

FOCUS

SCIENCE VISION: 15 YEARS FROM NOW

CHIEF SCIENTISTS FROM AROUND THE COUNTRY
LOOK TO THE FUTURE AND HIGHLIGHT
OUR OPPORTUNITIES



BATTERHAM MEDAL

FOR ENGINEERING EXCELLENCE



One of Australia's most innovative young engineers will win the 2016 Batterham Medal.

NOMINATIONS CLOSE ON 14 AUGUST.

The Batterham Medal is an early career award for a graduate engineer who has achieved substantial peer/industry recognition for his/her work in the past five years. The Academy administers the award on behalf of the Group of Eight Deans of Engineering and Associates and the Medal will be awarded at ATSE's Oration Dinner on 25 November 2016 in Melbourne.

The winner will receive the Batterham Medal and a cash prize of \$5000.

THE WINNER WILL BE AN ENGINEERING GRADUATE OF AN AUSTRALIAN UNIVERSITY, UNDER 40 AT 1 JANUARY 2016 AND WILL:

1. have demonstrated excellence, innovation and impact in a field of engineering;
2. be clearly acknowledged by peers for a signature contribution to engineering in the five years prior to his/her nomination; and
3. have advanced the standing of the engineering profession.

The Batterham Medal recognises **Professor Robin Batterham AO FEng FAA FTSE**, an Australian science and technology leader who was Chief Scientist of Australia from 1999 to 2006, President of the Academy from 2007 to 2012 and is Kernot Professor of Engineering at the University of Melbourne.

THE BATTERHAM MEDAL GUIDELINES AND NOMINATION FORM ARE AVAILABLE AT www.atse.org.au/batterham-medal

NOMINATE AN INNOVATIVE YOUNG ENGINEER TODAY.

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Front cover photo: The Ladybird robot can detect vegetable growth and pest species and remove weeds.
Photo: University of Sydney



ATSE *Focus* is produced to stimulate discussion and public policy initiatives on key topics of interest to the Academy and the nation. Many articles are contributed by ATSE Fellows with expertise in these areas. Opinion articles will be considered for publication. Items between 800 and 1400 words are preferred. Please address comments, suggested topics and article for publication to editor@atse.org.au.

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BY ALAN FINKEL
chiefscientist@chiefscientist.gov.au

Embrace change and seek better outcomes

SCIENCE VISION We must reverse the decline in science and maths participation and performance. In international testing, our students are slipping and this is unacceptable.

I love problems. They are opportunities to create solutions. And while we're at it, we can make sure that the solutions exceed the minimum requirements.

Two memorable events occurred in my first three weeks on the job.

The first was the restructuring at CSIRO that reduced Australia's climate research capability. In the spirit of never letting a good crisis go to waste I was able to work with numerous players in the research community to facilitate CSIRO itself finding a better way forward.

The second was the announcement of the discovery of gravitational waves. Quite remarkably, 100 years after their existence was predicted by Albert Einstein's Theory of General Relativity, and after 45 years of intense effort by the physics community to build ever more sensitive detectors, a gravitational wave event was recorded a mere *one hour* after the Advanced LIGO detector was switched on. To me, the trace that shows the gradually increasing frequency and amplitude of the gravitational waves emanating from the inward spiralling and eventual collision of two black holes 1.3 billion light years ago is the blip of the century.

Ten years ago most scientists and engineers, other than the funders and builders of LIGO (the Laser Interferometer Gravitational-Wave Observatory), thought the task was impossible. But the physicists, engineers and mathematicians in the LIGO team were undaunted. Ultimately, their machine detected a change in length a mere thousandth of the width of a proton along the four-kilometre-



Alan Finkel joins students to celebrate Victoria University Secondary College becoming the 500th STELR school in Australia.

long arms of the detector. Hats off to the team.

The stunning LIGO success illustrates what is critically important in a national science, research and innovation system: adequate funding; multidisciplinary teamwork; collaborations between universities, research institutions and industry; patience, commitment and vision.

AUSTRALIA NEEDS A PLAN

Australia does not yet have a long-term plan for its science, research and innovation system. I anticipate that this will be addressed in the not too distant future.

In the meantime, as a country we are enjoying many successes, most of which are rarely acknowledged. We have achieved almost 100 successive quarters of GDP growth in a row, making us the envy of other

developed countries. You could say we were lucky, but it is more than that.

Among many other factors, we should acknowledge the commitment to research and innovation in our mining, education, agriculture and banking sectors. Although we don't hear about these nearly as much in the media as we hear about our poor performance in digital technologies. And it is true, we could do much better in many areas and, through a deliberate approach, we can fill in the gaps in our capability. But we will do so more easily by celebrating and learning from our successes than by focusing on our shortfalls.

As Australia's Chief Scientist, championing science and innovation across society, one of my main messages is about embracing the two arms of an upside-down 'T'. The horizontal base is our science and research

endeavour, from fundamental science, humanities and social sciences, through to engineering and digital technologies. Science and research build the knowledge base that feeds the innovation engine, which is the vertical arm of my upside-down T. This combination of science, research and innovation contributes to our national health and prosperity.

To ensure our great science can continue to deliver, we need nationally accessible, large-scale research equipment.

The NCRIS and Super Science initiatives of the previous decade served us very well, but nothing lasts forever, especially in science, where the new knowledge gained using the current generation of equipment almost begs us to develop the next generation.

The challenge is to systematically plan and fund our upcoming needs. To that end, I am leading the Research Infrastructure Roadmap process that will deliver recommendations for the next decade of major research equipment.

Our definition of national research

infrastructure is broader than a strict interpretation of 'national' would suggest, so that we can leverage our skills and finances to be partners in international projects such as the Giant Magellan Telescope in Chile and, of course, the Square Kilometre Array. Will we be able to host the next generation of gravitational wave detector? That should certainly be an aspiration.

The funding sources for research infrastructure equipment are crucial and this topic was discussed broadly at the recent Forum of Australian Chief Scientists (FACS) held in Hobart. The forum was my first opportunity to chair a FACS meeting and I enjoyed the open discussion where we shared our strategic vision. Some of the conversations around the meeting table are reflected in this article and others articles by my fellow Chief Scientists from the states and territories.

LIFTING EXCELLENCE IN STEM

One of the issues discussed in detail in Hobart was the challenges facing the Australian education system.

The rapid approach of automation and artificial intelligence will substantially alter the job market in coming years.

The solution is to ensure the excellence of our education system from primary school through to on-the-job training. My predecessor, Professor Ian Chubb AC FTSE, identified many of the problems and now we need to act to address them.

I am encouraging universities to work ever more closely with industry to anticipate future job needs. But the reality is that it is impossible to keep up, so that instead of aspiring to produce job-ready graduates we must aspire to produce job-capable graduates who have deep discipline knowledge accompanied by workplace attributes such as written and oral communication skills, collaborative working, critical thinking and project management.

At the secondary school level we must reverse the decline in science and maths participation and performance. In international testing, our students are slipping in absolute results and in comparison to other countries. This is unacceptable.

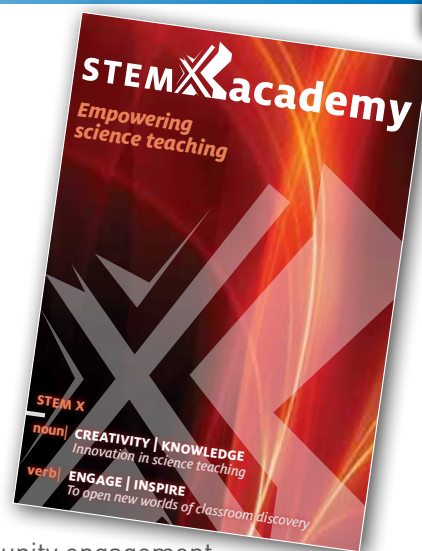
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Few people comprehend the enormity of the challenge to reduce greenhouse gas emissions.

