we are doing at our ARC Centre of Excellence for Gravitational Wave Discovery (OzGrav), where Swinburne's astrophysicists recently witnessed the first-ever detection of colliding neutron stars. A discovery that marks a new era in gravitational wave astronomy.

This exceptional centre partners across six Australian University nodes, and multiple other organisations in Australia and overseas. OzGrav is the only place in Australia with two ARC Laureate Fellows in Astronomy, Distinguished Professors Matthew Bailes and Karl Glazebrook; Nobel Laureate, Professor Barry Barish, also sits on OzGrav's Science Advisory Committee. Swinburne has invested $4M in OzSTAR, one of the most powerful supercomputers in Australia, facilitating the interrogation of huge amounts of data being drawn from the advanced Laser Interferometer Gravitational-Wave Observatory (aLIGO), operated by Caltech and MIT and the forthcoming Square Kilometre Array.

In our search for gravitational waves and study of the extreme physics of black holes and warped space-time, Swinburne is using innovation and collaboration to make waves of our own.

To find out more about Swinburne and OzGrav, visit: **www.swinburne.edu.au/research** or **www.ozgrav.org/**

CRICOS: 00111D

RAILWAYS AROUND THE WORLD ARE GETTING ON BOARD WITH OUR TECHNOLOGY

Trains across the world are running to timetable and arriving at their destinations safely using innovative technology developed by mathematicians at the University of South Australia.

As Australia's University of Enterprise, UniSA is at the forefront of innovation in a partnership with TTG Transportation Technology – a leading international provider of rail technology.

Researchers at our Centre for Industrial and Applied Mathematics (CIAM) worked with TTG to devise a train driver advice system called Energymiser. The app continually calculates the most efficient way to complete the journey, accounting for track gradients, speed and power limits, advising the driver when to apply power, maintain speed, coast and brake, all whilst reconciling against the timetable. The results are startling.

The CEO of Kiwi Rail said, "The amount we've saved in fuel and dollar terms has been a revelation." Likewise, after deploying Energymiser for just one year on its 125-train fleet, Arriva Trains Wales saved roughly 750,000 litres of fuel.

Energymiser is now in use on more than 4,000 trains across the UK, Belgium, Spain, France, Germany, China, India, Australia and New Zealand.

UniSA and TTG's jointly developed product has earned multiple awards including an Australian Export Award, NSW Premier's Export Award and Australian Rail Industry Award, and put the company right on track for global growth.

TTG Managing Director attributes the success to its long-term relationship with UniSA. "Through this association, and strong research funding support from the Australian Government, we have been able to produce technology and create opportunities, now in demand all around the world ... It's testament to the fantastic academic rigour we have here in Australia."

For more information on our Transforming Industries Research theme and other stories of how our research is addressing real-world problems, visit:

unisa.edu.au/research

University of South Australia

Focus on the frontrunners

In the age of the internet, we can now drill deep beneath university rankings to pinpoint Australia's areas of research excellence in far greater detail

By Tim Dodd

Hello big data! In academic research, as in many fields of endeavour, the ability to glean large quantities of data from the internet is changing the way critical information is gathered and disseminated.

The metrics that matter in the world of research – such as how many peer reviewed papers are published, the quality of the journals they are published in, the number of citations they receive, and the time period in which this happens – can now be calculated from information that is publicly available online.

Using data analysis we now have a much more up-to-date perspective on the recent performance and future potential of individual researchers and for the universities and research institutions where they work.

In this special issue of The Australian's *Research* magazine, we pick up and run with the new opportunities offered by big data, and use them to analyse the research specialties of Australian academics, universities and research institutes in fine detail.

Using publicly available information processed by our partner, data analytics firm League of Scholars, we have produced a leaderboard of star Australian researchers in eight major disciplines. These are the academics whose lifetime output places them ahead of their peers.

We have also made a leaderboard of up-and-coming research stars, the early career researchers who are in the first seven years of their research careers and whose output so far puts them ahead.

Aside from these big calls, we have also used the power of big data to delve deeply into more than 250 highly granular research fields, and identified a leading researcher and a leading university (or other research institution) in each one.

These 250 research fields are far too numerous for each researcher's work to be described in any detail, but we give you a flavour of the quality being produced by profiling 16 of the research scholars who are leading in their fields.

We think it's worthwhile to so acknowledge the excellence of the work being produced in Australia's universities and research institutions.

Does our approach add useful information to the sea of data that already exists about research in Australia? We believe the answer is yes, but that needs some explanation.

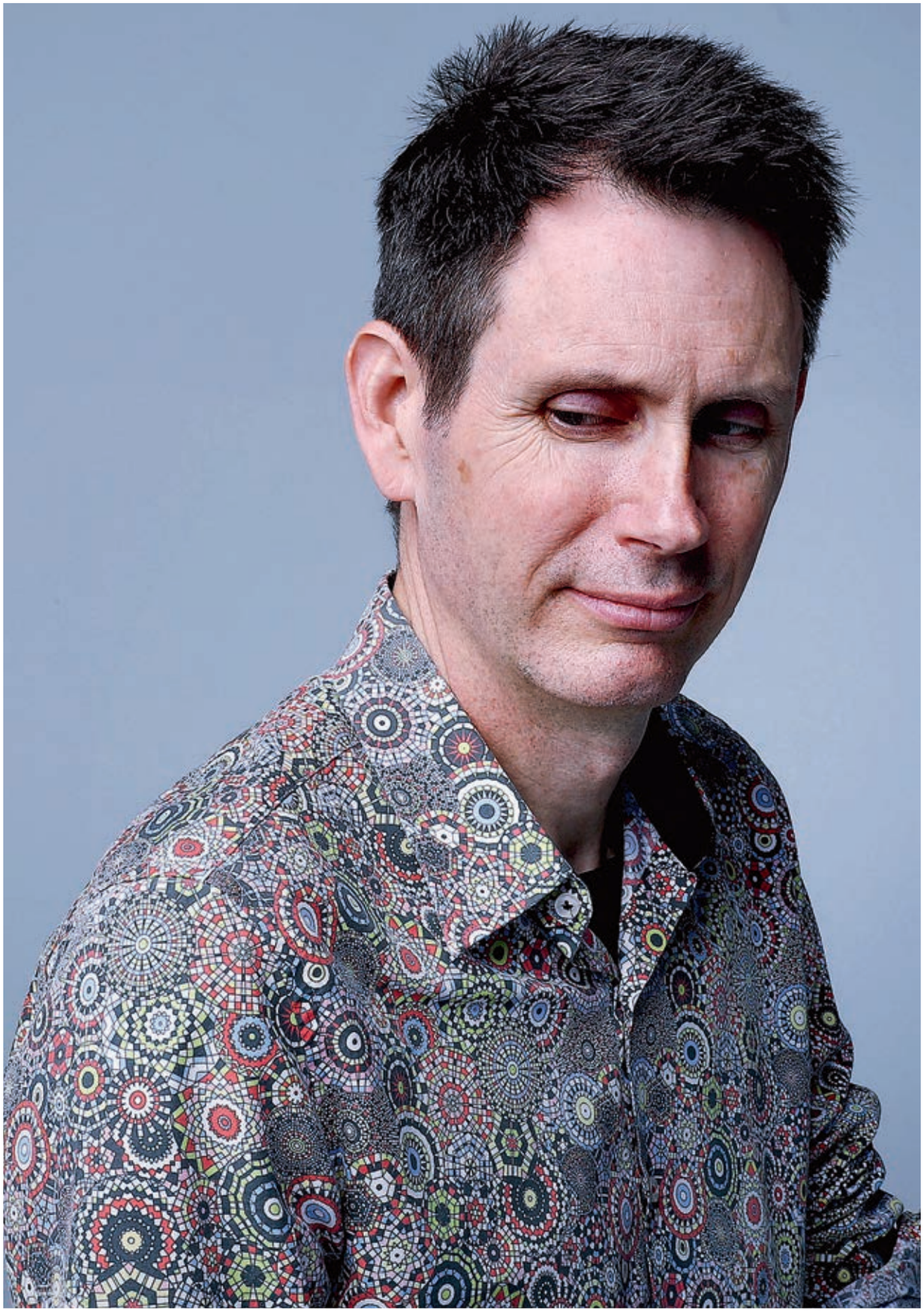
Bear in mind that we are already awash with university rankings. Seemingly every other week there is a new ranking of universities, or a new variant of one that is already published, that reports on universities' research performance.

But something is missing in the information offered by many of these rankings. While they give us headline results about each university's overall research performance, and also show how well universities do in broader research fields, there's a lack of fine granularity.

For example, try asking this question: exactly how well do researchers at University X rate in some highly focused areas, say game theory and decision science, or medical informatics, or ethnic and cultural studies?

In the past it has not been a simple task to compile such detailed information about research performance. Traditionally, data about the number of publications and citations associated with each researcher's work was only available from large global scientific and technical publishers who collect, index and sell this information, such as

Continued page 10



Q&A
Paul McCarthy
Co-founder & CEO League of Scholars

What is the basis of the methodology you used to create the research leaderboards and the leaders in each research field?
We follow the Google Scholar taxonomy, with eight broad research disciplines each divided into many detailed fields of research – more than 250 in all. We chose Google Scholar as the basis of our analysis because it's now the most comprehensive source of data about published research.

What metrics did you use to create the leaderboards of research stars and up-and-coming stars?
We needed to compare, in a fair way, the research output of people in different fields. We can't just count each researcher's citations because different fields of research have very different citation patterns. Broadly, we want to measure both the quality (measured by citations) and the quantity (measured by the number of publications). So we chose to use the H-Index, a single number that reflects both output and impact over a lifetime of research. For example, an H-Index of 10 means that a researcher has at least 10 publications, each with at least 10 citations. It tends to build over a career. By way of example, an H-Index of 40 is considered extremely good.

One of its benefits is that it screens out one-hit wonders and

From page 8
Clarivate and Elsevier. But now bibliometric data on academic research papers and citations is openly available on the web through sites such as Google Scholar, Microsoft Academic and Semantic Scholar. It enables more timely analysis and more finely detailed insights than offered by major university rankings. For our analysis we have used Google Scholar.

In an age in which research advances are made in highly specialised fields, granular detail is important. And the granularity of the analysis also throws up interesting results, identifying some universities and research bodies with excellent research records that are not often recognised. Because the results reflect current performance, they also give a fresh and up-to-date picture of where university research strengths lie.

As we would expect the research-intensive Group of Eight universities lead in a majority of fields, but the granularity of our analysis allows other universities that shine in particular disciplines to also be recognised.

Just to name some examples, the Australian Catholic University is the research leader in educational psychology and counselling; Charles Darwin University is the research leader in visual arts; La Trobe University leads in the three related fields of child and adolescent psychology, development disabilities and special education; Central Queensland University is tops in architecture; the University of New England shines in two very different areas, animal husbandry and mathematical analysis; the University of Newcastle leads in organic chemistry; and the University of Wollongong excels in an amazing array of diverse fields – algebra, archaeology, fuzzy systems, marketing and strategic management.

It is true that our approach is not the only one that offers detailed information about institutional research performance. The Australian Research Council's Excellence in Research in Australia project, conducted every three years, produces fine-grained detail about each university's research record, benchmarked against world norms. But it is a long process, with eac h outcome decided after extensive consideration by a committee.

The big data approach is different. It uses metrics that can be quickly calculated by employing algorithms based on available online data showing how many papers researchers have published, which journals they publish in and how many citations they get.

It has the advantage of speed, it's fully objective, and different algorithms can be experimented with.

The same advantages apply to recognising the excellence of individual researchers in this way. With big data we can also give public acknowledgement to many top performers who are currently little known except among their peers. Sometimes they don't know themselves that they play a starring role.

We don't claim that our way of identifying leading researchers is perfect. Clearly, who the leaders are depends on the data used and the algorithm employed to analyse it. In the accompanying Q&A, League of Scholars CEO Paul McCarthy explains why we made the choices we did.

We acknowledge this is a new approach, but we believe it has value and are very open to feedback.

doddt@theaustralian.com.au, paul@leagueofscholars.com

This methodology is more comprehensive, granular and up to date than traditional university rankings, which rely in part on things such as Nobel prizes, which typically reflect performance from decades ago

researchers who are highly productive but not often cited.

We decided to average each researcher's H-Index over their career, because it has been shown that this is a reliable way to compare performance of researchers in different fields and different career stages. (See Anne-Will Harzing's work at www.harzing.com)

How did you choose leading researchers and research institutions in each field?
There we took a different approach, while staying with our principle of measuring both quality and quantity.

For selecting researchers, we chose authors who had the most papers published in the top 20 journals in their field. (The top 20 journals are determined by their trailing five-year impact factor as measured by Google Scholar.) This recognises both their career output and, since it is limited to the top publication venues, the quality of their work as recognised by their peers worldwide. For institutions, we selected those with most impact, that is citations, from papers in the top 20 journals in each field in the past year.

Do you consider only research done in universities?
No, we also include bodies such as the CSIRO and medical research institutes. It makes sense to include them because they do high-level research at a similar level to universities.

How does this methodology compare to other ways of judging research excellence?
It is more comprehensive, up to date and granular than the traditional university rankings, which rely in part on things such as Nobel prizes, which typically reflect performance from decades ago, not today.

Our source in Google Scholar has been shown to have the greatest coverage of research output – including scholarly books, articles and papers. Our work is also bang up to date, with a currency many others don't have, because it reflects the 2018 performance of scholars and institutional performance over the past year.

In particular, it gives the humanities and social sciences more focus. They are indexed in more than 50 fields of research. I explain this in more detail in my blog post "Where are the rising stars of research working? Towards a momentum-based look at research excellence", on the London School of Economics website.

Does this methodology have any problems?
It doesn't show research into Australia-specific areas as much as we would like because it's based on an international classification system. So it misses out on areas such as Australian indigenous research, Australian literature and culture, and Australian history.

We also decided to leave out a handful of research fields such as American literature and studies, European law, and Latin American studies, which are not a focus for Australian researchers.

What is your background?
I'm a data science analyst and technology entrepreneur who co-founded League of Scholars in 2015. I'm currently also chairman of the mediatech hub The Studio, an adviser to ribit.net (part of the CSIRO's Data61) and an adjunct professor of computer science at UNSW. My book *Online Gravity*, which looks at economics in the age of the web, was published in 2015 by Simon and Schuster. It has been translated into Chinese and published by CITIC Press, and will soon be translated into Russian.

Lifetime Achievement Leaderboard
Stars of research

Per Davidsson
Business, economics & management

An expert on start-ups and the growth of firms, Davidsson is the director of the Australian Centre for Entrepreneurship Research at Queensland University of Technology Business School, where he is a professor. His papers have nearly 28,000 citations. He is one of the most cited researchers in entrepreneurship globally. and led the largest study of start-ups in Australia.

Jiazhao Wang
Chemical & material sciences

A professor at the University of Wollongong's Institute for Superconducting and Electronic Materials, Jiazhao Wang is one of the leading Australian authorities on battery technology. She came to the institute from China as a visiting fellow in the 1990s, then completed a PhD. She has been chief investigator for 16 successful competitive research grants.

Tony Fane
Engineering & computer science

Globally recognised for developing membrane technology for water purification. Fane joined UNSW in 1973 and was an adviser to Memtec, an early start-up that used university-developed technology. He received a Centenary Medal in 2002 for services to chemical engineering and environment, and has held senior posts at Nanyang Technological University in Singapore.

Herb Marsh
Health & medical sciences

Acknowledged as the world's most productive scholar in educational psychology, Marsh joined the Australian Catholic University from Oxford, where he is still an emeritus professor. His research is based around substantive-methodological research synergy and he has nearly 110,000 citations. He works at ACU's Institute for Positive Psychology and Education.

Adrian North
Humanities, literature & arts

Pre-eminent in research into pop music psychology, North has looked into the influence of music on mood and consumer behaviour, and theories of musical preference and taste. He played bass in a rock band in Manchester in the 1990s but believes he is more successful in his career as an academic. He heads the School of Psychology at Curtin University. (See profile page 36.)

Zheng-Xiang Li
Life sciences & earth sciences

One of Australia's most eminent geologists specialising in the movement of continents, piecing together how the map of the world looked in the past, Zheng-Xiang Li is interested in the relationship between tectonic events, patterns of mineralisation and environmental and climate change. He has worked in Perth for nearly 30 years, at the University of Western Australia and then at Curtin.

Brian Kennett
Physics & mathematics

A geophysicist who has made major contributions to understanding Earth's internal structure, including estimating the propagation velocities of seismic waves (used to determine the epicentre of earthquakes). Now an emeritus professor at ANU, he constructed the Australian Seismological Reference Model, a 3D representation of Australia's deep geological structure.