School education is a state and territory responsibility, so I will be working with the state and territory Chief Scientists to identify areas of concern, such as too many science and maths teachers teaching out of field.

At the national level, I am joining others in calling for universities to require intermediate or advanced mathematics across the board. It staggers me that 13 of the 34 engineering courses offered in Australia accept fundamental maths as a prerequisite even though this does not include calculus, and one of our engineering courses does not require any Year 12 mathematics at all.

Australia is fortunate to have many hundreds of science and technology educational activities that have been developed to complement regular teaching. ATSE's STELR program is a successful example.

However, too many times we hear that teachers and parents are unaware of what is available. The Office of the Chief Scientist has published a compendium of STEM activities and now, in collaboration with industry and with the unqualified support of the state Chief Scientists, we are in the process of converting this into a dynamic online database that will be accessible to teachers, parents and students.

Despite the problems, our schools and teachers are much better than the constant criticism implies. I spoke recently to the CEO of a major engineering design company that recruits dozens of graduates every year. "Are they any good?" I tentatively asked? "Alan, they are sensational!" was his reply.

AN ENORMOUS CHALLENGE

Of course, one of the biggest challenges that we face nationally and globally is climate change. The simple truth is that the world needs energy, lots and lots of it. Take it away and we are back in the Stone Age. But all that energy use is accompanied by carbon dioxide emissions.

Few people comprehend the enormity of the challenge to reduce emissions. For example, even though domestic solar penetration in Australia is the highest in the

world, solar electricity only contributes a bit more than two per cent of our annual electrical energy generation.

There is a long way to go but the cumulative investment in technology, manufacturing, installation and financing models in the past few decades, supported to a large extent through government subsidies, has succeeded in driving down costs. Today, the *unsubsidised*, levelised, wholesale cost of electricity generated from large-scale solar and wind is cheaper than the traditional benchmark – coal-fired electricity. In the US, 25-year power purchase agreements have been written at below A\$40 per megawatt-hour.

STUNNING ACHIEVEMENT

This is a stunning achievement, a victory. However, many will argue that it is a hollow victory because this price breakthrough ignores intermittency. And they are right. The target must now shift to the development of storage technologies, such as thermal storage, hydrogen storage, battery storage and pumped hydroelectricity.

We have to do it at scale; the challenge is enormous. If you took all the batteries that were manufactured for telephones, laptops, cars and industry in 2014 and removed them from their products and instead used them for a global electricity back-up system they would have the capacity to keep the global electricity supply running for a mere nine seconds.

The world needs to accelerate investment in research and development to reduce costs and increase capacity in all the available electricity storage technologies. Australia is already a major technology developer in thermal storage and there are ample opportunities for us to develop our hydrogen and battery storage science and technology capabilities.

It is worth stating the obvious – government is not the solution to all of our problems. It never has been and it never will be. Governments can correct market failures, they can fund research infrastructure that could not otherwise be funded, they can ensure the quality of our education system,

but at the end of the day we must believe in our own capacity to discover and innovate, and we must act accordingly.

The government-funded DARPA program in the US and the CERN facility in Europe gave us the internet and the World Wide Web. Building on this backbone, five digital technology companies sprang up through private investment to become five of the top 10 companies in the US – Apple, Amazon, Google, Microsoft and Facebook. In this party, government and industry dance together, but to their own tunes.

When it comes to building our science, research and innovation capabilities there is no simple solution. I've been on panels where I have heard and contributed to long lists of advice. At the end of the day, in my mind's eye it comes down to two essential attributes for leaders and individuals.

First, embrace change. The world of science and technology is moving too fast for anything less than a commitment from the top to embracing change.

Second, believe that there is always a better outcome. Conceive of a great solution, then bring together the minds of colleagues and end-users to constantly challenge yourself to find a better solution than the one you started with.

The engineers, physicists and mathematicians who built the Advanced LIGO are perfect examples of this. They made change after change, not because they were tinkerers but because they were committed optimists looking for better solutions. ☺

Dr Alan Finkel AO FTSE is Australia's eighth Chief Scientist and has an extensive science background as an entrepreneur, engineer, neuroscientist and educator. Prior to becoming Chief Scientist, he was the Chancellor of Monash University and President of the Australian Academy of Technology and Engineering (ATSE). He has a PhD in electrical engineering from Monash University and worked as a postdoctoral research fellow in neuroscience at the Australian National University. In 1983 he founded Axon Instruments, a California-based, ASX-listed company that made precision scientific instruments. After Axon was sold in 2004, Dr Finkel co-founded Cosmos Magazine.

Enhancing Australia's prosperity through technology and innovation

The Australian Academy of Technology and Engineering (ATSE)

ATSE is made up of some of Australia's leading thinkers in technology and engineering. One of Australia's four Learned Academies, it's an eclectic group, drawn from academia, government, industry and research, with a single objective in mind – to apply technology in smart, strategic ways for our social, environmental and economic benefit.

To achieve that goal, ATSE has formed a variety of expert, independent forums for discussion and action – platforms to move debate and public policy on issues concerning Australia's future. These focus on energy, water, health, education, built environment and innovation – and the international collaboration necessary to ensure that Australia is abreast of world trends.

It's an open, transparent approach – one that government, industry and community leaders can trust for technology-led solutions to national and global challenges. Each year, the Australian Government recognises the importance of the work we do by awarding the Academy an establishment grant to help with:

- Fostering research and scholarship in Australia's technological sciences and engineering;
- Providing and conducting administrative support, workshops, forums and events to enable the Academy and its Fellows to contribute on important national issues;
- Managing the development and execution of our programs; and
- Supporting relationships with international communities.

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AUSTRALIAN ACADEMY OF
TECHNOLOGY AND ENGINEERING



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Things are moving fast – and faster

SCIENCE VISION

Winston Churchill: "The further backward you can look, the further forward you can see".

Steve Jobs: "You can't connect the dots looking forward; you can only connect them looking backwards".

The Human Genome Project, completed in 2003, took 13 years and cost \$2.7 billion. Now? Maybe a couple of days and a few thousand bucks.

The world's current fastest supercomputer (China's Tianhe-2) runs at 33.86 petaflops – that's 33,860 trillion calculations every second!

And Google strategist Ray Kurzweil –

who in 1990 predicted that computers would beat the best human chess players "by the year 2000" (IBM's Deep Blue defeated World Champion Garry Kasparov in May 1997) – reckons, based on current data and current technological trends, that by 2050 we'll have a supercomputer exceeding the processing power of all human beings on Earth. And costing \$1000 ...

Some years back, I was privileged to be part of a gathering with Nobel-Prize-winning

and former Bell Labs physicist Arno Penzias who, when asked about the future of science over the next 50 years, said: "It's all about computers. And biology. Biology with computers. Roast beef from air and water and oil at will."

These days, the one thing we can be pretty sure of is that much exciting science and innovation is happening at the interfaces. And often 'strange' stuff, at that.

If you want to take a bet, take one on

'Love', by Ukrainian sculptor Alexander Milov.

PHOTO: DUST TO ASHES / BURNING MAN



“The 21st century ... will be typified by synergy, the cross-fertilisation between three fields: the quantum revolution, the computer revolution and the biomolecular revolution.” – PROFESSOR MICHIO KAKU

what will come out of Professor Paul Davies (distinguished astrophysicist from Macquarie University) having headed off to one of the new US Cancer Institutes to work on oncology.

Astrophysics? Oncology?

As far as science going forward is concerned, as distinguished physicist and author Professor Michio Kaku has said: “The 21st century, unlike the previous ones, will be typified by synergy, the cross-fertilisation between three fields: the quantum revolution, the computer revolution and the biomolecular revolution. The cross-pollination between these three revolutions will be vastly accelerated and will enrich the development of science, giving us unprecedented power to manipulate matter, life and intelligence. In fact, it will be difficult to be a research scientist in the future without having some working knowledge of all these three areas.”

Exciting times indeed – artificial intelligence, robotics, the ‘internet of things’, big data, next generation genomics, etc.

But let’s step back a bit, taking Winston Churchill’s advice: “The further backward you can look, the further forward you can see”. Correspondingly, Steve Jobs put it wisely: “You can’t connect the dots looking forward; you can only connect them looking backwards ...”.

NIKE TIME?

In November 2000, just two months before I arrived in Australia to head up CSIRO, the then Commonwealth Chief Scientist, Professor Robin Batterham AO FREng FAA FTSE, and his team released the *Chance for Change* report. It stated at the outset: “Innovation is the driver of every modern economy – it is the key to competitiveness, employment growth and social wellbeing. The cycle of innovation must be fed by new ideas and basic knowledge which are capable of being transferred and accepted by end-users.”

Fifteen years on, at the end of last year,

we get delivered the National Innovation and Science Agenda (NISA) – and with a billion dollars of new (?) money on the table. (What Samsung spend on R&D in three weeks, by the way.)

As my good friend Mark Dodgson (UQ Business School Professor of Innovation and Technology Management) observes, much of the same policy analysis and prescription behind NISA can be found in Paul Keating’s 1995 Innovation Statement. Talk about déjà vu

And surely we are also ‘reviewed out’ – maybe more than 100 reports on innovation of all sorts, from government/industry associations/consultancies over the past decade or so. For example, as Tony Peacock, CEO of the CRC Association (rightly) bemoans, 11 reviews/impact studies in the 25 years CRCs have been running.

Surely time to take Nike’s advice and ‘Just Do It!’.

PARTNER OR PERISH?

How long have we been talking about the need for much better collaboration? Yet we continue to languish at the very bottom of the OECD League Table of collaboration between our nation’s innovation-active firms and our universities and research institutes.

One of my favourite little books is Robert Fulghum’s *All I really need to know I learned in kindergarten*. This includes lessons such as ‘play fair’, ‘don’t hit people’, ‘put things back where you found them’. And germane to our environmental responsibilities to our planet – ‘clean up your own mess’. (And a special favourite amongst my academic friends ‘take a little nap every afternoon!’)

And Fulghum reminds us of back then, when our teacher might have taken us on a visit to the fire station or the chocolate factory, and would say “Hold hands and stick together. There’s a lot of heavy traffic out there.” Indeed there is ...

There are strong signs that the future belongs to the boundary-crosser and skilled collaborator, so we’d better get good at this. Harvard’s Rosabeth Moss Kanter has elegantly coined a spacefaring analogy, akin to astronauts, by introducing the concept of ‘collabronauts’, who are “... good at making connections, both human and intellectual. They are constantly on the look-out for new ways to benefit from combining forces with partners. They venture into unfamiliar territory, make deals, and return with knowledge that transforms their home base. They bring organisations closer together, introduce people and build relationships among groups that can initially seem like aliens to one another. They manage rumours, mount peace-keeping missions and solve problems. They convince their colleagues to forget old rules and try something new, something that comes with having partners.”

Lots of IQ, coupled with bags of EQ (emotional quotient). All business is people business.

BEWARE ‘LOST IN TRANSLATION’

There is a major gap between what we know and what we actually apply. Basically it’s a crying shame that there is so much great stuff around, in journals, on shelves and in heads, which is not getting utilised or built upon.

Sir Muir Gray, former Director of the UK’s NHS National Knowledge Service and NHS Chief Knowledge Officer, has said: “The application of what we know already will have a bigger impact on health and disease than any drug or technology likely to be introduced in the next decade.”

This challenge also applies in the policy space. Former Australian Public Service head, Dr Peter Shergold AC, wrote (2011) in the *Australian Literary Review* of the void between policy practitioners and policy academics ... and quoting (and agreeing with) his successor, Terry Moran AC: “Academic work was often ‘lost in translation’ because it was inaccessible, indigestible and obscure. Too often it was unresponsive to the immediate needs of governments. By the time research was published it was out of date.” Ouch.

We must accelerate the process from discovery – continuing (of course) to stimulate the excitement and support for working at the leading edge – through to delivery, and the rapid transfer/diffusion of technology between research and the market.

We must ensure that we just don't do great science but that it gets taken up, rapidly and effectively, creating jobs, wealth and improvement in quality of life.

'TWO TO TANGO'

We put a lot of heat on our universities and research institutions to collaborate better. But in the past financial year \$19.7 billion was claimed by business in Australia as R&D, as part of the R&D Tax Concession system currently under review. Yet detailed analysis has revealed that only 2.6 per cent of this (\$505 million) went to our universities and research institutions.

This begs the question – in terms of who's dancing with whom – who's doing the other 97 per cent? Especially, as we know, in recent times the big corporates have been outsourcing their R&D.

Definitional issues, no doubt, play a part. But it needs clarification.

My former CSIRO Chair, Catherine Livingstone AC FAA FTSE, notably lamented "if only Australia knew what Australia knows". 'Lights under bushels' is indeed a challenge. One of the delights – and corresponding concerns – of my job is that, most days, when I'm out and about, I find myself thinking: "Wow! I didn't know we were doing that stuff!"

We need business, government and the community to be 'greedy gobblers' of research outcomes and technology solutions. This, in turn, requires the science and research community to be (much) better relationship builders and communicators around where we spend our time, and (mostly) taxpayers' dollars.

'THE SMART STATE'

So what's happening in Queensland, now and for the years ahead?

I'm an unapologetic fan of former Premier Peter Beattie and the whole Smart State initiative – vision, coupled with serious investment, over more than a decade – a great foundation on which we are building, irrespective of which side of government you come down on.

The recent \$180 million Advance Queensland initiative has two key elements: *talent* – you don't turn that on and off like the

proverbial light switch – and (much) better *translation*.

We have major Partnership programs, linked to our well-defined Science and Research Priorities, with at least two research institutions 'holding hands', and with an end-user partner(s) with serious skin in the game. And in these, as well as in all our new Fellowship programs, the researchers involved have to spend at least half of their time 'in the business' – building relationships, solving problems in real time and working hard to minimise the lost-in-translation stuff.

A whole new cadre of industry-savvy researchers is what we're after – and a cadre that is also much better at communicating what they are doing, and why, supported by a funded and focused 'science engagement' strategy.

And far from resistance around this 'residency' requirement, anticipated by some, we observed a 34 per cent increase in applications.

In driving the translation and commercialisation agendas, we have put in place a suite of exciting programs stimulating startups and entrepreneurship and small business – the engines of jobs growth – with a strong commitment by government to unleash procurement as a driver of innovation, with much closer relationships and opportunities for small business in Queensland.

We have a clear understanding that STEM education is pivotal to our future – underpinning 75 per cent of new jobs, we're told – and know Australia is getting behind the pack, particularly the leaders of the international pack.

Recent months have shown a serious momentum shift. The 'buzz' is palpable. Things are happening.