Stephen Castles
Social sciences

A research professor in sociology at the University of Sydney, Castles is one of the world's top migration researchers. He works on migration dynamics, global governance, multiculturalism, transnationalism, migration and development, and migration trends in Africa, Asia and Europe. He was director of the International Migration Institute at Oxford until 2009.

Business, Economics & Management
Australia's Research Field Leaders

Field Accounting & Taxation
Field leader Craig Deegan, RMIT
Leading institution Uni of Sydney

Field Business, Economics & Management (general)
Field leader Andrew Burton-Jones, Uni of Qld
Leading institution Uni of Melbourne

Field Development Economics
Field leader Simon Feeny, RMIT
Leading institution Monash

Field Economic History
Field leader Gary B. Magee, Monash
Leading institution ANU

Field Economic Policy
Field leader Efrem Castelnuovo, Uni of Melbourne
Leading institution Monash

Field Economics
Field leader Xin Meng, ANU
Leading institution UNSW

Field Educational Administration
Field leader Scott Eacott, UNSW
Leading institution Uni of Qld

Field Emergency Management
Field leader Dale Dominey-Howes, Uni of Sydney
Leading institution UNSW

Field Entrepreneurship & Innovation
Field leader Per Davidsson, QUT
Leading institution QUT

Field Finance
Field leader Chris Veld, Monash
Leading institution UNSW

Field Game Theory and Decision Science
Field leader Erte Xiao, Monash
Leading institution UNSW

Field Human Resources & Organisations
Field leader Cristina B. Gibson, UWA
Leading institution UWA

Field International Business
Field leader Catherine Welch, Uni of Sydney
Leading institution Monash

Field Marketing
Field leader Janet R. McColl-Kennedy, Uni of Queensland
Leading institution Uni of Wollongong

Field Strategic Management
Field leader Cristina B. Gibson, UWA
Leading institution Uni of Wollongong

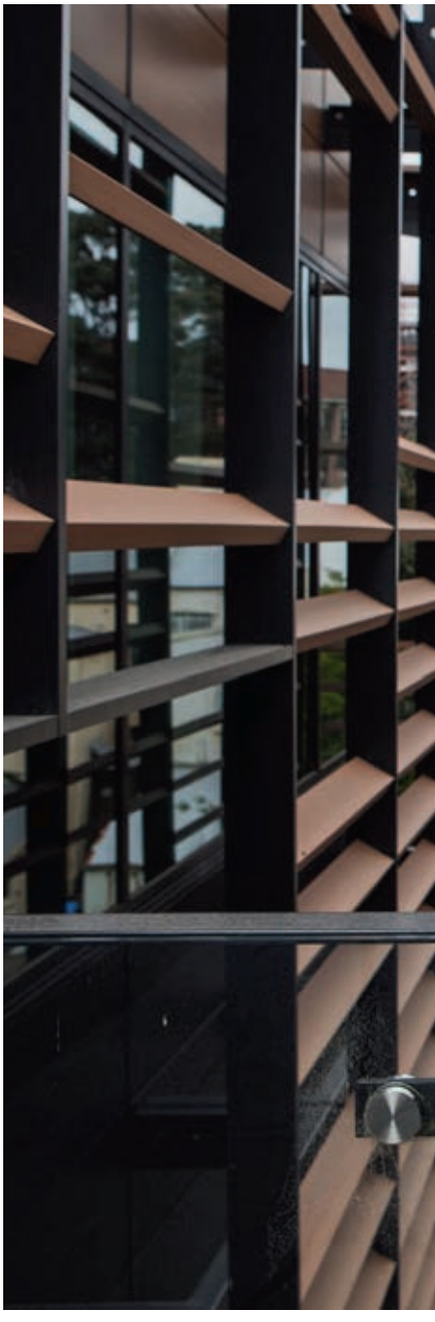
Field Tourism & Hospitality
Field leader Susanne Becken, Griffith
Leading institution Griffith

In business, economics and management, our analysis finds that the top research and talent is concentrated mainly in the upper-tier Group of Eight universities with large business faculties.

Globally, Australian universities rate well for their research in this discipline. For example, Monash University and the University of Melbourne rank in the world's top 30 in business administration research, according to the Academic Ranking of World Universities (ARWU) which rate institutions by research, although not at the finer level of detail that we have done.

In finance research, Australian universities do similarly well, with UNSW 16th in the world and the University of Melbourne 27th.And three Australian universities make the ARWU's top 50 in economics – the University of Melbourne, Monash University and the Australian National University

But as always, in niche areas there are universities apart from the research-heavy Group of Eight that do well. For example, we name Griffith University as the leading institution in the Tourism and Hospitality field. The leading researcher in this area, Susanne Becken, is also at Griffith.



Catherine Welch
International business expert, University of Sydney

Hollie Adams

We are at a turning point now. I think it is an important chance for us to stop and think about some of the assumptions that we have and [that have] probably misled us

The rise of protectionism, especially in the US, is creating some uncertainty in global markets, but has also made it an exciting time to be a researcher of international businesses.

Catherine Welch says many assumptions about the environment in which business operates – such as the liberalisation of trade and investment and the opening of borders – are now being challenged.

In the US, President Donald Trump kicked off a trade war, levying steep tariffs on foreign goods as a way to revitalise American manufacturing. The tit-for-tat retaliation of its trading partners and the interconnectedness of international supply chains means that the impacts are likely to spread everywhere.

Welch says companies around the world are trying to understand the consequences.

"We are at a turning point now. I think it is an important chance for us to stop and think about some of the assumptions that we have and [that have] probably misled us. All of us have a chance to reassess notions that we took for granted as being true."

Welch says her ambition is to help businesses and policymakers avoid being blindsided. "These events haven't come out of the blue, but of course it's very easy to miss them. And then the question is: how can we miss them? We regularly do."

"I guess what gets me up in the morning and keeps me going is a chance to try to think differently and try to get students to think differently, to look at the world in a different way," she says. "[My role] often means pushing back against the sort of simple recipes that consultants provide."

Welch's research focuses on two main areas: how Australian companies expand internationally and the internationalisation processes of high-tech start-ups.

There is little mystery about why Welch chose her career. It was a path well trodden by her parents, Denice and Lawrence Welch, both of whom are soon-to-be-retired professorial fellows at the Melbourne Business School who also specialise in international business.

"I think it's lack of imagination and inertia, as well, that you end up not that far from the tree," Welch laughs.

She says her interest in the area was spurred by events taking place during her first year studying at Monash University in 1989 – the fall of the Berlin Wall and the protests in Tiananmen Square in Beijing.

"There you were, as a student, watching the world change. I did have an advantage in that my family always thought global rather than local, but I think some of those cataclysmic events during that time when I was san undergraduate student were really the impetus."

FIONA SMITH

Erte Xiao
Economist, Monash University

Erte Xiao had set out to study traditional economics when a stroke of good timing led her into a whole new dimension. Moving from China to the US in the late '90s to do her PhD, she arrived at George Mason University in Virginia the same year as Vernon Smith, who in 2002 would share the Nobel Prize in economics with psychologist Daniel Kahneman.

Kahneman's bestselling book *Thinking, Fast and Slow* popularised his work with Amos Tversky in the new field of "behavioural economics", which upended the assumptions underpinning conventional economics.

"In the past, economists tended to be more like mathematicians, where you just do the model and you work out the math," Xiao says. "Many of those [traditional] theories and assumptions were not very intuitive for me. They usually assume people are rational, have rational expectations, always maximise their profits, etc., but of course that's not consistent with what we observe in the real world.

"Experimental economists today, instead of sitting in front of the computer building those models, go to the field; they go to the lab. Instead of mining existing data you probably purchased from some office or some government, we create our own data. We recruit participants ... and then we create simple environments that capture features of the real world. Then we say, 'How do you make those decisions in those environments?' And then we look at what extent their behaviour is consistent with economic theory and what extent it's not. If it's not, what does this mean in terms of improving the theory and better understanding human behaviour?

"I was very lucky to be able to work with the world's top scholars in this field." Xiao believes Smith went to George Mason because it was not an Ivy League institution and therefore more open to new ideas and risks.

She began studying social norms, incentives and punishment, and moved to the University of Pennsylvania, where she worked with Cristina Bicchieri, a well-known philosopher and behavioural ethicist. After a stint at Carnegie Mellon, she moved to Monash in January 2016 after hearing it "had hired a group of wonderful experimental economists" and was a supportive environment. It's a field that requires financial support as in many experiments subjects are given money to share or keep for themselves.

It's "a good question," Xiao says, as to how well lab results map to real-life conditions, and experimenters are aware that windfall money may be treated differently from hard-earned cash.

Her research topics have included altruism and charitable giving; attitudes to taxation; persistence as a better predictor of success than intelligence; and currently, a project to remove gender bias in work promotions by implementing an opt-out rather than opt-in mechanism. This edges into the territory of "nudge theory", or changing defaults to effect more socially desirable behaviour.

In experimental conditions, Xiao found that with opt-in, half as many women compete for positions as men whereas with opt-out the gap disappears. Now her team is talking to organisations to try to apply the test in the real world.

PENNY DURHAM

Aaron Francis

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- Exercise Medicine
- Neurosciences
- Nursing
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Health & Medical Sciences
Australia's Research Field Leaders

This is an area of strength for universities in Australia, where many institutions – including many outside of the research-intensive ones – do well.

Universities such as Charles Sturt (in audiology, speech and lang-uage pathology), La Trobe (in child and adolescent psychology), Griffith (in nursing as well as pregnancy and childbirth) are field leaders.

Not surprisingly, the specialist medical research institutes, such as Austin Health and Alfred Hospital, are also leading in some fields.

Some of the "research stars" who lead fields in the health and medical sciences discipline also have non-university affiliations, including with the Walter and Eliza Hall Institute, QIMR Berghofer Medical Research Institute, Neuro-science Research Australia, the George Institute for Global Health and the Murdoch Children's Research Institute.

Researchers working for the New South Wales and the South Australian governments are also chart toppers.

That said, the Group of Eight universities, which have tremendous strength in health and medical research, remain dominant in this discipline. They have well-established medical schools, most of them with deep links to large teaching and research hospitals as well as a strong network of medical research institutes. They are research powerhouses.

Field Addiction
Field leader Sharlene Kaye, UNSW
Leading institution UNSW

Field AIDS & HIV
Field leader Edwina Jane Wright, Monash
Leading institution UNSW

Field Alternative & Traditional Medicine
Field leader Anne Cusick, Uni of Wollongong
Leading institution UTS

Field Anesthesiology
Field leader André van Zundert, Uni of Qld
Leading institution Monash

Field Audiology, Speech & Language Pathology
Field leader Sharynne McLeod, Charles Sturt
Leading institution Charles Sturt

Field Bioethics
Field leader Michael Selgelid, Monash
Leading institution Monash

Field Cardiology
Field leader Dennis H Lau, Uni of Adelaide
Leading institution Monash

Field Child & Adolescent Psychology
Field leader Cheryl Dissanayake, La Trobe
Leading institution La Trobe

Field Clinical Laboratory Science
Field leader Hans G Schneider, Alfred
Leading institution SA Govt

Field Communicable Diseases
Field leader Bridget Barber, Menzies
Leading institution Uni of Melb

Field Critical Care
Field leader Christine Ball, Monash
Leading institution Austin

Field Dentistry
Field leader Ivan B Darby, Uni of Melbourne
Leading institution Uni of Adelaide

Field Dermatology
Field leader Catherine Olsen, QIMR Berghofer
Leading institution Uni of Qld

Field Developmental Disabilities
Field leader Mark Carter, Macquarie
Leading institution La Trobe

Field Diabetes
Field leader Stephen Rattigan, Uni of Tasmania
Leading institution Uni of Adelaide

Field Emergency Medicine
Field leader Naren Gunja, Uni of Sydney
Leading institution Monash

Field Endocrinology
Field leader Jeffrey D Zajac, Uni of Melbourne
Leading institution Uni of Melb

Field Epidemiology
Field leader Paul Horwood, James Cook
Leading institution Monash

Field Gastroenterology & Hepatology
Field leader Alan Wigg, SA Govt
Leading institution UNSW

Field Genetics & Genomics
Field leader Jonathan Beesley, QIMR Berghofer
Leading institution Uni of Qld

Field Gerontology & Geriatric Medicine
Field leader Jasmine Menant, NRA
Leading institution Uni of Sydney

Field Gynecology & Obstetrics
Field leader Padma Murthi, Monash
Leading institution Uni of Qld

Field Health & Medical Sciences (general)
Field leader Fiona Charlson, Uni of Qld
Leading institution Uni of Adelaide

Field Heart & Thoracic Surgery
Field leader Ajay J Iyengar, Uni of Melbourne
Leading institution Alfred Hospital

Field Hematology
Field leader David Ross, SA Health
Leading institution Monash

Field Hospice & Palliative Care
Field leader Associate Professor Joanne Bowen, Uni of Adelaide
Leading institution Uni of Melbourne

Field Immunology
Field leader Philip Hodgkin, WEHI
Leading institution Monash

Field Molecular Biology
Field leader Merlin Crossley, UNSW
Leading institution UNSW

Field Natural Medicines & Medicinal Plants
Field leader Rohan Davis, Griffith
Leading institution Uni of Qld

Field Neurology
Field leader Luca Cocchi, QIMR Berghofer
Leading institution Uni of Melbourne

Lyndon Mechielsen

Luca Cocchi
Neuroscientist, QIMR Berghofer

While neuro-disciplines have proliferated in some wild directions – neuroeconomics, neurohistory, neuropolitics – there are still many secrets of healthy and unhealthy brain function that scientists hope to reveal.

Swiss-Australian Luca Cocchi studied neuroscience at the universities of Lausanne and Geneva before coming to Australia on a postdoctoral fellowship to work in the University of Melbourne's department of psychiatry.

"I wanted to do neuroimaging, particularly to study psychosis, and at that time there were professors working in Melbourne in that area," he says. "One was Christos Pantelis, in neuroimaging, the other was psychiatrist Patrick McGorry. It was a very good choice to spend time with those people."

After his Swiss funding ran out, Cocchi moved to the Queensland Brain Institute and then, in early 2016, to QIMR Berghofer, where he heads the Clinical Brain Networks Group. His work is split between trying to understand brain processes and applying that understanding to pathologies. "We're trying to understand the fundamental principles that support brain activity and function, and using those principles to restore normal neural processes in psychiatric disorders," he says.

Cocchi focuses on brain networks and connectivity, both anatomical and functional. Using computational modelling and scanning methods such as EEG and fMRI, his team compares healthy brain network functioning to that of people with psychiatric disorders, and tries to understand the principles underlying those networks.

He also runs clinical trials using non-invasive techniques such as transcranial magnetic stimulation. TMS is already FDA-approved for treatment-resistant depression, and his team is trying it on OCD.

"The idea is to use these techniques to target specific network activity that we know [underlies] the symptoms, and try to reduce or change that so the symptoms become less strong," he says. "The advantage of what we're doing is that it's based on a mathematical model and [a neuroimaging] model of brain activity. So we have a strong neurobiological rationale, and we are able to personalise the intervention to re-establish healthy network function."

He says early results from two current OCD trials – one at QIMR and one with the Alfred Hospital and University of Melbourne – are promising. "The brain stimulation will not cure the disorder, but it will hopefully normalise things to the point where other interventions, such as behavioural, are feasible. Some patients have symptoms so severe it's almost impossible to have a conversation, so psychological interventions are not possible, and even medications are not enough."

Cocchi says there are not many researchers in Australia working in both neuroimaging and in clinical trials.

"A lot of scientists are working in silos – neurobiology or neuroimaging or clinical trials. I'm trying to build a bridge across these different dimensions, to inform a trial with strong scientific rationale and also to use pathology to help understand how the healthy brain functions."

PENNY DURHAM

Health & Medical Services continued
Australia's Research Field Leaders

Rebecca Traub
Parasitologist, University of Melbourne

If the idea of parasites makes your skin crawl, all the better, says Rebecca Traub. A good dose of disgust may be just the ticket to get more funding for her field.

Traub, who grew up in Calcutta, was not drawn to parasitology by a love of the insidious little organisms that live on bigger hosts, but through her childhood love of animals. "Every animal I had, stray or domesticated, eventually succumbed to parasitic diseases and died," she says. "So at the age of 12 I decided I wanted to become a veterinarian."

She came to Australia in 1989, did years 11 and 12 and went straight into veterinary school at Perth's Murdoch University. She worked for a while in clinical practice but decided it wasn't for her – her goal was to go back and help all those animals – so in 2000 she undertook a PhD, also at Murdoch.

Traub became involved in what is called "one health", which encompasses public health concerns such as zoonotic diseases, which transfer between animals and humans. Importantly, it includes controlling diseases not just in the human population but in their animal vectors.