We've had the hugely successful World Science Festival Brisbane in March – the first time ever out of New York – with more than 120,000 people involved over a four-day smorgasbord of science and technology, brilliantly orchestrated by Professor Suzanne Miller and her Queensland Museum team.

We've also had the inspiring April Innovation and Investment Summit – with a social media reach of more than 18 million and thousands of people in live-streaming – and its 'sister' Startup Festival, with hundreds of local entrepreneurs rubbing shoulders with national and international gurus.

If pushed to provide a single highlight (among many) of my tenure as Queensland Chief Scientist, it would be time spent with six, seven and eight-year-olds.

I'm there nominally to inspire them. The reverse always happens. They're creative, enthusiastic, questioning ... they can do anything.

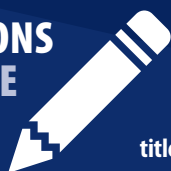
But as big people – as Alexander Milov's sculpture 'Love' suggests – a lot of the time we have our backs to each other. We're competing. Not communicating. Not collaborating. But our 'inner child' wants to connect – to hold hands, to break out, to question, to create.

Piece of cake, eh? ☺

Dr Geoff Garrett AO FTSE is a Cambridge-educated metallurgist who spent 13 years as an academic. He has been Queensland Chief Scientist for the past five years. Prior to this he led, as Chief Executive, two of the world's major national science agencies – CSIRO in Australia (2001–08) and CSIR in South Africa (1995 to 2000). A former South African 'Boss of the Year' (1998) and 'Engineer of the Year' (1999), he received the Centenary Medal for service to Australian society through science. In June 2008 he was appointed an Officer of the Order of Australia (AO).

There's a major gap between what we know and what we actually apply ... it's a crying shame that there is so much great stuff around, in journals, on shelves and in heads, which is not getting utilised or built upon.

**CONTRIBUTIONS
ARE WELCOME**
FOCUS



Opinion pieces on technology related topics, preferably between 600 and 1400 words, will be considered for publication. They must list the full name of the author, if a Fellow of the Academy. Other contributors should provide their full name, title/role and organisation (if relevant) and email address. Please address to editor@atse.org.au



Our vision is to create sustainability and excellence in Australia's power engineering.

What is the API?

The Australian Power Institute (API) is a not for profit national organisation established by the Australian power industry to boost the quality and numbers of power engineering graduates with the skills and motivation for a career in the energy industry which encompasses:

- Generation, transmission and distribution utilities
- Manufacturers and suppliers to the industry
- Consultants to the industry
- End users of electricity in their operations.

Value Proposition

To deliver a sustainable supply of highly skilled power engineering professionals working effectively to meet the challenges of creating Australia's new energy future, and underpin the technical and commercial success of member companies in the energy sector.

The key objectives of API are to achieve the following:

- Provide a sustainable supply of quality power engineering graduates to industry
- University power engineering teaching and learning provides relevant industry skills
- Value added continuing professional development programs
- A respected organisation leading the national development of power engineering skills.

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BY MARY O'KANE
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The University of Sydney's solar-powered Ladybird robot – in action on a Cowra, NSW, beetroot farm – has an array of sensors for detecting vegetable growth and pest species, and a robotic arm to remove weeds.

Reflect on trends to inform smart choices

PHOTO: UNIVERSITY OF SYDNEY

SCIENCE VISION If Australia makes some very clever choices on the back of looking at trends, it could absolutely reverse its productivity woes and have a very successful march to 2030.

T

The past is the good predictor of the future – barring disruptive events. So when exploring the opportunities in science

that might lie ahead for Australia in 2030 and beyond, it's worth considering past trends, as well as trends emerging from what's happening right now.

A few trends are very clear. Some of them are directly about science; others affect science, including geopolitical issues.

GEOPOLITICAL TRENDS

The biggest geopolitical issue facing Australia moving forward is the continued rise of China – as an economic and a science superpower.

China's national economy, although

slowing, is second largest in size behind the US and its total contribution to high-quality science has surged in recent years – placing second behind the US on the *Nature Index*.

The Chinese Government has invested significantly in research to not only grow its knowledge-based economy and spur innovation but also find solutions to complex health and environmental challenges, such as its ageing population, air quality and water shortages.

China's upsurge in science and innovation has been underpinned by a strong culture that is about supporting new knowledge – including high levels of education through to doctorates, and large respect for engineering and technology among its people. It is this culture that will see China continue to soar in science.

Similarly, I expect we will see India go from strength to strength in R&D, with particular specialties in the ICT space.

Other Asian nations will increase their contribution to science and technology – most notably Korea, Japan and Malaysia. But it's also likely we will see the evolution of Vietnam, Cambodia and Indonesia as serious science players as they attempt to follow China's lead.

It puts into sharp focus Australia's future role in science in the Asia-Pacific.

We are a small country with considerable research strengths for our size – although, since our population is small, our overall research impact is not large. In the future we will be neighbour to a very big research power in China, and that will present challenges, as well as opportunities.

Climate change is another geopolitical issue which will pose scientific challenges and opportunities for Australia moving forward. Ongoing concerns in this space will place renewed emphasis on new energy issues.

And there are straight geo trends that we should contemplate too. It is almost inevitable there will be catastrophic natural events in our region between now and 2030 – particularly around the Pacific Rim, where we will probably see some very large earthquakes. How that will affect science is unknown but it does show we need to continue scientific studies around earthquakes and tsunamis.

SCIENCE TRENDS

There are four really big characteristics that stand out right now – data, sensors, intelligence and new materials.

1 DATA is available in huge volumes from many and varied sources. And we're getting better at capturing, analysing, curating and sharing data – even when it comes to big, big data.

2 SENSORS are becoming cheaper, being deployed in cleverer ways, and are generating massive amounts of data which can be processed, analysed and interpreted in real time.

3 INTELLIGENCE. We're seeing the development of increasingly intelligent systems and devices. This includes machines which, when fed data from big data analytics or directly from sensors, use machine-learning techniques to become even more intelligent – and so the intelligence in turn will build.

4 NEW MATERIALS. There continues to be major advances in new materials through a lot of fascinating research in nanofabrication, biomaterials, quantum computing and photonics – and all of these coming together. And when you throw data, sensors and intelligence into the mix you get a potent brew!

DERIVED SCIENCE TRENDS

From that we have what might be termed 'derived science trends'. One example is the increasing deployment of big and small robots. Robots operate because they have sensors on them that take in data. They are intelligent, autonomous machines, which are often built of innovative new materials; and they have wide range of applications.

Another example of a derived science trend comes in the personalised medicine domain – where we draw heavily on developments in biology over the past half century or so and, in particular, on the rapid developments in genomics that are happening at present. These link, of course, to developments in big data and data analytics.

RESEARCH PROCESS TRENDS

There are also research process trends – two in particular:

- the move to big transnational research – researchers working together in virtual space, simultaneously doing work that is intensely local and intensely global. This, of course, is enabled by very big, very fast data pipes and this will continue and we'll have very good interfaces for people to work together and act and interact at a distance. For example, we could see a surgeon sitting in Nigeria and the patient in Iceland;

- the strong culture of 'open' – which will be very well established by 2030 but is already gaining impetus

In particular, the move to **open data** has been widely embraced – including by governments internationally. A prime example is the open.gov initiative of US President Barack Obama, which has been replicated in many countries around the world.

We're also seeing more and more **open science** initiatives – such as that being led by Associate Professor Matthew Todd at the University of Sydney, who has a keen interest in open science and how it may be used to accelerate research, with particular emphasis on open source discovery of new medicines. He founded and currently leads the Open Source Malaria (OSM) and Open Source TB (OSTB) consortia, and is a founder of a broader Open Source Pharma movement.