She did field work in remote tea-growing communities in Assam in north-east India, and received a scholarship from Bayer Animal Health, "which was a miracle in itself. They were very interested in health and neglected tropical diseases." Her work then took her to Thailand, Cambodia and Vietnam, looking at parasites, and tick- flea- and fly-borne diseases.

A lot of her research now is developing high-throughput molecular diagnostic tools to spot known and unknown infections – because "the more you look, the more you find". Asked to name her most horrifying parasite, she cites *Macracanthorhynchus hirudinaceous*. "Look up 'thorny-headed worm'," she says. "You'll see how ugly it is. They're like reproductive sacs with heads with spines."

But her "baby" is a hookworm called *Ancylostoma ceylanicum*, the predominant hookworm in dogs in Asia and the Pacific. "When I started looking for it in humans I found it more and more, and it's now known to be the second-most common hookworm in the Asia-Pacific – we reckon about 100 million people must be infected with it." Highly prevalent in places such as the Solomon Islands, the worm has hitched a ride here inside Australian peacekeepers. Large-scale epidemiology hasn't been done for lack of funding, but recorded symptoms include bloody diarrhoea, severe abdominal pain and a rash where the larvae enter the skin.

Itching yet? "We want people's skin to crawl so we can get more attention to these neglected tropical diseases," Traub says.

Harking back to her original goal, she founded the not-for-profit organisation Tropical Council for Companion Animal Parasites in 2016. It provides best-practice guidelines, outreach, training and education to vets in the tropics to diagnose, treat and control parasites, "so that's my childhood dream coming to reality", she says.

PENNY DURHAM

Stuart McEvoy

Field Neurosurgery
Field leader Michael Morgan, Macquarie
Leading institution Uni of Melbourne

Field Nuclear Medicine, Radiotherapy & Molecular Imaging
Field leader Peter B Greer, Uni of Newcastle
Leading institution CSIRO

Field Nursing
Field leader Kath Peters, WSU
Leading institution Griffith

Field Nutrition Science
Field leader Elizabeth Dunford, George Inst
Leading institution Uni of Qld

Field Obesity
Field leader Andrew Hills, Uni of Tasmania
Leading institution Uni of Sydney

Field Oncology
Field leader Prudence A. Francis, Uni of Melb
Leading institution Uni of Melb

Field Ophthalmology & Optometry
Field leader Allison M McKendrick, Uni of Melb
Leading institution Uni of Melb

Field Oral & Maxillofacial Surgery
Field leader Andrew Heggie, MCRI
Leading institution UWA

Field Orthopedic Medicine & Surgery
Field leader Lucian Bogdan Solomon, Uni of Adelaide
Leading institution Monash

Field Otolaryngology
Field leader Raymond Sacks, Macquarie
Leading institution Macquarie

Field Pain & Pain Management
Field leader Michael Nicholas, Uni of Sydney
Leading institution Macquarie

Field Pathology
Field leader Christopher Toon, Uni of Sydney
Leading institution Uni of Sydney

Field Pediatric Medicine
Field leader Elizabeth Elliott, NSW Govt
Leading institution Monash

Field Pharmacology & Pharmacy
Field leader Roger Summers, Monash
Leading institution Uni of Qld

Field Physical Education & Sports Medicine
Field leader Kevin G Thompson, Uni of Canberra
Leading institution Uni of Qld

Field Physiology
Field leader Dirk van Helden, Uni of Newcastle
Leading institution Monash

Field Plastic & Reconstructive Surgery
Field leader David J Hunter-Smith, Monash
Leading institution Macquarie

Field Pregnancy & Childbirth
Field leader Jennifer Fenwick, Griffith
Leading institution Griffith

Field Primary Health Care
Field leader Andrew Bonney, Uni of Wollongong
Leading institution Uni of Sydney

Field Psychiatry
Field leader Ashleigh Lin, Telethon Kids Institute
Leading institution UNSW

Field Psychology
Field leader Herbert W. Marsh, ACU
Leading institution Macquarie

Field Public Health
Field leader Hidde van der Ploeg, Uni of Sydney
Leading institution Uni of Sydney

Field Pulmonology
Field leader Anthony Kicic, Telethon Kids Institute
Leading institution SA Govt

Field Radiology & Medical Imaging
Field leader Prof. Fernando Calamante, Uni of Sydney
Leading institution Uni of Qld

Field Rehabilitation Therapy
Field leader Leanne Togher, Uni of Sydney
Leading institution Uni of Qld

Field Reproductive Health
Field leader David K Gardner, Uni of Melbourne
Leading institution Uni of Adelaide

Field Rheumatology
Field leader Yuanyuan Wang, Monash
Leading institution Uni of Sydney

Field Social Psychology
Field leader Peter Jonason, WSU
Leading institution Uni of Melbourne

Field Surgery
Field leader David Watson, Flinders
Leading institution Uni of Sydney

Field Toxicology
Field leader Volker Herzig, Uni of Queensland
Leading institution Uni of Qld

Field Transplantation
Field leader Rochelle Boyd, Macquarie
Leading institution Monash

Field Tropical Medicine & Parasitology
Field leader Rebecca Traub, Uni of Melbourne
Leading institution Menzies

Field Urology & Nephrology
Field leader Joseph Ischia, Uni of Melbourne
Leading institution Monash

Field Vascular Medicine
Field leader Dianne Marsden, NSW Govt
Leading institution Monash

Field Veterinary Medicine
Field leader Priscilla F Gerber, UNE
Leading institution Uni of Sydney

Field Virology
Field leader Jason Mackenzie, Uni of Melbourne
Leading institution UNSW

Stuart McEvoy

VITAL ROLE FOR HUMANITIES

Over the past decade, developed and developing world countries alike have been producing reports and initiatives that seek to improve science, technology, engineering and mathematics (STEM) education, with research funding being directed towards priority fields that connect STEM with the development of the economy's leading sectors.

In Australia, the National Science and Innovation Agenda (NISA) articulates this strategy and, with the inclusion of medical research, we may turn STEM into STEMM – since there is no dispute about its societal and economic value. In the face of these initiatives, the humanities and social sciences (HASS) sometimes seem invisible.

This is not just an Australian phenomenon. In the US, the emphasis on STEM is just as strong, and in that fraught political landscape humanities have often been framed by some politicians as an expensive indulgence. Humanities deans have presented compelling arguments for the value of their disciplines in developing "real world" student capabilities – but what about the role of HASS research, and how can we provide support in an age of engagement and impact?

The Australian Research Council (ARC) has a long history of support for industry engagement via the Linkage scheme, which is open to all disciplines; and more recently the Industry Transformation Research Program, which includes research hubs and training centres. These are firmly linked to the priority areas of the Department of Industry, Innovation and Science, and thus seem to offer limited scope for involvement of HASS disciplines.

In the UK, Centres for Doctoral Training are equivalent to our Industrial Transformation Training Centres, but the presence of a dedicated Arts and Humanities Research Council has enabled the development of doctoral training partnerships that provide innovative research training environments connected to a wide variety of end users, including theatres, museums, media and creative arts/industries.

The ARC's engagement and impact assessment currently in progress indicates a broad understanding of industry engagement in Australia that includes end users of the HASS disciplines; so following this up with investment in research hubs and centres dedicated to supporting this HASS engagement could have tremendous societal (and economic) benefits.

But what about impact? In STEMM areas, measures can often be direct and sometimes facile, but in the HASS disciplines they are sometimes not so easy to quantify. However, search for evidence of impact and you'll find it.

At the University of Queensland (UQ), our research impact web page celebrates impact from across all disciplines, and in the "transforming societies" section you can find some wonderful examples of impactful HASS research.

Beyond the arts, where should we look for engagement and impact from HASS disciplines? UQ's director of the Institute for Social Science Research, Mark Western, recently argued in the London School of Economics impact blog that "one of the great strengths of the social sciences is their ability to systematically identify and analyse problems. In doing this they help us understand and explain the world... [but] social scientists need to recognise that problem-oriented social science needs to be complemented by more solution-oriented social science."

Professor Western suggests an approach that builds on a model developed by the University of Maryland's Ben Shneiderman in *The New ABCs of Research: Achieving Breakthrough Collaborations* (OUP, 2016).

This design thinking-inspired approach may work well in the quantitative social sciences and related areas. In the humanities, an approach that frames its research in relation to the problems facing humanity and how these problems can be solved also offers great potential benefits.

As we grapple with the effects of climate change, the emergence of artificial intelligence and the impact of medical technologies, it becomes clear that history, philosophy, political science, communication and the HASS disciplines in general are critical for meeting these challenges. This is certainly being recognised, as illustrated by Oxford University's Future of Humanity Institute, for example, and at the UQ Centre for Policy Futures.

Philosopher John Gray has observed that "technology is both a giver of good and an ongoing source of tragedy, because it is used by fallible human beings". In our rapidly changing world, the case for more investment in humanities (and social science) research is compelling. Creative solutions to contemporary and future challenges in society will most likely be met by HASS and STEMM disciplines collaborating together.

Professor Alastair McEwan
PRO VICE-CHANCELLOR (RESEARCH TRAINING) AND DEAN
UQ GRADUATE SCHOOL
UNIVERSITY OF QUEENSLAND

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Engineering & Computer Science
Australia's Research Field Leaders

This discipline joins the old and the new: the traditional engineering fields such as civil, mechanical and structural, and brand new types of engineering as well as the ever-expanding cutting edge fields that relate to computer science.

The new fields give universities outside the traditional research-heavy group a chance to shine. The University of South Australia is a leader in data mining and analysis, as well as in educational technology and a third new field, multimedia. The University of Wollongong heads the field in fuzzy systems. Curtin University is up there in both signal processing and a related field, radar, positioning and navigation. RMIT is a leader in computer security and cryptography. But go back to traditional engineering and you see that Monash University leads in civil engineering and the University of Queensland leads in mechanical engineering.

This is not to overlook the universities with traditional strengths in engineering and an earlier generation of computer science – institutions such as Monash, UNSW and the University of Queensland, which shine in these areas.

And it's not to say that the Group of Eight institutions can't also do well in new areas. The University of Queensland is a leader in bioinformatics and computational biology, and the University of Melbourne is a leader in human-computer interaction.

Field Architecture
Field leader Zhonghua Gou, Griffith
Leading institution CQU

Field Artificial Intelligence
Field leader Thanh Thi Nguyen, Deakin
Leading institution UTS

Field Automation & Control Theory
Field leader Professor Zhiyong Chen, Uni of Newcastle
Leading institution Swinburne

Field Aviation & Aerospace Engineering
Field leader Vincent Wheatley, Uni of Qld
Leading institution RMIT

Field Bioinformatics & Computational Biology
Field leader Matthew E Ritchie, WEHI
Leading institution Uni of Qld

Field Biomedical Technology
Field leader Cuie Wen, RMIT
Leading institution QUT

Field Biotechnology
Field leader Ka Yu Cheng, CSIRO
Leading institution Uni of Qld

Field Civil Engineering
Field leader Yong-Lin Pi, UNSW
Leading institution Monash

Field Computational Linguistics
Field leader Robbie Vogt, QUT
Leading institution Monash

Field Computer Graphics
Field leader Tim Dwyer, Monash
Leading institution Monash

Field Computer Hardware Design
Field leader Hai Huyen Dam, Curtin
Leading institution Uni of Adelaide

Field Computer Networks & Wireless Communication
Field leader Jinhong Yuan, UNSW
Leading institution UNSW

Field Computer Security & Cryptography
Field leader Fuchun Guo, Uni of Wollongong
Leading institution RMIT

Field Computer Vision & Pattern Recognition
Field leader David Suter, Edith Cowan Uni
Leading institution Uni of Adelaide

Field Computing Systems
Field leader Jinjun Chen, Swinburne
Leading institution Swinburne

Field Data Mining & Analysis
Field leader Jeffrey Chan, RMIT
Leading institution UniSA

Field Databases & Information Systems
Field leader Wenjie Zhang, Deakin
Leading institution QUT

Field Educational Technology
Field leader Lori Lockyer, UTS
Leading institution UniSA

Field Engineering & Computer Science (general)
Field leader Kathryn Smith, Uni of Melbourne
Leading institution Uni of Sydney

Field Environmental & Geological Engineering
Field leader Nasser Khalili, UNSW
Leading institution Curtin

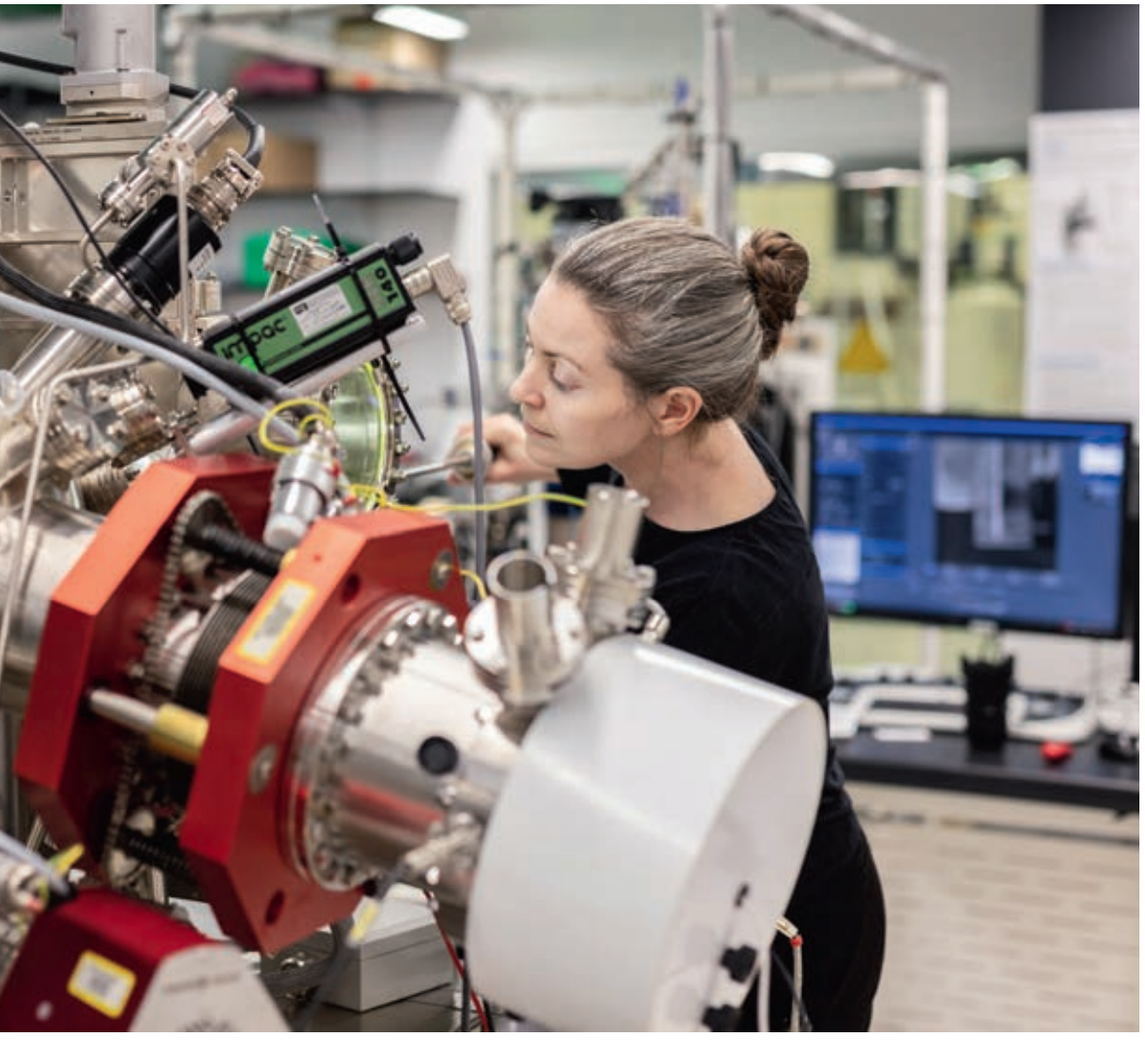
Field Evolutionary Computation
Field leader Marcus Gallagher, Uni of Qld
Leading institution Monash

Jennifer MacLeod
Nanotechnologist, Queensland University of Technology

The next generation of super-materials could be built molecule by molecule using technology being developed in a lab in Queensland.

Dr Jennifer MacLeod is a member of the Science and Engineering faculty at Queensland University of Technology. A Canadian by birth, she came to Brisbane three years ago to continue her research into the underlying science behind how so-called two-dimensional materials – substances that are just one atom thick – function at the molecular level.

"What I'm trying to do is to create a fundamental understanding that



Jeff Camden

will pave the way for new technology, rather than focusing on the technology itself," she says.

The best-known 2-D material is graphene, a form of carbon that has unparalleled strength, transparency and conductivity, but fails in one key area: it is not a semiconductor, as is required for all modern electronics.

"The main driver is to try and design new materials that are like graphene but better. Materials that are also one-atom thick and good at conducting electricity, or very transparent, or very strong but can also do other things at the same time," MacLeod says.

Historically, most device manufacturing has involved a process of refining or miniaturising. The science that MacLeod and her colleagues envision starts at the opposite end, designing and building new nanomaterials molecule by molecule, but their success will hinge on acquiring a deeper understanding of how materials behave at the atomic level, and then creating the equipment to manipulate and test them.

What I'm trying to do is to create a fundamental understanding that will pave the way for new technology, rather than focusing on the technology itself

"Our building blocks are individual molecules, and the work is to figure out how to get them to link up and then to study the product to see if we have made what we intended to make." But this comes with its own challenges.

"There is not a whole lot of instrumentation in the world that can examine the electrical properties of individual molecules, and one of the things I am doing is building new equipment so that we can understand the materials we grow in a more profound way," she says.

"We can make materials with radically different properties from anything we already know of."

TIM JOHNSTON

Field Food Science & Technology
Field leader Robyn Warner, Uni of Melb
Leading institution Uni of Qld

Field Fuzzy Systems
Field leader Gleb Beliakov, Deakin
Leading institution Uni of Wollongong

Field Human Computer Interaction
Field leader Frank Vetere, Uni of Melb
Leading institution Uni of Melbourne

Field Information Theory
Field leader Nikola Zlatanov, Monash
Leading institution Uni of Melbourne

Field Library & Information Science
Field leader Yi Zhang, UTS
Leading institution Uni of Melbourne

Field Manufacturing & Machinery
Field leader Sami Kara, UNSW
Leading institution Curtin

Field Materials Engineering
Field leader Lan Fu, ANU
Leading institution ANU

Field Mechanical Engineering
Field leader Evgeny V Morozov, UNSW
Leading institution Uni of Qld

Field Medical Informatics
Field leader Farah Magrabi, Macquarie
Leading institution Uni of Qld

Field Metallurgy
Field leader Suming Zhu, Monash
Leading institution RMIT

Field Microelectronics & Electronic Packaging
Field leader Mahdi Moosazadeh, WSU
Leading institution Griffith

Field Mining & Mineral Resources
Field leader Malcolm Powell, Uni of Qld
Leading institution CSIRO

Field Molecular Modeling
Field leader Lars Goerigk, Uni of Melbourne
Leading institution Uni of Qld

Field Multimedia
Field leader Yipeng Zhou, Macquarie
Leading institution UniSA

Field Nanotechnology
Field leader Jennifer MacLeod, QUT
Leading institution Monash

Field Ocean & Marine Engineering
Field leader Amir Etemad Shahidi
Leading institution Uni of Tasmania

Field Oil, Petroleum & Natural Gas
Field leader Reza Rezaee, Curtin
Leading institution UNSW

Field Operations Research
Field leader Damien Power, Uni of Melb
Leading institution Uni of Sydney

Engineering & Computer Science Cont
Australia's Research Field Leaders

Field Plasma & Fusion
Field leader Matthew Hole, ANU
Leading institution ANU

Field Power Engineering
Field leader Branislav Hredzak, UNSW
Leading institution RMIT

Field Quality & Reliability
Field leader Sharon Newnam, Monash
Leading institution RMIT

Field Radar, Positioning & Navigation
Field leader Jinling Wang, UNSW
Leading institution Curtin

Field Remote Sensing
Field leader Xiuping Jia, UNSW
Leading institution Uni of Melb

Field Robotics
Field leader Elizabeth Croft, Monash
Leading institution Uni of Sydney

Field Signal Processing
Field leader Yue Rong, Curtin
Leading institution Curtin

Field Software Systems
Field leader Chris Lokan, UNSW
Leading institution Monash

Field Structural Engineering
Field leader Yong-Lin Pi, UNSW
Leading institution UNSW

Field Sustainable Energy
Field leader Tania Urmee, Murdoch Uni
Leading institution UNSW

Field Technology Law
Field leader Dan Svantesson, Bond
Leading institution Griffith

Field Textile Engineering
Field leader Maryam Naebe, Deakin
Leading institution Deakin

Field Theoretical Computer Science
Field leader Serge Gaspers, UNSW
Leading institution Swinburne

Field Transportation
Field leader Alexa Delbosc, Monash
Leading institution QUT

Field Water Supply & Treatment
Field leader Tony Fane, UNSW
Leading institution UTS

Field Wood Science & Technology
Field leader Khamtan Phonetip, Uni of Melb
Leading institution Monash

Colin Murty

David Suter
Computer vision expert, Edith Cowan University

Take a one-eyed driver, David Suter says, in what sounds like the start of a bad joke. Not so: the Edith Cowan University professorial research fellow in computer vision and machine learning says such a person is living proof safe motoring is possible with the input of a single "camera". It is the quest to replicate that vision in computers and robots, to boost their ability to recognise and interact with objects in images and video, that keeps him and colleagues grinding away.

"At a subconscious level we all 'know' how we see," says Australia's most cited scientist in the Google Scholar category of computer vision and pattern recognition. "But we don't know it at a conscious level. There have to be some processes underlying that and we really have very little clue about it."

That fascination has gripped him throughout his career, although as a young man Suter found computing a bore – the late 1970s was the era of punch cards and paper clips – and chose high school science teaching for its flexibility while he pursued competitive kayaking.

When he was ready for further study the personal computer explosion was upon us and Suter was ready to take another look. He talked his way into postgraduate studies at La Trobe University and began the climb towards the elite level of science.

"I thought I'd solve it all in two or three years," he says in a wry dig at his youthful confidence in tackling computer vision. That was more than three decades ago.

A major interest for him these days is to marry scientific model-based methods (including robust statistics) that enable computers to estimate properties of images such as size, shape and motion, with the aspect of machine learning known as "deep learning", which makes it possible to identify a set of pixels in an image or frame as a car, for example, as opposed to a tree or a pedestrian.

Autonomous vehicles are only the most relatable example of what success would mean. The ripple effect would dramatically improve medical imaging, video surveillance, drones, and robot interpretation of human behaviour. "Intelligent" transport would inevitably feed into other great research themes, such as "smart" cities.

JILL ROWBOTHAM

> **At a subconscious level we all 'know' how we see, but we don't know it at a conscious level. There have to be processes underlying that and we have very little clue about it**

Research at ACU: Areas of research excellence

Top 100
THEOLOGY
QS World University Subject Rankings 2018

Top 40
SPORTS SCIENCE
ARWU Special Focus Subject Rankings 2017

Top 50
NURSING
ARWU Subject Rankings 2018

Top 75
EDUCATION
ARWU Subject Rankings 2018

Institute for Religion, Politics and Society (IRPS)

International, cross-disciplinary collaborations at IRPS address contemporary issues of religion, political conflict, and public culture.

With global expertise spanning China, USA, Europe, and Australia, our researchers investigate the interplay between religions, law, the economy, politics, and social change.

Studying the erosion of citizenship and measuring the decline of civility, along with the growth of populism, extremism, and authoritarianism across liberal democracies, IRPS aims to inform public education programs and policy debate, in order to advance knowledge of the underlying causes of public alienation from conventional political agendas, parties, and policies.

Institute for Positive Psychology and Education (IPPE)

IPPE researchers seek to understand how individuals and groups thrive.

With expertise in self-determination theory and educational psychology, the study of human motivation and behaviour is at the core of our research collaborations with government, industry, and community organisations.

The Australian Centre for Indigenous Thriving, in partnership with Indigenous and non-Indigenous researchers, the Aboriginal Education Council NSW, the Department of Health, the National Catholic Education Commission, the NSW Department of Education, and the Indigenous Affairs Group within the Department of the Prime Minister and Cabinet, examines the drivers of Indigenous success and wellbeing using evidence-based measures and curriculum that incorporate the voices and agency of Indigenous children and youth.

TAKING THE LEAD

Marked by youthful dynamism and determination, the University of Canberra has been on a unique journey since its inception. With a dual focus on producing profession-ready graduates and mission-oriented, problem-solving research, the university has risen in just a quarter of a century to rank among the world's top 100 universities under the age of 50 and sits in the top 2 per cent of universities overall.

Our success and impact have come from the courage to take risks, make considered choices, and forgo the temptation to follow the prevailing standards and attitudes of our contemporaries. Throughout our history, we have challenged orthodoxy and boldly traced our own distinctive path, leading the way into uncharted territories and staying the course against significant headwinds.

We pride ourselves on being a beacon of equity, diversity, inclusion and access. Ground-breaking discoveries by our researchers have spawned commercial, advisory and social enterprises. Our 84,000 alumni hold influential positions in public and private sectors in 128 countries.

It is from this bedrock that the University of Canberra is now launching the next phase of its audacious journey as a leader in pragmatic learning, impactful research and sustainable living. The next decade will see the university grow and evolve into a confluence of scholars, learners, innovators, practitioners and enablers.

Are you one of them? We're looking for exceptional academics to tell us where they fit in our bold vision for the future.

Our unique campus, which is undergoing a significant transformation in preparation for the way students will learn in the future, serves as an interactive and connected hub from which our global presence extends to all corners of the globe. Our location is pivotal to our close relations with the diplomatic community and a key catalyst for our worldwide engagement.

Anchored as a leading institution in Australia's capital, we occupy a ringside seat at national debates and in decision-making, frequently informing and influencing deliberations as a powerful engine of economic development, social wellbeing, creative thought and public discourse.

None of this would be possible without our people, our most treasured asset. Our success has been shaped by the ingenuity of our people, who are the primary means through which we will deliver on our commitment – a commitment to delivering excellence in our core missions of teaching, learning, research, scholarship, innovation and public engagement.

As we enter this period of growth and transformation, we are seeking academic and professional leaders with unbridled potential to boldly take the lead in redefining the value and function of our university of the future.

If you are a bright, energetic, out-of-the-box thinker seeking a distinctive environment in which to flourish, we want to hear from you. The University of Canberra is where you come to build an enduring and adaptive career in an inclusive environment, to breathe oxygen into your creative passions, and to unleash your ingenuity to solve real-world problems.

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Professor Deep Saini
VICE-CHANCELLOR AND PRESIDENT
UNIVERSITY OF CANBERRA

Chemical & Material Sciences
Australia's Research Field Leaders

This discipline has only 14 fields in Google Scholar's taxonomy, which is probably a reflection of how many areas that are highly reliant on chemistry-related fields have migrated to other areas of science.

Nanotechnology, metallurgy and molecular modelling are part of engineering and computer science. But in the areas still considered part of chemistry and material science, the University of Queensland shines. It is a leader in dispersion chemistry, electrochemistry, inorganic chemistry and medicinal chemistry.

When it comes to individual researchers who are leaders, the universities outside the Group of Eight assert themselves. For example, the University of Tasmania's Michael Breadmore leads in analytical chemistry and La Trobe's Marc Kvansakul leads in biochemistry. And the federal government's Australian Nuclear Science and Technology Organisation has a leading researcher in crystallography and structural chemistry.

Field Analytical Chemistry
Field leader Michael Breadmore, Uni of Tasmania
Leading institution Uni of Tasmania

Field Biochemistry
Field leader Marc Kvansakul, La Trobe
Leading institution UNSW

Field Ceramic Engineering
Field leader Tesfaye Tadesse Molla, Uni of Melb
Leading institution UNSW

Field Chemical & Material Sciences (general)
Field leader Huaiyong Zhu, QUT
Leading institution Uni of Adelaide

Field Chemical Kinetics & Catalysis
Field leader Xiaoguang Duan, Curtin
Leading institution Monash

Field Combustion & Propulsion
Field leader Evatt R. Hawkes, RMIT
Leading institution UNSW

Field Composite Materials
Field leader Adrian Mouritz, Uni of Sydney
Leading institution RMIT

Matthew Netwon

Michael Breadmore
Analytical Chemist, University of Tasmania

Professor Michael Breadmore trained in analytical chemistry, but he has used that as a launch pad to extend his expertise into engineering, pharmacology, environmental sciences and beyond to develop cheap and elegant solutions to some of our most pressing social, medical and environmental problems.

Breadmore's speciality is developing so-called "lab on a chip" technology – devices that can detect chemicals in the environment, allowing almost real-time monitoring of potential problems such as explosives, pollution, or the efficacy of medicines for patients.

His first commercialised product plugs a gaping hole in security screening. The explosives scanners commonly seen in places such as airports are very effective at detecting commercial explosives but less useful in pinpointing the sort of explosives that can be made at home. The GreyScan system developed by Breadmore and his collaborators solves this problem by detecting soluble explosives picked up by swabbing clothing or luggage.

GreyScan is an example of what he calls "taking research out of the lab and putting it in the hands of ordinary people". This means overcoming not just scientific constraints, but also engineering and commercial limitations.

"We can engineer a solution, but it's probably going to be very complicated and very expensive. Or we could create a chemistry solution that is going to require someone in their home to do five different things, which means that it is not going to be useful," he says. "But by engineering something differently and combining that with doing chemistry differently, we can come up with something that will allow that single drop of blood or that milk sample to →

Chemical & Material Sciences Cont
Australia's Research Field Leaders

Field Crystallography & Structural Chemistry
Field leader Yingjie Zhang, ANSTO
Leading institution Monash

Field Dispersion Chemistry
Field leader Piotr Kowalczyk, Murdoch Uni
Leading institution Uni of Qld

Field Electrochemistry
Field leader Jiazhao Wang, Uni of Wollongong
Leading institution Uni of Qld

Field Inorganic Chemistry
Field leader Philip C Andrews, Monash
Leading institution Uni of Qld

Field Medicinal Chemistry
Field leader Telukutla Srinivasa Reddy, RMIT
Leading institution Uni of Qld

Field Organic Chemistry
Field leader Rohan Davis, Griffith
Leading institution Uni of Newcastle

Field Polymers & Plastics
Field leader Michael Monteiro, Uni of Qld
Leading institution Monash

Marc Kvansakul
Biochemist, La Trobe University

At a molecular level, the progress of an infection is a long chain of biochemical reactions. For the past 14 years La Trobe University's Dr Marc Kvansakul has been successfully identifying the weakest links in that chain and finding ways to break them.

"What I want to understand is, how do pathogens take cells over and how do we fight them off?" says Kvansakul.

In 2014, he was part of the team that discovered the critical role played by phospholipids on the membranes of unwelcome pathogens in triggering the body's defence mechanisms.

Since then he has focused on a very particular aspect of the way pathogens such as viruses and fungi neutralise some of our most basic cellular defence mechanisms.

"One of the first things that happens when a virus gets into a cell is that the cell triggers a regulatory program called programmed cell suicide, to ensure that the virus gets killed along with the cell and stops the infection spreading," he says.

Viruses can subvert this mechanism, allowing them to spread throughout the body. But, says Kvansakul, "If you neutralise the virus's ability to hijack some of the cell signalling, then they can no longer establish an infection."

His research fits in with a broad modern trend of trying to find ways to make our natural defence mechanism more effective against infection and disease, rather than mounting direct attacks.

"The areas I look at all deal with some very fundamental defence mechanisms that hosts use," he says.

TIM JOHNSTON

Continued from previous page

be analysed directly – you hit a button and you come up with an answer in a minute or two."

The GreyScan system was developed in collaboration with law enforcement, but Breadmore says that his interest is turning more towards solving some of the larger, more long-term problems facing society, particularly the environment.

"A lot of my research is shifting to a more environmental focus," he says. "I think purely commercial interests are great, but I think there is perhaps a higher calling to ensure that our environment is protected and preserved for the future and there have to be commercial solutions."

To that end, he is developing technology for real-time testing of water quality. It's a passion that is close to Breadmore's heart: he is a native Tasmanian who hiked regularly in the island's wildernesses before his range was curbed by the logistics of bringing along a young family.

He says he likes hard problems.

"If you want to put a system in the water that is going to last for three months, it's got to be durable and cheap. Taking a laboratory instrument that might cost $100,000 and making that for $200, that's robust and reliable in the field for three months, poses really hard problems."

One of the most prolifically published Australian researchers in respected academic journals, Breadmore believes that scientists like him need to keep their eyes on bigger goals than mere science.

"I think there is a growing realisation, particularly in universities and by academics, that that next paper is not as important as creating something that is going to deal with our energy challenges, for example, or provide clean water and food to ensure our survival," he says.

This view has informed much of his other work, including the affordable hemaPEN system that allows ordinary people to collect blood samples at home and then preserves them long enough for them to be mailed to a laboratory; and the technology for hospitals and doctors to measure pharmaceutical levels in blood in real time.