And there's **open innovation** too – think of the University of NSW's Easy Access IP Scheme, which has been picked up by other universities and supported by the NSW Government.

These will be very significant trends to watch. They are by no means all the relevant trends – but they are some important lines pointing to the future.

So what does this mean for Australia? Predicting the future is a very dangerous game and it's one that very few people are good at. But for Australia, in many cases, these trends really give us the chance to make some choices – often very bold choices.

There are some good examples.

Already we have seen some industries make some very bold choices using some of these trends. Possibly some of the best known examples of this are in the areas of big robotics.

The mining and freight and logistics industries have been transformed through advanced field robotics technologies developed in NSW. Rio Tinto's fully-automated 'mine of the future' in Western Australia's Pilbara region, and Patrick's robotic-reliant Port of Brisbane both use technologies developed by researchers at the Australian Centre for Field Robotics (ACFR) at the University of Sydney, formerly headed by Professor Hugh Durrant-Whyte FRS FAA FTSE.

The ACFR team, now led by Professor Salah Sukkarieh FTSE, is having a major impact in agriculture. They're working closely with several of the rural research corporations to do a lot of automation in agriculture – using big robotics to gather information to make farmers more effective, but moving in the future towards automated harvesting. Already they can do things like rounding up sheep.

We also see the work going on at the CRC for Spatial Information on precision farming – using satellite data to do things like measuring soil moisture to direct tractors for tilling soils.

NEW SENSORS

All the time we are seeing new sensors being developed using new materials and materials properties – to make a lot of the intelligence embedded in the new materials. UNSW's Professor Justin Gooding and the University of Wollongong's Professor Gordon Wallace FAA FTSE are leaders in this field.

In genomics, Professor John Mattick at the Garvan Institute is working collaboratively with Professor Durrant-Whyte on big data issues, which will lead to personalised medicine. A lot of that great work is already embedded in the NSW health system.

We're seeing a lot of work in the new energy space – including the world-leading research being undertaken by the 'father of photovoltaics', Professor Martin Green AM FRS FAA FTSE, from the Australian Centre for Advanced Photovoltaics at UNSW. Professor Green's team has repeatedly set new world records in solar cell energy efficiency – recently achieving an electricity conversion rate of more than 40 per cent. It comes as

take-up of these technologies around the world grows.

Once of the challenges in moving to cleaner energies is understanding storage. Professor Thomas Maschmeyer FAA FTSE at the University of Sydney, a great creator of successful new companies, is addressing this issue creatively. There's also excellent work at UNSW, and the University of Newcastle through the Newcastle Institute for Energy and Resources, and at CSIRO.

In the data realm, the NSW Government has established the Data Analytics Centre to facilitate data sharing between agencies (and between agencies and the private and community sectors) to inform more efficient, strategic, whole-of-government, evidence-based decision-making. We also see coming out of the Independent Review of Coal Seam Gas Activities in NSW, the NSW Government's adoption of a recommendation to have a whole-of-government environmental data portal. This will increase productivity by enabling more effective and efficient management of government-held data, and help build trust by making that data publicly available and transparent.

In the move to 2030, we will see industries such as mining, which have traditionally been great leaders in the uptake of new technologies, push even harder than at present to find the next big minerals undercover: trying to find the next Olympic Dam, the next Broken Hill, and the next Mount Isa. And we'll see them using those new technologies associated with big data analytics, sensors and intelligence to find that. I predict that by 2030 two or three of those big undercovers will be uncovered. Another plus is the fact that, using big robotics, we will have increasingly safer underground mining techniques, as well as open cut.

There are choices that other industries could make too. One of the other geopolitical challenges facing the developed world is a very much greater ageing population. But it also opens up a wonderful opportunity in things like robotics-assisted aged care – something Japan has already made great strides in.

There are four really big characteristics that stand out right now – data, sensors, intelligence and new materials.

Similarly, the area of genomics will really get going if the big actors in healthcare take it up. That includes governments at all levels. While the notion of genomics is being explored, it won't be until all of Australia's health systems move to a dedication to personalised medicine that we will be able to use big data to inform increasingly tailored treatments and medicines for individuals.

We see through the Ministry of Health in NSW a strong dedication to taking up new technologies, including through the Medical Devices Fund established by NSW Health Minister Jillian Skinner. The Fund invests in productive new technologies only if they have clinical relevance.

Australia also has big opportunities if it makes choices around the environment. Because we are a relatively big country and sparsely populated, we have always had to develop techniques to get loads of data so that we can operate effectively across the continent.

A good example of this is the development of AMDAR (Aircraft Meteorological Data Relay – automated meteorological reports from aircraft) in the Bureau of Meteorology – even if it wasn't brought fully into commercial operation here, the idea originated here.

Likewise, with many, many sensors we could develop lots of technologies about sensing in the environment, and this is of particular help to companies that wish to operate in the environment – perhaps negatively impacting it: for example mining and gas operations. But if they can do that and give environmental assurance using sensor and big data technologies that will increasingly deal with agitation in the community.

But when it comes to geopolitical trends and what that means in terms of choices – particularly in relation to the rise of China – Australia must be very realistic about how we can use partnerships with the rising science super power. What should we do at home? What should we do in partnership with China? We need to remember that China will have a lot of investment in Australia.

There are many questions of this kind that can be posed. How might industries look clearly at where the trends are and new opportunities they present? In doing so, they can help themselves be very productive if they remember the strengths of our universities and other research organisations as super problem solvers.

Universities, because of their research expertise, are good at posing and refining problems and working together to ask and articulate what the issue is. And universities are great connectors with a strong international reach. Ask an academic to solve a hard problem and if they don't know how, they know who will.

If Australia makes some very clever choices on the back of looking at trends, it could absolutely reverse its productivity woes and have a very successful march to 2030. ☺

Emeritus Professor Mary O'Kane AC FTSE is the NSW Chief Scientist and Engineer, a company director, and Executive Chairman of O'Kane Associates, a Sydney-based consulting practice specialising in government reviews and research and innovation matters. She is also Chair of the boards of the Cooperative Research Centre for Spatial Information, the Space Environment Management CRC and the Institute of Marine and Antarctic Studies at the University of Tasmania. She is also a director of the New Zealand Antarctic Research Institute, Capital Markets CRC and Business Events Sydney. Professor O'Kane was formerly Vice-Chancellor of the University of Adelaide and Chair of the Australian Centre for Renewable Energy.





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BY LEANNA READ
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Mobilising our *Mittelstand* of growing SMEs

SCIENCE VISION My vision for 2030 is to transform our economic mix to one dominated by export of high value-add goods and services.

H

Happily, we are hearing a lot these days about the importance of innovation, science and technology to drive Australia's economic

recovery. In contrast with just a few years ago, there is recognition by both government and industry of the need to transform our economy.

This is because our traditional industry base is eroding. Automotive manufacturing is winding down, falling commodity prices are impacting employment in the mining sector and primary agricultural production is under threat from climate change.

Innovation through the application of science and technology is key to this transformation – working smarter so we can stay ahead of the game.

This is particularly critical for South Australia with its small population and historical reliance on primary production. Resources and agriculture together account for nearly half of the state's exports. Basically, we dig it up or grow it and ship it out!

Yet through innovation, we have enormous opportunity and capacity to value-add to these natural resources.

My vision for 2030 is to transform our economic mix to one dominated by the export of high-value-add goods and services.