"Rather than being focused on what we do and what we want to do, it is more about trying to reach those larger end goals to make a piece of technology or a method that can change how somebody lives their life," he says.

TIM JOHNSTON

Stuart McEvoy

ACHIEVING RESEARCH EXCELLENCE

Five years ago, Australian Catholic University (ACU) developed a research intensification strategy that has sought to achieve research excellence through concentrated investment in areas of strategic priority, all of which support our overarching commitment to social justice and the common good.

These areas of research priority – health, education, theology and philosophy – align strongly with our institutional mission as a Catholic university and with the profile of our institution. That profile is distinctive in the following ways:

– our significant enrolments in health, as we have the largest enrolments in nursing and midwifery courses in Australia

– our significant enrolments in education, as we have the largest enrolments in teacher education courses in Australia

– our commitment to theology and philosophy from ancient times through to the contemporary period, which brings with it a broader commitment to the humanities and social sciences.

Stuart McEvoy

The implementation of this research strategy involved the establishment of research institutes in our key priority areas, charged with the responsibility for driving our research performance by attracting world-leading researchers.

These researchers ensure that others partner with us, and that we can remain at the forefront of scholarship in a global knowledge era and deeply connected to world-leading institutions.

Key to our research development is the range and strength of the partnerships we have developed to build our research. As a national university with campuses in Adelaide, Ballarat, Brisbane, Canberra, Melbourne and Sydney (North Sydney and Strathfield), we benefit from the opportunity to collaborate with health, education, and church authorities across Australia.

In terms of international collaboration, a key development has been the establishment of our Rome Campus, which has succeeded in facilitating international research collaboration. Seminars hosted, for example, by our Institute for Religion and Critical Inquiry have significantly strengthened partnerships with overseas scholars and universities.

With six seminars each year, and each held over several days, the institute has gathered together major scholars to focus on research topics designed to address major issues and shape thinking in the relevant field. Multi-volume publications from these seminars are produced by leading scholars in the field, including a soon-to-be launched series with Cambridge University Press.

The outcome of these collaborations has lifted ACU to a ranking among the top 100 universities in the world for theology, divinity, and religious studies[1] with, not surprisingly at this stage in our development, much stronger ratings in the publication metrics than in the reputation metrics.

In rankings based only on research indicators we rank in the top 50 in the world in nursing[2] and in sports sciences[3], and in the top 75 in the world in education[2].

Our research growth is not only being recognised in international rankings, but also by peer recognition. We have been invited by the directors of the Australian Research Council (ARC) Centre of Excellence for the History of Emotions to develop a new node within the centre, which has received funding from various sources to continue its interdisciplinary research into the history of individual and communal emotions in Europe. We welcome the opportunity to contribute to this outstanding centre and trust that our distinctive strengths will add to the value of its work, especially through our research in early Christianity and late antiquity, our emerging program in medieval and early modern studies, and the study of emotions from the perspective of the constructive study of religion and philosophy, including moral psychology.

Our research intensification in theology and philosophy necessarily extends into related disciplines, ensuring that we continue to achieve research excellence through strategic partnerships and international collaborations across the humanities and social sciences.

In 2021 we will host the 78th annual conference of the Studiorum Novi Testamenti Societas (SNTS), the world's most prestigious society in the field of New Testament studies. The conference at our Melbourne Campus will be just the fourth held outside Europe and North America in the society's history. The decision by the committee and membersof SNTS to accept our invitation testifies to our growing reputation as an international hub of research excellence in this field.

Professor C.W.F. McKenna
DEPUTY VICE-CHANCELLOR, RESEARCH
AUSTRALIAN CATHOLIC UNIVERSITY

1. QS World University Rankings by Subject 2018
2. Academic Ranking of World Universities (ARWU) Subject Rankings 2018
3. Academic Ranking of World Universities (ARWU), Special Focus Institution Ranking of Sport Science Schools and Departments 2017

Sydney Research

The next level of health and medical research

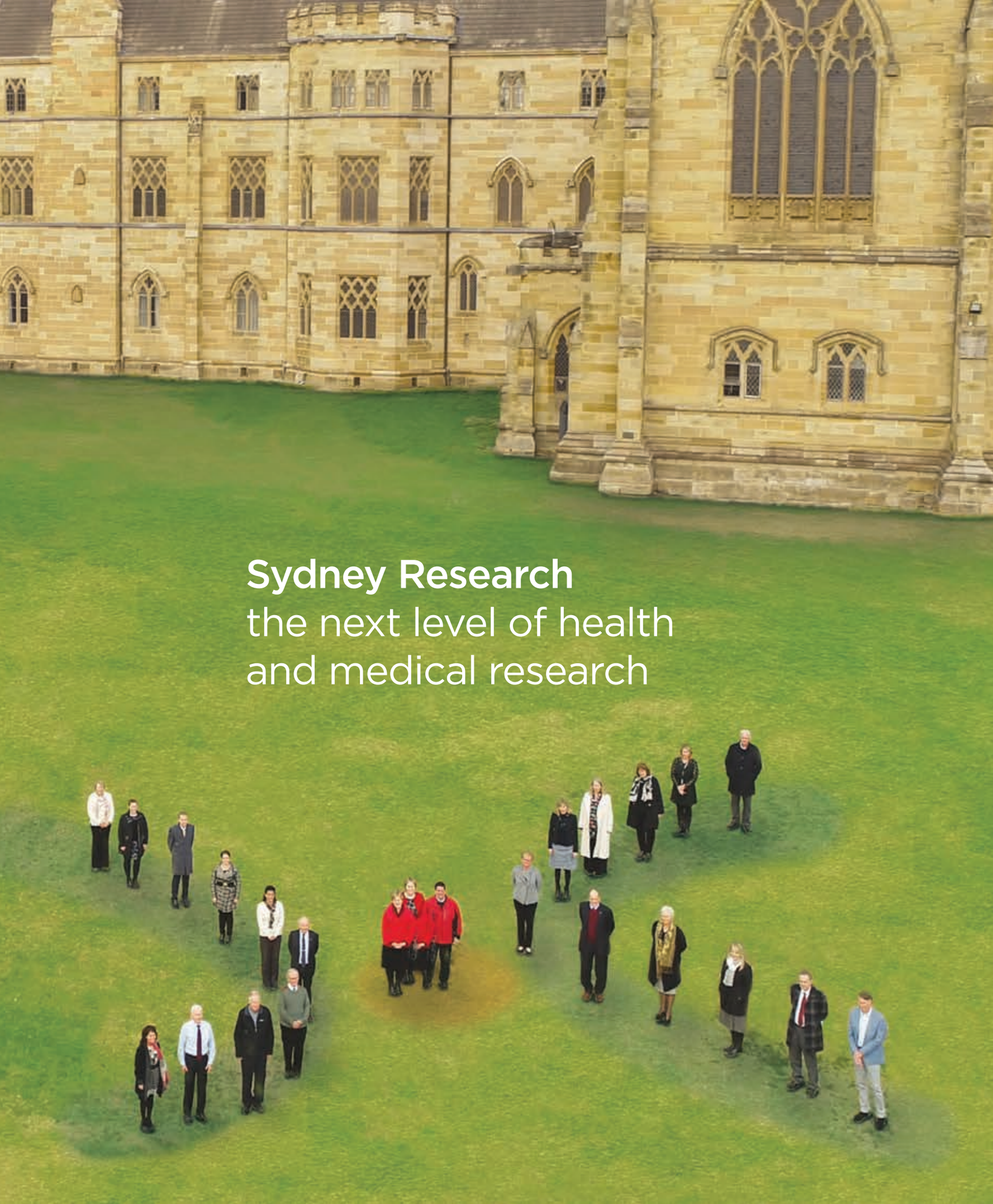
Sydney Research is a unique cluster of established, world-class health and medical research institutions in the heart of Australia's largest city.

With ready access to a diverse population base for recruitment to clinical trials, together our translational research potential continues to thrive.

We are better, stronger and smarter together.

Our partners

ANZAC Research Institute
Chris O'Brien Lifehouse
NHMRC Clinical Trials Centre
ADRI
Collaborative Centre for Cardiometabolic Health in Psychosis
RPA Institute of Academic Surgery
The Baird Institute
The George Institute for Global Health
SOuRCe Surgical Outcomes Research Centre
Centenary Institute research for life
HRI Heart Research Institute
NSW Government Health Sydney Local Health District
The University of Sydney
cera
phn Central and Eastern Sydney An Australian Government Initiative
Woolcock



Sydney Research
the next level of health and medical research

Humanities, Arts & Literature
Australia's Research Field Leaders

Field African Studies & History
Field leader Ceri Shipton, ANU
Leading institution Charles Sturt

Field Asian Studies & History
Field leader Vedi Hadiz, Uni of Melb
Leading institution Uni of Melb

Field Chinese Studies & History
Field leader James Leibold, La Trobe
Leading institution Uni of Melb

Field Communication
Field leader Kristy Hess, Deakin
Leading institution QUT

Field Drama & Theatre Arts
Field leader Joanne Tompkins, Uni of Qld
Leading institution UniSA

Field English Language & Literature
Field leader Graham Parr, Monash
Leading institution Uni of Qld

Field Epistemology & Scientific History
Field leader Adrian Currie, ANU
Leading institution ANU

Field Ethnic & Cultural Studies
Field leader Greg Noble, WSU
Leading institution WSU

Field Feminism & Women's Studies
Field leader Chris Beasley, Uni of Adelaide
Leading institution Monash

Field Film
Field leader Ted Nannicelli, Uni of Qld
Leading institution Curtin

Field Foreign Language Learning
Field leader Neomy Storch, Uni of Melb
Leading institution Curtin

Field French Studies
Field leader Philip Dwyer, Uni of Newcastle
Leading institution Uni of Canberrra

Field Gender Studies
Field leader Alison Pullen, Macquarie
Leading institution Uni of Sydney

Field History
Field leader Gary B. Magee, Monash
Leading institution ANU

Field Humanities, Arts & Literature (general)
Field leader Melinda Cooper, Uni of Sydney
Leading institution Monash

Field Language & Linguistics
Field leader Evan Kidd, ANU
Leading institution Curtin

Field Literature & Writing
Field leader Chris Danta, UNSW
Leading institution ANU

Field Middle Eastern & Islamic Studies
Field leader Serdar Kaya, Uni of Qld
Leading institution Griffith

Field Music & Musicology
Field leader Adrian North, Curtin
Leading institution Curtin

Field Philosophy
Field leader Toby Handfield, Monash
Leading institution Macquarie

Field Religion
Field leader Lindsay B. Carey, La Trobe
Leading institution Uni of Melbourne

Field Sex & Sexuality
Field leader Amy D. Lykins, UNE
Leading institution UNSW

Field Visual Arts
Field leader DJ Huppatz, Swinburne
Leading institution Charles Darwin

Our methodology gives the humanities, arts and literature far more space than they receive in most of the traditional university ranking systems, which are science and technology orientated. This flows from our decision to use Google Scholar's taxonomy, which pays far more attention to this discipline than the main systems commonly used to index academic research.

For this reason we are able to list leading researchers and research institutions in fields as various as drama and theatre arts (leader is the University of South Australia); feminism and women's studies (leader is Monash University); history (leader is the Australian National University); philosophy (leader is Macquarie University); film (leader is Curtin University); and sex and sexuality (leader is UNSW).

Adrian North
Musicologist, Curtin University

Being a "rubbish" bass player in a succession of rock bands in and around Manchester in 1990s only whetted Adrian North's appetite for a career in musicology.

"There are only so many times you can get booed off stage, or go with a smattering of applause, before you start to think, 'Hang on, what's going on there? Why don't they like me?'" says North, now a professor and head of Curtin University's school of psychology and speech pathology.

Recognising that that seems harsh, as well as counter-intuitive, he revises his musical self-assessment to "at best, average".

However, he sticks with the point, which is this that, together with endless shifts stacking shelves at the local supermarket over Christmas 1988, with Bing Crosby's *White Christmas* on a loop, that early experience was enough to propel him into a permanent state of curiosity about what people respond to in music.

"'I need to do this one day', I thought. And 'What's going on? why are they playing this and what effect is it having, not just on the customers but on the staff?' All that eventually found its way out in print."

That's a reference to his many academic papers, whose success underpins his distinction as Australia's most cited researcher in music and musicology, according to Google Scholar.

Top of his greatest hits list, with 725 citations, is 2000's "The importance of music to adolescents", which found that more than half of English 13 and 14 year olds either played or had played a musical instrument regularly; and that they listened to music for 2.45 hours per day, mainly as means of "expressing one's identity to other people". North still finds it curious that this trumped simple enjoyment as a motivator.

Other papers that did well include

Colin Murty

> **Given that we have 40 million tracks in our back pockets, you'd expect people's musical taste to become more niche, not just focused on the mainstream**

2004's "Uses of music in everyday life" (472 citations), but he is candid about the one that made his name: 1997's "In-store music affects product choice" (217), which appeared in the journal *Nature*.

"I did that paper in the 12 months after the PhD and that's what set me up. At that time it caught a lot of attention, which was very helpful for a new researcher."

The longer-form version, 1999's "The influence of in-store music on wine selections" also did well (505). It found that customers who heard French music playing from a display stand near the beer, wine and spirits aisle of the supermarket were predisposed to buy French wine, and playing German music produced similar results. "It's a simple, straightforward priming effect," he says. "We just applied it to music."

In the past five to 10 years, it's all been about the technology for North, who vividly remembers lugging bags of cassette tapes to university to play on his Walkman, then state of the art. Now, it's streaming services. "Psychologically it's a big time in music research," he says. "The historical model has been that the composer would compose something, pass this through a filter of some sort – a benefactor or a record label – and it would be released on a limited scale to a public who had no choice but to pay a reasonably large amount of money for it, or listen to what was served up to them on the radio."

The business model now favours listeners who can stream whatever they like, whenever and as often as they wish, for comparatively little cost, rendering music "an active resource". No longer hostage to the system, they are served by it.

"We listen to music these days through headphones, not through loudspeakers," North says. "Where we're going with these streaming services is towards increased personalisation."

A rich seam of new research will be on "how individual differences play a part in this. Given we have 40 million tracks in our back pockets, you'd expect people's musical taste to become more niche, not just focused on the mainstream".

So far, a study of 36,000 Americans rating 104 styles of music has revealed nuggets such as that "people more open to experience tend to favour high art styles, whether classical, opera or modern, while those less open favour mainstream music like the Top 40 hits".

Which brings us to North's own preferences. With all those tracks to choose from, what are his favourites? "The Beatles and The Stone Roses, The Smiths, New Order. – the music of his Manchester youth.

JILL ROWBOTHAM

Melinda Cooper
Sociologist, University of Sydney

When she was in her twenties and working in a casual job, Melinda Cooper could afford to live independently, renting a two-bedroom flat in Sydney. That was in the 1990s. Today, almost one in three adults under the age of 35 still live at home.

Cooper, an associate professor in the Faculty of Arts and Social Sciences at the University of Sydney, says her students often question the value of their student loans.

"When I talk to my students, they are weighing up if it is worth it," she says. They are racking up a significant debt for their education, and hoping to establish themselves at a time when jobs are often insecure and house prices are unaffordable.

Cooper says the root cause of their situation is a political philosophy that is loading up families with responsibility for the welfare of adult family members.

Over 40 years, governments around the world have been cutting social programs, transferring responsibility to families to pay for the private education of their children, taking on university debts, supporting them in unemployment and paying for private healthcare.

Cooper says the political force behind this is a collaboration of neoliberals (who emphasise personal responsibility) and social conservatives (the moral importance of family). These philosophies cut across party lines.

"The consequence is that young people have a lot of trouble moving out of home. They don't have an independent income that will allow them to go to university, they need the income support of their family," she says. "If they want to get on the housing ladder they will need support from their parents.

"Young adults are pushed back towards the family," says Cooper, who last year published a book on the subject: *s* (mitpress.mit.edu/books/family-values).

These arrangements discriminate against those who have families who can't, or won't, support them, and those who have no family.

Cooper is now undertaking research with colleagues Professor Lisa Adkins and Associate Professor Martijn Konings to examine the connection between rising inequality and rising house prices.

"We're seeing this return of inherited wealth as something that has again become absolutely central in shaping people's opportunities in life. This is a disturbing development if you consider that, for a very long time, people just assumed that we were moving away from these kind of societies – based on family wealth and inherited status – and the kind of natural course of progress was to move toward a situation where you earned your way in life, where your skill or your merit would be the major factor in your social mobility."

FIONA SMITH

RESEARCH BRINGS HOPE

As Australia transitions to an ideas economy, the development and commercialisation of research, clinical practice and innovation will be paramount in the nation's ongoing economic success.

Investing in innovation is best harnessed through the development of dedicated precincts centred on the catalytic institutions of science, health, education and technology.

The Sydney Research Precinct is unique in its clustering of established, world-class institutions located in the heart of a major international city.

It was this unique proximity of more than a dozen medical research institutes in a relatively small geographic area, anchored by the twin heavyweights of Sydney Local Health District's Royal Prince Alfred Hospital (RPA) and the University of Sydney, that underpinned the creation of Sydney Research in 2013.

At Sydney Research, our mission is to be Australia's leading translational research entity, converting discoveries into better health for the people of Sydney, Australia and the world.

We are uniquely positioned to translate scientific and health-related innovations into real world health gains. RPA is one of Australia's premier tertiary and quaternary referral hospitals. Since its foundation more than 135 years ago, it has had a record of pioneering innovative techniques and treatments, including Australia's first aortic valve replacement, first liver transplant and first nuclear medicine department, among many others.

In 1884, the first 14 medical students from the university were accepted, establishing RPA as the first teaching hospital in NSW. This collaboration has endured and prospered, and is one of the most significant health-related partnerships in the history of Australia.

Sydney Research holds another key advantage over other comprehensive research centres and precincts: our researchers, scientists, clinicians and staff have ready access to a diverse community and population base for recruitment to clinical trials.

RPA's location in the heart of the precinct provides the perfect environment for translational research to thrive. In addition to the Camperdown precinct, two medical research institutes are co-located with Concord Hospital – internationally recognised for its innovative treatment of burns, geriatrics and cancer.

Beyond our precinct, Sydney Research plays a pivotal role in Sydney Health Partners (SHP), one of the first four Advanced Health Research and Translation Centres in Australia.

Translating basic research to clinical applications at earlier stages greatly enhances the opportunities for products, systems, models of care and programs to be rolled out and commercialised, attracting private sector and industry investment and maximising the return on investment, as well as making a real difference to the health of our patients and community.

In 2016-2017, Sydney Research was awarded a total of $97 million in competitive category one grants, produced 5500 publications and supported 934 higher degree research students. Across and within the District, more than 550 clinical trials are currently under way, including stage I and II trials.

In just two years, our flagship Big Idea program has provided a springboard for three promising researchers to win grants of up to $1.5 million through the NSW Medical Devices Fund.

The Sydney Research Council provides oversight and coordination while maintaining the brands and heritage of its members: the District, The University, ANZAC Research Institute, Asbestos Diseases Research Institute (ADRI), Baird Institute, Brain and Mind Centre (BMC), Central and Eastern Sydney PHN, Centenary Institute, Centre for Education and Research on Ageing (CERA), Charles Perkins Centre (CPC), Chris O'Brien Lifehouse, Collaborative Centre for Cardiometabolic Health in Psychosis (ccCHiP), The George Institute for Global Health, Heart Research Institute (HRI), NHMRC Clinical Trials Centre, RPA Institute of Academic Surgery (IAS), RPA Surgical and Robotic Training Institute, Surgical Outcomes Resource Centre (SOuRCe) and Woolcock Institute of Medical Research.

We have a governance framework regarding intellectual property that facilitates the sharing of benefits of ownership and commercialisation of IP generated. Our medium-term focus is to identify a space where we can co-locate several medical research institutes.

Proximity can support collaboration, but co-location takes this a step further: sharing big data, technology platforms, programs, staff, governance and infrastructure to create one consistent experience for clinicians, researchers, patients, consumers and students across and within the precinct.

Sydney Research is at the cutting edge of translational research as healthcare adapts to the major pressures and challenges of significant population growth, ageing populations, diversity, lifestyle risk factor prevalence, the rising incidence of chronic diseases, the changing nature of health service delivery, workforce recruitment and retention, ageing infrastructure, rising costs and funding challenges.

In my 40 years as a clinician and health executive, I have seen first-hand the value of collaborative research and the life-changing outcomes for our community. Most importantly, research brings hope.

We are better, stronger and smarter together. Sydney Research: the next level of health and medical research.

Dr Teresa Anderson AM
CHIEF EXECUTIVE,
SYDNEY LOCAL HEALTH DISTRICT
CHAIR, SYDNEY RESEARCH

Physics & Mathematics
Australia's Research Field Leaders

Field Acoustics & Sound
Field leader Nicole Kessissoglou, UNSW
Leading institution UNSW

Field Algebra
Field leader Andrew Mathas, Uni of Sydney
Leading institution Uni of Wollongong

Field Astronomy & Astrophysics
Field leader Julia Bryant, Uni of Sydney
Leading institution Uni of Sydney

Field Computational Mathematics
Field leader Frances Y. Kuo, UNSW
Leading institution UNSW

Field Condensed Matter Physics & Semiconductors
Field leader Dimitrie Culcer, UNSW
Leading institution UNSW

Field Discrete Mathematics
Field leader Daniel Horsley, Monash
Leading institution Monash

Field Electromagnetism
Field leader Pei-Yuan Qin, UTS
Leading institution UTS

Field Fluid Mechanics
Field leader Mark Thompson, Monash
Leading institution Uni of Melbourne

Field Geometry
Field leader Stephan Tillmann, Uni of Sydney
Leading institution Monash

Field Geophysics
Field leader Brian Kennett, ANU
Leading institution ANU

Field High Energy & Nuclear Physics
Field leader Michael Schmidt, Uni of Sydney
Leading institution Uni of Sydney

Field Mathematical Analysis
Field leader Yihong Du, UNE
Leading institution UNE

Field Mathematical Optimisation
Field leader Vaithilingam (Jeya) Jeyakumar, UNSW
Leading institution UNSW

Field Mathematical Physics
Field leader Ian Marquette, Uni of Qld
Leading institution Uni of Sydney

Field Nonlinear Science
Field leader Tonghua Zhang, Swinburne
Leading institution Swinburne

Field Optics & Photonics
Field leader Stephen Madden, ANU
Leading institution Uni of Sydney

Traditionally it's the research-intensive Group of Eight universities that do well in this area, particularly because of the expense of the research equipment used in physics, and the fact that a quality mathematics department is some thing on which every leading research university prides itself.

But while the Group of Eight is well represented, the University of Wollongong is a leader in algebra and the University of New England is a leader in mathematical analysis.

That said, in the main the big research universities dominate, leading in fields such as geophysics and quantum mechanics (the Australian National University); fluid mechanics (the University of Melbourne); thermal sciences; and spectroscopy and molecular physics (the University of Queensland).

In a blockbuster performance, UNSW is a leader in four fields: acoustics and sound; computational mathematics; condensed matter physics and semi-conductors; and mathematical optimisation.

Interestingly, most of the universities that lead in the physics and mathematics discipline also have the leading researcher in the field working for them.

Field Physics & Mathematics (general)
Field leader David Blair, UWA
Leading institution ANU

Field Probability & Statistics with Applications
Field leader Malwina Luczak, Uni of Melb
Leading institution Uni of Sydney

Field Pure & Applied Mathematics
Field leader Daniel Horsley, Monash
Leading institution Monash

Field Quantum Mechanics
Field leader Murray K Olsen, Uni of Qld
Leading institution ANU

Field Spectroscopy & Molecular Physics
Field leader Darryl Jones, Flinders
Leading institution Uni of Qld

Field Thermal Sciences
Field leader Associate Professor Xiaolin Wang, Uni of Tasmania
Leading institution Uni of Qld

Nicole Kessissoglou
Physicist, UNSW

Two decades ago, Nicole Kessissoglou considered taking a job with the Defence Science and Technology Group but decided to remain in academia instead.

Now the career of the University of NSW professor of mechanical engineering has come full circle, with her leading work in acoustics and sound being drawn on by the government's DST to help develop stealth capability in submarines.

Kessissoglou's work focuses on developing predictive capabilities in acoustics and vibration, mainly with application to maritime defence.

In layman's terms, she is looking at the noise and vibrations made by submarines. There are three sources of noise. First is the noise directly radiated from the propeller; the second is from the way the submarine vibrates due to the propeller and other onboard machinery; and finally there is the sound and vibration from the submarine moving through the water.

Kessissoglou started working on the second problem and people in the research group she leads are working on the others. "We're trying to add more pieces of the jigsaw to the overall picture, but it's complicated," she says.

In fact, rather than examining an entire submarine, the researchers look at simplified models and parts, such as cylinders, plates spheres and air foils.

Her work is being used to develop models that allow researchers at DST to predict how different designs and submarine parts will affect the noise. Previous models would require a supercomputer and take months to solve, but the new models are slikely to be much faster.

"What we're trying to do is provide a numerical capability and a simplified model that allows you to run what-if scenarios, so you can do, 'What if you change the flow conditions? What if you change the design?'" Kessissoglou says.

"You can run these models in a matter of weeks and even days, and not even on a supercomputer." →

Nicole Kessissoglou

Continued from previous page

DST provides funding for her work and uses it to help design submarines with stealth capacity – those that can move through the water more quietly and so are harder to detect.

Kessissoglou's career path began when she enrolled in mechanical engineering at the University of Western Australia because she wasn't sure what else to do and it sounded intriguing.

In her third year, she took a subject called vibrations. "I enjoyed it and found I could understand it easier than my other courses," she says. "I pursued my final-year thesis project and eventually my PhD in structural vibration.

Then when she started working at UNSW she was required to teach an acoustics course, which led to her current research.

"I'm always learning," she says, adding that venturing into a new topic is fascinating. "When we can report something new, it is very rewarding."

Kessissoglou's work is looking at the three sources of submarine noise in isolation from each other. Eventually researchers will start looking at how they interplay, but it won't be any time soon, she says.

"I'll be retired before you even get there. It's really baby steps – very, very incremental steps."

It's an indication of how much more there is to discover in her field.

"We start off with a new project and we really don't know the end – that's what I try and say to my PhD students," she says. "You start a research project, it's going to for three or three and a half years, and it's not mapped out every month.

"You might not know what you're going to be doing in the next few months, because you might get some really interesting results and then that'll take you in a different direction from what you originally planned."

CHRISTOPHER NIESCHE

Darryl Jones
Molecular physicist, Flinders University

Darryl Jones spends his days examining the movement of molecular particles with a spectrometer and gathering data used to develop more effective radiation therapies.

A research fellow at the College of Science and Engineering at Flinders University in South Australia, he describes his field as trying to understand where energy and/or atoms exist in molecules and how much energy is shared between the electrons moving around in a molecule, and how they interact with their environments.

Radiation therapy works by putting high-energy particles – known as free electrons – into a biological system to ionise cells. This is effective in destroying cancer but it can also destroy healthy cells, and this is the problem Jones is working on.

"We're trying to provide the essential data needed to understand the complex processes that are occurring when you're exposing living systems to radiation, because the biological medium is made up of many different parts – you've got DNA, you've got water," he says.

"We want to understand how the incident particles are interacting with each of those different components, so that you can then understand the complete picture of what's happening when you're exposed to the radiation."

A leader in the field of spectroscopy and molecular physics, Jones says he developed his interest in molecular physics when he started his science degree and became interested in how physical principles could be used to control chemistry.

"I like the idea of being able to control a process. For me, it's about how can we understand molecules and then get them to behave in a way or control their behaviour in certain environments," he says.

Jones is also working on plasma environments, a state of matter where free electrons and ions move around that has potential for better wound sterilisation and breaking down bacteria.

CHRISTOPHER NIESCHE

Hollie Adams; Kelly Barnes

Australian Government

Department of Defence
Science and Technology

Innovating for Defence capability through collaboration in Science and Technology

Defence's science and technology team is harnessing the brightest talents in Australia's industry to find next generation solutions and deliver a capability edge.

DST's Unmanned Underwater Vehicle under development at Ron Allum Deepsea Services.

DST | Partner and Prosper

Australian Government
Department of Defence
Science and Technology

NEXT GENERATION TECHNOLOGIES
FOR THE AUSTRALIAN DEFENCE FORCE

AUSTRALIAN COMPANIES AND UNIVERSITIES ARE PARTNERING WITH **DEFENCE SCIENCE AND TECHNOLOGY** ON RESEARCH AND DEVELOPMENT TO DELIVER GAME-CHANGING CAPABILITIES FOR THE AUSTRALIAN DEFENCE FORCE OF THE FUTURE.

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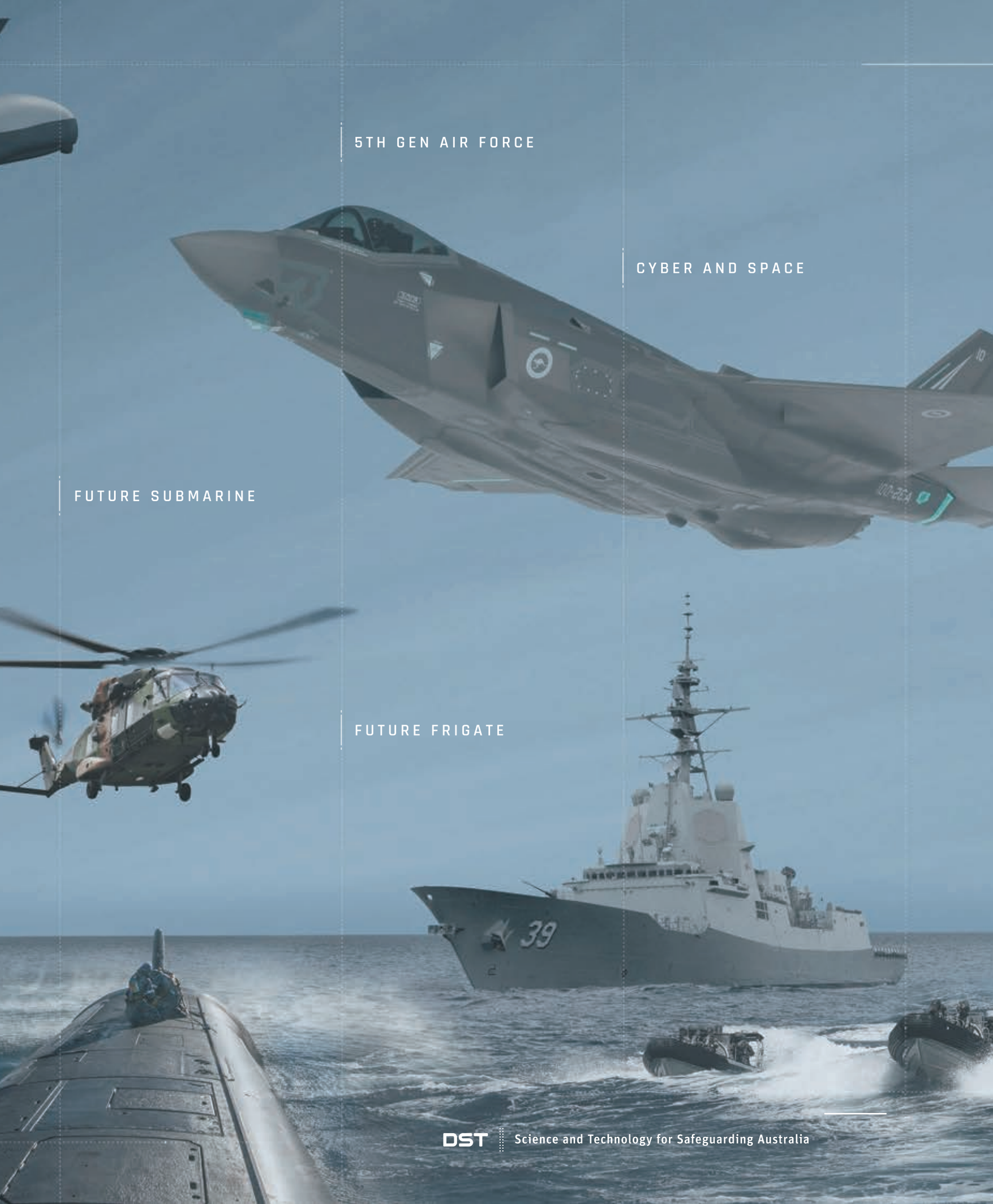

DST Science and Technology for Safeguarding Australia

Social Sciences
Australia's Research Field Leaders

Field Academic & Psychological Testing
Field leader David Andrich
Leading institution Uni of Qld

Field Anthropology
Field leader Tanya M Smith, Griffith
Leading institution ANU

Field Archaeology
Field leader Andrew S Fairbairn, Uni of Qld
Leading institution Uni of Wollongong

Field Cognitive Science
Field leader Marcus Taft, UNSW
Leading institution Uni of Qld

Field Criminology, Criminal Law & Policing
Field leader Lorraine Mazerolle, Uni of Qld
Leading institution Griffith

Field Diplomacy & International Relations
Field leader Wesley Widmaier, Griffith
Leading institution ANU

Field Early Childhood Education
Field leader Rauno Parrila, Macquarie
Leading institution Griffith

Field Education
Field leader Jan van Driel, Uni of Melb
Leading institution Monash

Field Educational Psychology & Counseling
Field leader Andrew J Martin, UNSW
Leading institution ACU

Field Environmental & Occupational Medicine
Field leader Geoffrey G Morgan, NSW Govt
Leading institution Monash

Field Environmental Law & Policy
Field leader Chunbo Ma, UWA
Leading institution ANU

Field Ethics
Field leader Michelle Greenwood, Monash
Leading institution Monash

Field Family Studies
Field leader Kim Halford, Uni of Qld
Leading institution University of Qld

Field Forensic Science
Field leader Xanthe Spindler, UTS
Leading institution UTS

Field Geography & Cartography
Field leader Robyn Dowling, Uni of Sydney
Leading institution Uni of Melb

Field Health Policy & Medical Law
Field leader Seye Abimbola, Uni of Sydney
Leading institution Uni of Adelaide

Field Higher Education
Field leader Kirsten Zimbardi, Uni of Qld
Leading institution Monash

Field Human Migration
Field leader Stephen Castles, Uni of Sydney
Leading institution WSU

Field International Law
Field leader Holly Cullen, UWA
Leading institution UNSW

Field Military Studies
Field leader Benjamin Schreer, Macquarie
Leading institution Griffith

Field Political Science
Field leader Ian McAllister, ANU
Leading institution ANU

Field Public Policy & Administration
Field leader Joshua Newman, Flinders
Leading institution ANU

Field Science & Engineering Education
Field leader Lambert Schuwirth, Flinders
Leading institution Deakin

Field Social Sciences (general)
Field leader Sarah Foster, UWA
Leading institution Monash

Field Social Work
Field leader Cathy Humphreys, Uni of Melb
Leading institution Griffith

Field Sociology
Field leader Garry Robins, Uni of Melb
Leading institution UNSW

Field Special Education
Field leader Suzanne Carrington, QUT
Leading institution La Trobe

Field Sustainable Development
Field leader Bradley Ridoutt, CSIRO
Leading institution Monash

Field Teaching & Teacher Education
Field leader Jeanne Allen, Griffith
Leading institution Deakin

Field Urban Studies & Planning
Field leader Sun Sheng Han, Uni of Melb
Leading institution Uni of Qld

Social sciences is a discipline that our methodology treats well due to our decision to use Google Scholar data for publications and citations, as it includes more social sciences research than traditional sources.