South Australia's new industries will not look like the ones they are replacing. In 2030, the majority will still be small to medium enterprises (SMEs), but they will need to be highly innovative and nimble to prosper in an increasingly competitive world.

This is termed the '*Mittelstand*' sector in Germany.

So how will SA achieve this?



PHOTO: SUNDROP FARMS

Sundrop Farms, near Port Augusta – one of SA's Mittelstand – where fresh fruit and vegetables are grown – without 'arable' land, fresh water or grid energy.

NISA POSITIVE

The suite of initiatives announced in the National innovation and Science Agenda (NISA) is very positive. The breadth of measures around research commercialisation, including support to translate research outcomes and encourage research–industry collaboration, as well as increased funding to early-stage companies, will bring welcome cultural change.

These complement nicely a range of initiatives that the SA Government has introduced, such as loan guarantees for growth companies, and the establishment of new industry precincts, including: a Food Park in Adelaide's northern suburbs – the

Tonsley Innovation Precinct for advanced manufacturing; an expanded bioscience precinct at near-city Thebarton; and BioMedCity, in Adelaide's western CBD, which includes the South Australian Health and Medical Research Institute (SAHMRI) and the new hospital, as well as the universities.

In particular, I welcome NISA's reforms to promote investment in innovative, high-growth start-ups by providing concessional tax treatment for investors. When Israel introduced similar measures in 2011, it drove an exponential growth in the number of early stage (angel) investors.

What will the economy of South Australia

SA's new industries will not look like the ones they are replacing. In 2030, the majority will still be SMEs, but they will need to be highly innovative and nimble.

look like in 2030 if it takes advantage of these initiatives?

Ideally, we will have at least several large, global companies headquartered here – such as innovative pharma/biotechs like CSL (Australia's largest exporter of manufactured goods) and a Lockheed Martin equivalent for defence manufacturing.

SA's central role in the submarine and frigate manufacturing programs is a very positive development in this regard.

But it will be some time before SA can expect to grow these large corporations from the ground up. SA is an SME state – of the 143,000 registered businesses, 65 per cent are sole traders and less than one per cent have more than 20 employees.

In the shorter term, we can draw on some useful lessons from the German *Mittelstand* SME sector.

There are many differences between Australia and Germany – population and proximity to large markets, in particular. But we share the common feature that SMEs comprise over 99 per cent of all companies.

A key distinction between the two economies is that Australian exports are dominated by large enterprises, with only five per cent of the export value attributable to SMEs. In Germany, SMEs generate more than 30 per cent of total export value.

A second distinction is that Germany concentrates on elaborately manufactured goods, in contrast to Australia's dependence on primary production for its exports. For this reason, Germany is rated the third most complex economy according to the Economic Complexity Index developed by the Observatory of Economic Complexity. Australia ranks 56th.

The significance of this difference is that the Economic Complexity Index is estimated to predict more than 70 per cent of a country's future wealth. Consistent with this, Germany is the third largest export economy in the world, where Australia ranks 21st.

FAMILY COMPANIES

Germany's *Mittelstand* SMEs are not household names and most are family-owned companies. Their success has been achieved through identifying and perfecting a niche technology with a big global market, with a strong focus on manufacturing products such as laser cutting machines, industrial automation and measuring equipment. Examples include Micon (drilling equipment that helped save trapped Chilean miners) and Poly-Clip System (the ubiquitous clip at the end of sausage or meat packaging).

The lesson here is that an SME-intense state such as South Australia can achieve a strong globally competitive position if we shamelessly focus industry policy on supporting the local *Mittelstand* enterprises. This will require a degree of picking winners, and considerable cultural change.

The SA Government has already moved in this direction with the formulation of '10 Economic Priorities', which identify the sectors that can best contribute to the strategic aim of positioning SA as "the place where people and business thrive".

If SA to achieve this vision of growth through innovative SMEs, the question is, who are our *Mittelstand*? Many of our small companies – perhaps 90 per cent – have little ambition to grow.

But there are hidden gems. SA has a large proportion of Australia's electronics industry. Another gem is Sundrop Farms.

Located near Port Augusta in the Spencer Gulf, Sundrop Farms is reinventing agriculture by growing high-value crops hydroponically using desalinated seawater. Its greenhouses can be located on degraded land and in arid climates, which typically would not be considered suitable for agriculture, let alone horticulture. This horticultural system uses desalinated seawater, powered by concentrated solar-thermal technology (not solar PV panels), to grow fresh fruit and vegetables for sale to

businesses across Australia – without 'arable' land, fresh water, or grid energy.

It is important that we develop a clear and comprehensive picture of our innovative companies. Only then can we take the necessary steps to ensure they flourish and drive the state's prosperity. We also need to create the right climate to establish many more innovative start-ups – this will require cultural change to promote a more entrepreneurial mindset than has traditionally been the case.

To answer the question of who are our innovative companies I have taken a lesson from the OECD, which conducts a Community Innovation Survey every four years. This survey provides great insight into the achievements and challenges facing innovative European companies.

Under the auspices of the SA Economic Development Board, the South Australian company innovation survey has been rolled out for the first time this year, with more than 1500 SA companies approached. Respondents have spanned the manufacturing, food and wine, information technology, electronics and medical technology sectors. Most are SMEs with five to 20 employees and annual revenues of \$1 to \$5 million.

The interim findings are encouraging, with 80 per cent of respondents indicating they have developed or plan to develop new products or services, with a strong export focus. Their biggest challenge relates to the high cost of innovation – they either lack the internal funds or have inadequate external financing to fund high-risk projects.

With this survey we will establish, for the first time a comprehensive picture of the state's innovative companies – their offerings, size, customers, suppliers and technology, as well as opportunities and barriers to growth.

This is of course only the start – the real challenge is transforming our economy so that these 'gems' become the South Australian *Mittelstand*.

But – as in the old adage – if you can't measure it, you can't manage it! ☺

Dr Leanna Read FTSE is the Chief Scientist for South Australia and chairs the SA Science Council. She also chairs the CRC for Cell Therapy Manufacturing and is a member of the SA Economic Development Board, the Council for the University of South Australia and the Federal Biomedical Translation Fund Committee. She is a long-standing member of BioAngels, an 'angel investor' network. Prior roles have included CEO of the CRC for Tissue Growth and Repair and the founding managing director of biotechnology company, TGR BioSciences Pty Ltd. She is a former Director of ATSE.



BY PETER KLINKEN
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The Pawsey Supercomputing Centre in Perth.



Taking the lead – based on science

SCIENCE VISION Science will provide amazing new opportunities, with the potential to create new industries. We must be wise and agile enough to grasp them.



Western Australia has become a world leader in mining, petroleum and agricultural industries, all strongly based on science. For example, WA's geological survey has been operating for more than a century and has been instrumental in developing the resource sector.

Significant investment by the sector has produced amazing capabilities in many areas, such as remote mining methods, and offshore oil and gas technologies. In addition, the application of science in processing methods has allowed the state to mine large, low-grade mineral deposits and become a world leader, not just in mineral exports, but in technology as well.

Agriculture is also an area in which WA excels. The agrifood business is one of the state's

biggest export industries. WA's agricultural and fisheries sectors are highly innovative by world standards, especially in dryland farming and sustainable seafood production.

The agricultural sector is harnessing big data technology to manage smarter farming techniques across a range of industries. One example is a free app for growers, developed by the WA Government, to improve water use efficiency and simplify crop irrigation using real-time data from the state's 136 weather stations. The app is increasing productivity for 2500 agricultural irrigators, across 61,650 hectares of food, vegetables, orchards, pasture and turf.