In this discipline, the fields of research are hugely varied. They are as different as military studies (where Griffith University is a leader); archaeology (led by the University of Wollongong); ethics (Monash University); environmental law and policy (the Australian National University); geography and cartography (the University of Melbourne); family studies (the University of Queensland); and educational psychology and counselling (the Australian Catholic University).

Some areas have close connections with the natural sciences, as illustrated by the University of Queensland's Andrew Fairbairn. He leads in archaeology but has a specialty in botany, and studies the preserved traces of plants and grains in order to build a fuller picture of ancient societies.

Social sciences is a discipline in which researchers often see the worst that human society has to offer, as University of Queensland criminologist Lorraine Mazerolle attests in her interview.

But as she acknowledges, there is also a hopeful side. She asks her students "What can we do to make people's lives better?"

Jeff Camden

Lorraine Mazerolle
Criminologist, University of Queensland

"How could a person murder another individual? How could they actually do it?" These questions preoccupied a young Lorraine Mazerolle when at the age of 14, she was given a large book of alphabetically arranged professions by the school guidance counsellor and told to choose one. She got as far as C.

"I didn't even know there was such thing as a criminologist," she says, "but I thought 'this is what I want to do with my life'.

Told she would have to become a police officer first, she applied straight out of school to the South Australian Police Force but was rejected for her (lack of) height. Crushed, she studied economics instead but discovered a criminology elective – and she was off. She was so keen she volunteered during summer holidays doing data entry in the Office for Crime Statistics.

It was while working in Adelaide for the federal Attorney-General's Department that she met two professors of criminology from the US. Both invited her to do a PhD there, and she chose Rutgers in New Jersey.

She flew into Newark in 1990 – straight into the massive crack epidemic and its wake of violent crime.

Mazerolle would spend 10 years in the States, with postings in Boston and Cincinnati, and work with George Kelly, one author of the famous "broken windows" theory of policing.

"I just landed in the right place at the right time. Two of my mentors have won the Stockholm Prize in Criminology, so I was incredibly fortunate to have exposure to really leading theorists and empirical researchers in criminology."

After she had two children, with no maternity leave, reality bit and she returned to Australia in 2000, working at Griffith for eight years, then at UQ.

"It's really hard to juggle [scholarship and motherhood]," she says. "It is quite a different challenge from what a lot of male academics face."

I don't know if you've ever been into a drug den or a crack house, but they are dangerous, sad, horrible places.

Mazerolle is hugely prolific, writing papers on policing legitimacy, problem-oriented policing, third-party policing (where cops partner with other organisations), and across such areas as drugs, terrorism and truancy.

What unites her work is a passion for "evidence-based policing". Using a scientific, experimental approach, she runs large randomised controlled trials in the real world and systematic reviews of the literature to see what crime-reduction measures really work.

She has found procedural fairness and treating offenders with dignity results in less crime and delinquency, and police forces in several countries have adopted dialogues created at UQ. A controlled truancy trial using a low-cost, 90-minute intervention increased school attendance and reduced anti-social behaviour.

Crime trends have changed over her career, most obviously with the rise of cyber-crime. But Mazerolle, who leads the ARC Centre of Excellence for Children and Families over the Life Course, will never forget the scenes she saw in the US. "I've never seen anything like it in my life. Literally people being shot in the street in front of you. I don't know if you've ever been into a drug den or a crack house, but they are dangerous, sad, horrible places – you see tiny babies crawling through syringes and absolute filth.

"One of the things that I try to convey to my students is: what can we do to make people's lives better? When I was 14 years old I couldn't understand how people could harm. I still feel a very strong sense of trying to make the world safer and nicer to live in, for the children."

PENNY DURHAM

Social Sciences
Australia's Research Field Leaders

> Gordon Hillman gave this introductory lecture and it's like his hand reached inside my brain and just dragged me into his world. I've never really left

Andrew Fairbairn
Archeobotanist, University of Queensland

If you want your kids to be interested in the past, Northumberland in northeast England is the place to bring them up: medieval castles, Roman fortifications and prehistoric earthworks are everywhere.

Andrew Fairbairn, though "not from a university family", grew up surrounded by the traces of deep history and never lost his boyish fascination. As an archeobotanist, he studies the preserved traces of plants and grains that tell stories about ancient plant use, food consumption and farming – all central to the story of civilisation.

"I can't quite believe that I've had the strange career that I've had, to be honest," he says. "Career advisers get often quite heavily criticised, but I sat down and talked to the career adviser at school when I was 15 and he said, 'Have you ever thought about doing archeology at university?' And I followed that up and went off to uni. I went to University College London, to the Institute of Archeology, and I sort of dropped in to this amazing, international, very outward-looking institution, and my head was just kind of blown off. My consciousness about the world and what I could do was transformed by the people I met there.

"They'd been taught by people like Sir Mortimer Wheeler and Kathleen Kenyon. The person who probably had the most effect on me at university was Gordon Hillman, an archeobotanist. A lot of our lives are based around the ability to control and use plants, for food or construction or feeding our stock animals. Hillman gave this introductory lecture and it's like his hand reached inside my brain and just dragged me into his world. I've never really left that world since then." The esteemed Hillman died on July 1.

Working from project to project while doing his PhD, in places such as Avebury in southern England and in eastern Europe, he met his Australian future wife. She eventually wanted to come home, so he took his career down under, working at UQ, which he says "had a history of training really good archeologists". He continued to work on one of the world's most famous Neolithic settlements: Çatalhöyük in Anatolia, modern Turkey.

Since Anatolia is a crucial place in the development of agriculture, Fairbairn still works on projects there, including on an antecedent of Çatalhöyük, Boncuklu, and Kültepe-Kanesh. You can tell from the way wheat chaff changes, he says, whether the crop is wild or farmed.

He has also worked on plant use in Papua New Guinea, and on a project of great significance in Australia: the dig at Madjedbebe, a rock shelter in Arnhem Land, whose results dated the arrival of the first people in Australia to as far back as 65,000 years ago.

That project was led by Fairbairn's UQ colleague and friend, Chris Clarkson. "It's been a wonderful experience for me and the students to be able to work as part of this really huge, quite impressive, largely Australian-based team, and doing some fantastic technical archeology.

"This is my 30th year doing archeology, and I thought I couldn't get surprised by finds and have my concept of the world and time challenged. For me, thinking about societies that were around 10,000, 15,000 years ago is pretty standard. But Madjedbebe blew my mind open, having to think about what people were doing 65,000 years ago."

His next challenge is to find a valid way to determine the extent of farming in Australia before colonisation.

PENNY DURHAM

Lyndon Mechielsen

Australian Government
Department of Defence
Science and Technology

INVESTING IN SCIENCE AND INNOVATION FOR OUR SECURITY

The growing uncertainty over security around the world and in our region prompted the federal government to commit $195 billion in the 2016 Defence White Paper for advanced military capabilities over the next 10 years. Those capabilities are being underpinned by a revitalised innovation system with cutting-edge science and technology.

The new innovation system was highlighted in the Defence Industry Policy Statement that the Minister for Defence, Christopher Pyne, has been prosecuting vigorously. The government is investing $1.6 billion in a single, coherent innovation pipeline to deliver defence capability aligned with Australia's strategic requirements.

The pipeline consists of two signature innovation programs – the Defence Innovation Hub, with $640 million in funding, and the Next Generation Technologies Fund, which has a budget of $730 million.

The Defence Innovation Hub brings industry and Defence together to undertake innovation activities from concept through to introduction into service, while the Next Generation Technologies Fund focuses on research in emerging and future technologies that can be transitioned to the Hub for further development. Research can be risky; however, it creates and prevents strategic surprise. It is our best option for developing the innovative solutions for delivering the next generation of leading-edge defence capabilities.

The Next Generation Technologies Fund is a bold R&D program that addresses nine priority areas identified in the Defence White Paper. It draws on the innovation capabilities and support of Australian industry and academia. Australia's universities represent a $140 billion enterprise, with more than one million students and 60,000 academic staff. This under-utilised resource can be deployed to develop the game changing technologies of the future.

Since the Next Generation Technologies Fund was launched in March last year, Defence has entered into more than 100 collaborations with 17 companies, 23 universities and two publicly funded research agencies. Investment in future technologies scales from $16 million to $130 million per annum over 10 years.

Seven targeted programs were chosen, each with its own form of engagement for optimising collaboration.

One of the largest initiatives is the Grand Challenges program, a first for Defence and Australia, with an investment of $250 million over 10 years.

The program is designed to address tough Defence problems that can only be solved through innovative approaches requiring cross-disciplinary research across organisational and geographic boundaries. The inaugural Grand Challenge to counter improvised threats attracted more than 200 research proposals and is now under way, with more than 20 partners developing a threat detection and defeat prototype for delivery in four years.

Defence adapted the successful Cooperative Research Centre (CRC) model to establish its own inaugural CRC for Trusted Autonomous Systems.

The approach is mission driven to ensure the Defence requirement for future autonomous technologies but delivered by industry, working with Australia's research community.

The foundation members are BAE Systems, DefendTex, RMIT University, and Defence Science and Technology.

This Defence CRC is a $50 million project that has attracted an equivalent level of funding from the Queensland government.

The Next Generation Technologies Fund has also tapped into the US Department of Defense's longstanding Multi-University Research Initiative (MURI), giving Australian universities the opportunity to collaborate on defence projects with their American counterparts. With funding from Defence, Griffith University, the University of Sydney, the University of New South Wales and the University of Technology Sydney are now collaborating with a number of US universities on quantum technologies and advanced material sciences, which are critical for future defence capabilities.

In its first 17 months, the Next Generation Technologies Fund has clocked up some impressive results.

They include:

– a Small Business Innovation Research for Defence program for SMEs with funding of $10 million to 2025-26;

– a successful start-up, Silentium Defence, that markets Defence's passive radar technology to commercial markets;

– state-based university research networks in South Australia and NSW modelled on Victoria's successful Defence Science Institute;

– $5.7 million to 22 universities for 59 exploratory research projects; and

– calls for research proposals on cyber capabilities, quantum technologies and signature management of autonomous aircraft.

The Next Generation Technologies Fund has opened up exciting new opportunities that are attracting talented researchers who are partnering on defence projects for the first time. The government is committed to positioning defence as an agile and potent force for the future, backed by state-of-the-art technology.

Dr Alex Zelinsky,
CHIEF DEFENCE SCIENTIST

Lyndon Mechielsen

Professor
Michelle Simmons

Pioneering Quantum Physicist and 2018 Australian of the Year

Life Sciences & Earth Sciences
Australia's Research Field Leaders

Field Agronomy & Crop Science
Field leader Victor Sadras, SA Govt
Leading institution CSIRO

Field Animal Behavior & Ethology
Field leader Andrea S. Griffin, Uni of Newcastle
Leading institution Macquarie

Field Animal Husbandry
Field leader Luciano Adrian Gonzalez, Uni of Sydney
Leading institution UNE

Field Atmospheric Sciences
Field leader Harry H. Hendon, BOM
Leading institution CSIRO

Field Biodiversity & Conservation Biology
Field leader Michael McCarthy, Uni of Melbourne
Leading institution Uni of Melbourne

Field Biophysics
Field leader Marc-Antoine Sani, Uni of Melb
Leading institution Monash

Field Birds
Field leader Richard E Major, Aust Museum
Leading institution Charles Sturt

Field Botany
Field leader Robert Sharwood, ANU
Leading institution ANU

Field Cell Biology
Field leader Ben Hogan, Uni of Qld
Leading institution Uni of Qld

Field Developmental Biology & Embryology
Field leader Andrew Elefanty, MCRI
Leading institution Monash

Field Ecology
Field leader Dustin J. Marshall, Monash
Leading institution Uni of Melb

Field Environmental Sciences
Field leader Peta Neale, Griffith
Leading institution CSIRO

Field Evolutionary Biology
Field leader Carla Sgro, Monash
Leading institution ANU

Field Forests & Forestry
Field leader David I Forrester, Uni of Melb
Leading institution Uni of Melb

Field Geochemistry & Mineralogy
Field leader Kliti Grice, Curtin
Leading institution CSIRO

Field Geology
Field leader Zheng-Xiang Li, Curtin
Leading institution Uni of Adelaide

Field Hydrology & Water Resources
Field leader Peter Cook, Flinders
Leading institution CSIRO

Field Insects & Arthropods
Field leader Mark K Schutze, QUT
Leading institution CSIRO

Field Life Sciences & Earth Sciences (general)
Field leader Alan Cooper, Uni of Adelaide
Leading institution James Cook

Field Marine Sciences & Fisheries
Field leader Marcus Sheaves, James Cook
Leading institution James Cook

Field Microbiology
Field leader Staffan Kjelleberg, UNSW
Leading institution Uni of Qld

Field Mycology
Field leader Mark Krockenberger, Uni of Sydney
Leading institution UWA

Field Oceanography
Field leader Ming Feng, CSIRO
Leading institution UNSW

Field Paleontology
Field leader Guang R Shi, Deakin
Leading institution Deakin

Field Pest Control & Pesticides
Field leader Christopher Preston, Uni of Adelaide
Leading institution UWA

Field Plant Pathology
Field leader MingPei You, UWA
Leading institution ANU

Field Proteomics, Peptides & Aminoacids
Field leader Nichollas E Scott, Uni of Melbourne
Leading institution Uni of Qld

Field Soil Sciences
Field leader Jingyi Huang, UNSW
Leading institution Uni of Sydney

Field Zoology
Field leader Scott Keogh, ANU
Leading institution Macquarie

Not at all surprisingly, the institution that dominates the list of leaders in life science and earth sciences is Australia's biggest public research body, the CSIRO.

It leads in agronomy and crop science (a tribute to its role in building Australia's agricultural industries); atmospheric sciences (where it has always been strong); environmental sciences (where it has increasingly taken a role); geochemistry and minerology (another area in which it built world-class expertise to support Australian industry); hydrology and water resources (reflecting its work in preserving the country from the impact of drought); and insects and arthropods (probably due to its work on agricultural pests).

Looking at other leading institutions is also interesting, with many coming from outside the group of research-intensive universities. Charles Sturt University is a leader in studies of birds, Deakin University is a leader in paleontology, and Macquarie University a leader in zoology.

Again not surprisingly, James Cook University is a leader in marine sciences and fisheries.

In global terms Australia is strong in many of the fields of this discipline. In the strictly research-based global ranking, the Academic Ranking of World Universities, Australian universities do very well in agricultural sciences, with six institutions in the top 50, led by the University of Western Australia at 14th. It is what we would expect due to the priority given to research in agriculture, which directly benefits one of the country's strong industries.

Jeff Camden

Peta Neale
Environmental scientist, Griffith University

When environmental scientists and regulators conduct water quality tests, they typically only detect a small fraction of the chemicals in the water and might not get a complete picture of how safe it is.

Peta Neale and her collaborators are trying to overcome the problem by developing a new method of water testing that takes a different approach.

Instead of looking for specific chemicals, they are employing in vitro bioassays, where they use human or animal cells grown in the laboratory and look at how exposure to the water sample affects them.

"With bioassays, we can't detect the individual chemicals," says Neale, Research Fellow at the Australian Rivers Institute at Griffith University. "But in a water sample where you have lots of chemicals, we're looking at the mixture effect of all active chemicals in the sample – all the known chemicals and all the unknown chemicals.

"For some other assays, we can see that maybe less than 1 per cent of the effect is explained by those chemicals we're detecting. This points to the fact that lots of chemicals can have an effect in these assays and, by just using chemical analysis alone, we're really just seeing a small fraction of the total chemicals that are causing an effect."

Some studies have identified the "something from nothing" effect, where chemicals in low levels of concentrations interact with each other and have a larger effect on the cells than they might alone.

There are always new things to discover. There are always new chemicals that we're finding out about – things like perfluorinated compounds or microplastics. We're always learning

Australia's leading researcher in environmental sciences, Neale is working on the European Union SOLUTIONs project, conducting bioassays and chemical analysis on the Danube to help develop the tests.

"The Danube was sent to me, unfortunately," she says. "I didn't get to go and collect the samples," she says.

There is a lot of interest in the potential of bioassays, although they are not yet regulated for monitoring. Neale and others are working to make the method robust and reliable so they can eventually be used for monitoring.

Neale completed an undergraduate degree in environmental science thanks to an inspiring high school teacher. Then in the final year of her degree, a lecturer gave her a book on the effect of endocrine-disrupting chemicals on humans and wildlife, which in turn led her to do a PhD at the University of Edinburgh.

She says she has always been fascinated by chemicals in the environment. "There are always new things to discover," she says. "There are always new chemicals that we're finding out about – things like perfluorinated compounds or microplastics. We're always learning."

Neale also enjoys being exposed to new ideas and different ways of thinking about environmental problems when she works with other scientists from around the world and from different disciplines.

CHRISTOPHER NIESCHE

Courtesy of Alan Cooper

Alan Cooper
Ancient DNA researcher, University of Adelaide

Alan Cooper's first encounters with giant moa were not entirely respectful.

He grew up in a mountainous part of New Zealand where his paleontologist-geologist father worked, and developed a love of caving. "I spent most of my teenage years up to my early 20s underground," he tells *Research*. "I spent a good amount of time exploring all these places that no one had been to before.

I became good at excavating rockfalls to get to new passages – it's not the cleverest, but you're guaranteed something on the other side. I'd never have any tools, so what I used to choose – which now seems quite sacrilegious – was the large leg bones of New Zealand moa, the giant ratite bird. It was about 3m tall, the biggest one, so a leg bone stands about 1m tall. And so I got quite interested in moa."

He was studying biochemistry and physiology at Victoria University of Wellington in the late '80s when the first papers on ancient DNA started, inspiring him to work on the DNA inside those bones rather than using them as tools.

The flightless birds have remained with him over his career. It has taken him and his team more than 20 years to establish with certainty that it was not the drift of continents that spread emus, ostriches, cassowaries, moa, kiwi and other species around the world, but that they dispersed by flying and then lost the ability as it ceased to be an advantage.

Back in Wellington, thinking about a PhD, Cooper had the luck to meet Allan Wilson, renowned pioneer molecular evolutionist and proponent of the Out of Africa and Mitochondrial Eve hypotheses, who invited him to visit his lab at UC Berkeley. There Cooper learned "how to do ancient DNA properly", before returning to complete his PhD at Victoria.

He did postdoctoral research in Washington DC before moving to Oxford, where at just 31 he became

Courtesy of Alan Cooper

The problem with DNA is that the worse you do it, the worse your standards are, the better your results will be. You've got to be very rigorous in your approach and very sceptical about the results you get

one of the youngest professors ever appointed there.

After about 10 years, Cooper and his Hawaiian wife had had enough of the rain. He left the large research group he had built, and accepted a fellowship and funding from the University of Adelaide to set up an ancient DNA research centre there. He has studied the development of human diseases, the impact of climate change on animal DNA, extinctions, and Australian Aboriginal heritage.

As in court, DNA is powerful but highly susceptible to contamination, so it must be handled with extreme rigour. The oldest credible DNA sequence, Cooper says, is from a horse that lived 700,000 years ago. Don't believe claims of 65 million-year-old DNA recovered from amber.

"The problem with DNA is that the worse you do it, the worse your standards are, the better your results will be. You've got to be very rigorous in your approach and very sceptical about the results you get. Trying to falsify your results is one of the most important things in ancient DNA."

Since DNA decays over time in predictable ways, the team can take multiple specimens of one species from different eras (at the moment Cooper is studying North American bison), make a timeline of genomes or gene sequences using radiocarbon dating, and overlay climate data and look for patterns. "This is still very new science but we're seeing a very, very big impact," he says. "We're seeing the climate as doing much more damage than people are thinking."

Genetic data also reveals huge extinctions undetectable from the fossil record, because populations were replenished from a small subset of survivors, with less diversity. "The sheer number of extinctions is much greater than we thought – which does tend to make you worry about what happens when human activities do finally tip the climate system outside of what we're used to. This work is suggesting the results are going to be pretty dramatic and pretty rapid."

Cooper, who was South Australia's scientist of the year in 2016, last month won an SA Science Award for his work on the Aboriginal Heritage Project, which won a Eureka prize in 2017. This involves visiting communities around Australia seeking permission to analyse a trove of hair samples collected from Aboriginal people between 1927 and 1960 by anthropologists from the University of Adelaide and the South Australian Museum.

"We take total direction from the elders," Cooper says. "We've worked with, I think, 1500 families so far across Australia and only two have declined to participate. The more I dig into Aboriginal history, the more amazed I am at just how generous and benevolent these people are when another pack of white scientists turn up and ask to work with them.

"It is one of the more enriching scientific projects I've ever been involved in, because quite often there's a lot of emotion – people are happy at the things we find, rediscovering family links and confirming long-told stories.

"Australian history is one of the more interesting chapters in human history, and yet it's the one with the least amount of knowledge. Aboriginal people are very keen to find it out, and so using science to help that is just fantastic."

PENNY DURHAM

Early Career Leaderboard
Up and comers

Nik Steffens
Business, economics & management

A specialist in organisational psychology, Steffens focuses on concepts of self and identity in organisations, and the implications for behaviour in the workplace. This has led him to examine related issues such as leadership and followership, motivation and creativity, and health and wellbeing in organisations.

Xiaoguang Duan
Chemical & earth sciences

Xiaoguang Duan is researching the use of no-carbon materials for environmental remediation. He is currently applying nanotechnology to the problem of removing micro plastic pollutants from waste water, rivers and oceans. A research fellow at the University of Adelaide, he also supervises research students and recently completed his PhD at Curtin University.

Jian Zhen Ou
Engineering & computer science

A senior research fellow at RMIT, Jian Zhen Ou is developing nano materials into cheap and effective chemical sensors. Applications include a sensor that can detect tiny concentrations of cancer cells in the blood; a swallowable sensor to detect gut problems; and a small, cheap sensor that will help developing countries detect pollution.

Felix Ogbo
Health & medical sciences

A Nigerian-trained doctor, Ogbo completed a master of public health at Western Sydney University, then a PhD researching breastfeeding practices in developing countries. Now a WSU lecturer, he continues to research maternal and child health, as well as epidemiology and global health. A recent focus is the shift in patterns of disease as developing countries get richer.

Stephen Gadsby
Humanities, literature & arts

A PhD student in Monash's cognition and philosophy laboratory, Gadsby is focusing on anorexia and other cognitive disorders that involve illusions about the self. His work aims to offer insights into why people have false beliefs about themselves. His research cuts across disciplines, drawing out the philosophical issues from "the nuts and bolts" of how the mind works.

James Allan
Life sciences & earth science

A PhD student at the University of Queensland, Allen is looking for solutions to the problem of protecting wilderness while also encouraging economic growth in developing countries. His doctorate includes field work in Mozambique with the Wildlife Conservation Society, looking at ways land-use planning can be used to meet multiple objectives.

Pouria Amani
Physics & mathematics

A chemical engineering PhD student at the University of Queensland, Amani is investigating ways coal seam gas can be extracted with low environmental impacts. He is researching the flow behaviour of gas-liquid-solid systems and their lift capacity under varying gas-liquid ratios and pressures. He has bachelor and masters degrees from the University of Tehran.

Gayathri Naidu
Social sciences

A Malaysian-born engineer, Naidu completed her PhD at the University of Technology Sydney and developed a solar-powered system for producing fresh water from saline groundwater using a combination of membrane purification and distillation. Her papers rate highly in the sustainable development field. She now has a UTS postdoctoral fellowship.

AT UNISA, PARTNERSHIPS DRIVE RESEARCH THAT MATTERS

Scratch the surface of most sensational scientific breakthroughs and you'll find there is nothing sudden about them. Years of hard work, deep thinking, teamwork, problem solving and collaboration sit behind most discoveries.

As Thomas Edison and, for younger generations, AC/DC noted, genius is one per cent inspiration and 99 per cent perspiration – or, it's a long way to the top if you want to rock and roll.

For Professor Tanya Monro, University of South Australia Deputy Vice Chancellor, Research and Innovation and a highly successful photonics researcher, creating the environment for researchers to bring their best game, to make the breakthroughs, is central to her role.

And while there is rarely a blank slate to start from, Professor Monro says there are some key elements that create the very best environment for research.

"You need to be able to attract and combine teams of smart, creative thinkers, and they should be researchers and technicians with expertise across different disciplines and with diverse perspectives," she says.

"World problems and challenges don't sit in neat discipline boxes."

"It's critical to encourage a culture within research teams and institutions that makes it OK, even desirable, to challenge the status quo and strive to explore."

Professor Monro says breakthroughs are born from debate and from an openness to new ideas.

"All new ideas and great innovations are built on the successes and failures of those who have gone before – that is the way knowledge advances," she says. "It takes more time than people realise, and a commitment to the long game.

"It's also important to harness Australia's best talent, regardless of gender or background."

Professor Monro says understanding how and where the research could make an impact is key.

"There is a perennial debate about the value of applied versus fundamental research, as though they are incompatible approaches," she says.

"But in the right environment, they fit together hand in glove."

"The greatest criticism of fundamental research is that it's so keenly focused on the theoretical that it and the researchers engaged in it are disconnected from everyday concerns and the world outside.

"But fundamental research is invaluable when it is led by true thought leaders who are engaged, genuinely curious, connected, researchers – people with the capacity and depth to see how the results of the work inform our understanding of the world."

"Those who dismiss applied research as narrow, or captive to industry, also have the wrong idea."

"It takes a sophisticated mix of creativity, tenacity and an understanding of the needs of industry to deliver truly impactful applied research. The impact of applied research across the nation is changing industry practices and procedures, resulting in ever-increasing environmental efficiencies, better pharmaceuticals, life-saving health approaches, improved crop yields and safer food production, to name just a few."

She says the great benefit of industry-partnered research is that it brings discoveries into the wider world – it provides a pathway for new knowledge to change policy and deliver innovation in products or services.

"Research partnerships with industry are crucial for the range of benefits they provide the community, especially in countries like Australia where few companies employ R&D teams.

Professor Monro says universities are full of great examples of beneficial collaboration. "At my own university we have determined to look at the big challenges society confronts and, in partnership with industry, focus our research on solving them," she says.

From beating cancer and transforming industries to managing scarce resources, the six research themes at UniSA focus the collective effort of research teams across the university, she says.

"These are broad themes that nurture a research environment that brings together researchers from different disciplines. A terrific example is the way that our mathematicians have developed an energy-saving and time-management system for trains.

"Working with the international rail systems company TTG Transportation Technology, researchers at UniSA's Centre for Industrial and Applied Mathematics developed a train driver advice system.

"Using algorithms to continually calculate the most efficient way to complete a train route, accounting for track gradient, speed and power limits and timetabling, they worked with engineers to construct a new software system called Energymiser, which is saving fuel for train systems around the world.

"This has been a long-term collaboration. The research has been informed by people working in the industry. It has delivered tangible environmental and safety benefits, and has delivered those benefits globally to transport networks across the UK, Belgium, Spain, France, Germany, China, India, Australia and New Zealand.

"It's important to seize opportunities – opportunities to collaborate with industry and other research end users, to connect across research fields and to allow space for exploring fundamental discoveries and new territory that emerges along the way. This allows us to create an environment in which our most capable researchers can contribute to delivering solutions to the big challenges facing society."

AS

By Robin Batterham

Scientific research is not about fake news, opinion polls, Twitter followership, or any other description or understanding of the world not informed by high-quality evidence and rigorous logic

a former Chief Scientist of Australia, I well recall the need to produce metrics justifying the significant increases in research funding that were delivered by the science and innovation focused Backing Australia's Ability (BAA) package of 2001. The thesis then and now is that the roughly 2 per cent of the world's scientific output that we deliver is both more than expected for our size and delivers significant benefits to our population. The new world of "big data", with its potential to winnow deep, granular insight from huge data sets, represents a huge step forward in making informed decisions about where and how to invest in research.

The notion of using data and logic as a basis for making informed decisions has evolved over nearly a thousand years to form the foundation for all modern research. Scientific research is not about fake news, opinion polls, twitter followership, or any other description or understanding of the world not informed by high-quality evidence and rigorous logic. That government ministers have key performance indicators (KPIs) focused on social media followership is mildly disturbing; populist acclaim is hardly a sound foundation for policy. Ministerial KPIs that emphasise the measurable impact of prevailing policies (for example, emissions reduction) should be the basis of good governance.

German Chancellor Angela Merkel is an interesting case in point. Time and again she is guided by evidence, logic and experienced pragmatism, as befits a physicist. As a consummate politician, she also moderates policy in response to deeply felt public opinion, for example limiting the life of Germany's nuclear power sector despite its superior emissions track record. This is as it should be in a democracy. But policy tuned daily to popular demand both eschews the benefits of the scientific method in making robust decisions and makes it impossible to lay the stable policy foundations on which many long-term initiatives depend.

The health and productivity of all Australians benefits from governance based on the scientific method, with its iterative postulation and evidence-driven validation of ideas. In guiding our nation's investment in science and engineering research, the challenge is measuring the impact of that investment. If, for example, we believe a focus on high-quality science delivers more bang for our limited bucks, how do we measure that impact?

The Australian Research Council has just completed a major exercise in measuring engagement and impact for more than one million research outputs. We await the results with interest. I expect it will be in line with the London Economics study of the economic impact of the Go8 Univesities, which in 2016 had costs of $12.4 billion and benefits of $66.4 billion, of which $24.5 billion were from research.

Right now, we have only two readily available activity measures: citations, as an indicator of academic merit, and patents, as a proxy for off-campus impact. Contrary to common opinion, studies show that even in basic science there is a positive relationship between patenting and publishing. To quote Breschi et al, "it is not patenting per se that boosts scientific productivity, but the advantage derived from solid links with industry, as the strongest correlation between publishing and patenting activity is found when patents are owned by business partners, rather than individual scientists or their universities". Similarly van Looy et al, in analysing the entrepreneurial activity of 105 European Universities, observed that "scientific productivity is positively associated with entrepreneurial activity".

This certainly reflects my experience in a career covering CSIRO, industry, government, learned academies and now at a leading university. External engagement creates a virtuous cycle benefiting those both on and off campus.

With our limited resources, our challenge is to maintain, or better yet improve, our research excellence and impact. Logic suggests we should focus more of the available resources on current and potential top performers – and in particular with productive external engagement. This is not to downplay the importance of early career or even of a diversity of funding to encourage new growth; it is simply to argue that for a small nation, we increase our impact by concentrating on excellence.

In summary, research excellence does lead to more impact, and enhanced external engagement will improve both. The evidence is clear, and as such, analyses such as these undertaken by *The Australian* are most welcome in shaping perspectives and policy.

Robin Batterham was Chief Scientist of Australia from 1999 to 2006

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Image: UniSA's Dr Kamil Zuber examines one of the thin-film cells that can change colour depending on their environment. Dr Zuber has been working on this research in partnership with Defence Science and Technology developing the cells to apply to various military platforms.

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