WA also has a strong base of medical research and translation, with world-class clusters of health-care delivery and research facilities. The state has invested \$7 billion in health infrastructure over recent years.

Numerous researchers, including Nobel Laureates Professor Barry Marshall AC FRS FAA and Dr Robin Warren AC, have made seminal contributions to global health and medicine.

This proud history has been underpinned by extensive collaboration between government, universities, medical research institutes and the private sector.

One strength is long-term population health studies: the Busselton Health Study and the Raine Study are both globally recognised for their longitudinal population health analyses. Another strength has been data linkage of health records.

WA has done extremely well in these sectors, but there are other areas where I believe there are massive opportunities for Western Australia.

One of the biggest opportunities is the

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Square Kilometre Array. The world's biggest radio astronomy project, shared with South Africa and driven by a massive international consortium, is being built in remote WA.

A decade ago, WA had virtually no radio astronomy. Now, thanks to the initiative of CSIRO, the Commonwealth and State governments, the University of Western Australia and Curtin University, Perth has become an internationally recognised centre for radio astronomy. Through excellent recruiting of international research leaders, WA now has more than 130 radio astronomy researchers.

This shows what is possible if you have a common vision, investment and long-term planning.

As a result of the efforts and vision of local researchers, Edith Cowan University is leading efforts to combat cyber crime through the Australian Cyber Security Research Institute. The Institute is developing innovative software, processes and algorithms to generate new cyber security technologies that will provide long-term benefits to governments and industry.

When I took on the role of Chief Scientist I knew that WA was a terrestrial biodiversity hotspot. However, until recently, I was unaware that WA is one of the hottest spots worldwide for aquatic biodiversity, and that much of this aquatic biodiversity occurs only 20 kilometres west of Rottnest Island, which is just off Perth.

Given the uniqueness of this vast resource, I believe that we should be looking to extract value from biodiversity. Identifying novel compounds in this unique biota may uncover new antibiotics, anti-cancer agents and other medicinal compounds. This would enable WA to develop new industries, including biotechnology and pharmaceuticals.

I would love to see WA develop a new life sciences industry where we could build on strengths that link agriculture, medical research, biodiversity and marine sciences.

Another area that I have been really impressed with is the renewable energy sector, particularly companies that are using Indian Ocean wave power to generate energy. As a keen surfer, wave power is especially meaningful to me. One of these companies is Carnegie Wave Energy, whose technology is converting wave energy into electricity while also producing desalinated water.

Other companies include Bombora Wave Power and Protean Wave Energy, which utilise different forms of wave technology. Innovations such as these capitalise on the natural advantages that WA possesses, and present wonderful opportunities for the state.

Currently, there is considerable excitement around analysing big data, which will propel WA towards a new era of computing and analytics. New infrastructure at the Pawsey Supercomputing facility, the major data processor for the Square Kilometre Array, will be able to perform billions of calculations simultaneously, opening up enormous opportunities for researchers and industry to manage and process vast amounts of data.

These data science capabilities will have applications in many other areas, such as locating new mineral deposits,

modelling coral reef systems and analysing the effects of genes on health.

While the Pawsey Centre may be the largest research supercomputer in the country, an even larger supercomputer, owned by Perth company Down Under GeoSolutions, provides massive capability for geoseismic data analyses.

Cisco recently opened its 8th global Innovation Centre in Perth, in partnership with Woodside and Curtin University.

These and numerous other projects being undertaken by government, academia and industry are leveraging cloud technologies, data analytics, cyber security and 'internet of things' network platforms, focused on resources, geosciences and radio astronomy.

Paramount to our success in future years will be a clear vision for science, investment and planning. It is crucial that we articulate these strategies well to foster innovation.

Research is critical for solving the challenges we face. New solutions don't fall magically from the sky. Science should, therefore, be seen as an investment rather than a burden. Too often I have heard the statement that research is a 'black hole' into which money gets poured, and from which there are no tangible benefits.

What that tells me is that scientists, engineers and mathematicians have not been able to explain convincingly what they do and the value they provide to society.

In my view, it is incumbent on scientists to explain what they do in simple terms and to engage with the community. If that is achieved, the community will come along as passionate advocates. This will develop a culture that values scientific endeavour and

WA is one of the hottest spots worldwide for aquatic biodiversity ... Identifying novel compounds in this unique biota may uncover new antibiotics, anti-cancer agents and other medicinal compounds.

understands the powerful role that it plays in society.

WA has benefited enormously from the wealth generated by the resources sector, all based on remarkable innovative approaches. I would now love to see Perth transform itself into a centre of innovation and creativity.

Such a transformation requires the joint effort of universities, government, industry and the community to create an exciting environment for science and innovation to flourish, and to be complemented by a rich arts and culture scene, vibrant music, and fantastic food and wine.

Most of the elements are already in place. The WA start-up technology ecosystem is already blossoming, with more than 335 early stage companies employing more than 3000 people.

In 2015 the Premier launched 'A Science Statement for Western Australia', which identified five priority areas that the WA Government would concentrate on – the document also showcased many of WA's scientific, engineering and mathematical achievements.

The five key priority areas are based on WA's existing strengths, as well as areas of

great opportunity. This clear direction for science is essential for the most efficient use available resources and for alignment of research efforts across the state.

I believe we have a wonderful opportunity to do something very special in WA right now. Our state is strategically placed geographically and is situated in the same time zone as 60 per cent of the world's population, which is responsible for 40 per cent of world GDP.

This is our time, and we must be the masters of our own destiny. Science will provide amazing new opportunities, with the potential to create new industries. We must be wise and agile enough to grasp them. ☺

Professor Peter Klinken is a leading WA medical research scientist, highly regarded for his work in advancing the understanding of genes involved in leukaemia, cancer and anaemia. His many research achievements include the discovery of a gene that suppresses the growth of tumours. After obtaining his PhD from The University of Western Australia, he undertook research at the US National Institutes of Health in Washington and the Walter and Eliza Hall Institute in Melbourne. His previous roles have included Professor in Clinical Biochemistry at UWA, Director of Research at the Royal Perth Hospital, and Director of the Harry Perkins Institute of Medical Research (previously the WA Institute for Medical Research).

"ENTHUSIASM FOR THE POSSIBLE"

Innovation and Science Australia chair Mr Bill Ferris AC has urged Australian entrepreneurs and researchers to embrace collaboration with confidence, telling a conference on Driving Research Impact that Australians needed "an enthusiasm for the possible".

"Australians have proved themselves to be exceptionally good competitors," Mr Ferris said. "We compare ourselves with the biggest and the best, not with 'nations of comparable size and population'. We take a bold approach and it's worked for us, again and again.

"Finishing outside the Top 10 in the Olympic medal tally would be regarded as outrageous in Australia," Mr Ferris said. "But where do we sit in regard to collaboration between industry and academia? – 30th out of 30 OECD countries in terms of collaboration

between large businesses and higher education and public research institutions."

Mr Ferris said that change had to occur and was occurring under the National Innovation and Science Agenda.

"What will a successful response look like in future years? Universities will be the hotbed of entrepreneurship, where spin-offs of new technology businesses number in the hundreds annually.

"Businesses, big and small, will be collaborating with the smart research campuses in their sectors, competing to co-invest in the development of new products and services.

"We will at last have an entrepreneurial ecosystem that gets Australia into the Top 10 innovation nations of the world."





BY LEONIE WALSH
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Change key to competitiveness and economic growth

SCIENCE VISION The willingness and flexibility to change in all sectors of the technology ecosystem and the increased openness to collaboration has been encouraging.

In my role as Lead Scientist I have had a unique opportunity to view first-hand the changes in the Victorian science, technology and innovation sector. My perspective has been to observe the gaps and improve the effectiveness of the technology ecosystem to better support the changes necessary to increase our global competitiveness and support economic growth.

A number of themes have emerged as concerns from within the sector that will require significant attention. These themes fall under the broad categories of:

- keeping pace with the changing demand for jobs and skills of the future workforce;
- reaping the rewards of the innovation economy;
- unraveling the complexity of industry/academic collaboration; and
- maximising access to our talent pool.

JOBS AND SKILLS

It has always been a challenge for students to predict where the market is heading when they choose the subjects that will help define their career path, but it is fair to say that it may never have been as challenging as in the current market.

Technology is impacting the evolution, elimination and replacement of many jobs across a broad range of sectors. The rate of change is faster than most companies or the education system can keep up with. This dynamic environment has resulted in an oversupply of graduates in some areas and a greater than normal lag in the supply of graduates with new and emerging skills in areas such as cyber security, bioinformatics and data science.

This is compounded by industry's demand for a broader range of attributes such as interpersonal skills, workplace readiness and creativity – placing a heavy demand on students, teachers and the education system as a whole.

This demand is unlikely to change any time soon and will require a greater degree of communication, collaboration and shared responsibility between the public and private sector to provide improved outcomes for the workplace and the students entering it.

The solutions and resources provided to better inform students, bridge gaps in the education system and respond to additional skills and capabilities as they emerge will need to be based on technology and teaching styles that can evolve in line with the dynamic nature of change and be flexible

and fast to implement.

The Victorian Government's Tech Schools initiative is one example of a flexible and collaborative solution created with partnerships between multiple sectors of the education system and industry that will provide innovation, entrepreneurship and other 21st century workforce skills.

Internships, work experience models and outreach programs are also being introduced in abundance to bridge the skill gaps. Much effort will be required to effectively match and manage these types of programs and evolve curriculum and teaching styles to keep pace with the change.

REAPING THE REWARDS

A recent disruptive innovation presentation to a group of Geelong business people raised many questions and highlighted some of the challenges and opportunities facing organisations and communities embracing the innovation agenda.

Questions were focused on how to support companies or industries that are being disrupted, and how to recognise the opportunities, build better commercialisation skills and develop a community-wide culture of innovation. These are all good questions at a company, community and country level.

Examples of organisations responding to disruption in their sector in a very positive way resulting in revenue and market and value growth on a global scale are plentiful in Victoria. The common theme amongst these companies is a combination of regular horizon scanning and product or service innovation, along with business model innovation. The other very important

What has been encouraging over the past three years is the flexibility and willingness to change exhibited by all sectors of the technology ecosystem.

ingredient is a flexible, nimble, risk-taking and open leadership style that gets the best from employees, partners and the market.

An innovation culture can spread from increasing these types of companies and embedding more of this type of leadership in broader areas of the public and private sector, but this is a slow process.

Attracting companies and international leaders with this type of profile can help move along this process and build skills at a more rapid rate. Victoria has attracted a number of these highly innovative companies in recent times, with the potential for more to follow.

Improving Australia's position on the Global Innovation Index from a ranking of 81 out of 141 OECD countries to at least a top 20 would demonstrate our ability to generate value from innovation and attract businesses and funding to Australia.

COLLABORATION

Much has been said about Australia's poor performance on industry/academia collaboration and the main point to raise is that we have significant room for improvement in this area.

There is a range of reasons why every Victorian university is focusing on improved collaboration. Sadly, some universities are driven predominantly by the reduction in public sector funding. Others are building on an already established base or have new leadership driving change at an organisational and faculty level because they see the opportunities and value potential for all stakeholders.

Industry interest in engagement is also patchy, with a need to see the value proposition and outcomes for this investment in time and funds.

The trend is a positive one, however it is early days with significant cultural shifts required to create sustainable change. Funding model change will continue to drive collaboration behaviours and new models of engagement will emerge as universities start to introduce mechanisms to focus on more

targeted research and introduce measures around research impact.

MAXIMISING ACCESS

In the three years I have been the Lead Scientist for the Victorian Government I have seen an increase in focus on supporting women in science. However, we have a long way to go before significant and sustained positive changes are embedded that help remove barriers to women in science, technology and innovation achieving their full potential.

Programs such as Inspiring Women have helped provide support to high-potential women in research, allowing them to

that appeals to girls and women.

Although we have had a high level of attention on maximising our talent pool of STEM women, there are other diverse areas that get little attention but could make a significant contribution if addressed. Those that have been raised recently as untapped resources include people with disabilities, the over 55s, returning mothers, men who are primary carers and our very significant multicultural community.


We are missing out on capturing knowledge, experience and networks from these valuable resources and will need to find transferable solutions for programs that

provide increased support across these diverse sectors of the community.

Victoria has demonstrated that it has the ability to leverage talent in the science, technology and innovation community to support industry growth and become a thriving and globally competitive contributor to the economy.

What has been encouraging over the past three years is the flexibility and willingness to change exhibited by all sectors of the technology ecosystem, and the increased openness to collaboration.

Well-targeted policies and programs, regulatory change and altered funding models will all help. However, the

biggest and most difficult change required involves developing a more risk-taking culture and breaking down embedded behaviours. Showcasing examples of strong leadership in these areas will be necessary. 



Leonie Walsh looks on as a student interviews a Victoria Prize award winner.

progress their careers while raising a family. A number of institutions and universities are providing similar support along this theme, however we need more. An emerging issue is the need for the same level of support for female entrepreneurs starting a business while raising a family.

These programs support women already in the science community, however a bigger challenge is to get more women to take up science, technology, engineering and maths (STEM) careers. To be successful in addressing these issues we will need a serious focus on unconscious bias, more male champions of change, significant promotion of role models for existing and emerging careers, and promoting science-based subjects in a way

Dr Leonie Walsh FTSE was appointed as the inaugural Victorian Lead Scientist in mid-2013. She chairs the Victorian Government Innovation Expert Panel, has been a member of the Future Industries Ministerial Advisory Council, provides contributions to the Education State activities via the Tech Schools STEM Future Industries Advisory Panel and STEM advisory committee, represents Victoria on the Forum of Australian Chief Scientists and participates in a range of innovation, education and advanced manufacturing advisory committees. Dr Walsh has more than 30 years' local and global technology leadership experience in a broad range of industrial applications, with a focus on the development and commercialisation of technology.

The Gardiner Dairy Foundation vision is to invest in emerging leaders and practices to help develop a long term future for the dairy industry.



The Monash Industry Team Initiative, known as MITI, is a significant component of the Gardiner Dairy Foundation's manufacturing support, RD&E strategy.

The three month MITI program exposes high achieving, multi-disciplinary students from Monash University to the dairy industry and gives the industry the benefit of bright young minds to design solutions to their real world challenges. MITI teams have resolved issues for their dairy industry partners: in waste management, environmental impact, natural gas utilisation efficiency, heat regulation, and milk powder product solubility.

Through MITI, the Gardiner Dairy Foundation aims to create a cohort of young engineers to enhance capability and skills within the dairy industry. Students are given the opportunity to apply their knowledge in a sophisticated dairy manufacturing facility and gain exposure to the benefits of living in regional Victoria.

**Winner BHERT Award
for Outstanding Excellence
in Collaboration 2015**



Women in building program launched

The Prime Minister and the Minister for Women, Senator Michaelia Cash, have launched a pilot mentoring program to support women in the building and construction industry – where they account for just 11 per cent of the total construction workforce and leave the industry at a rate almost 40 per cent higher than men.

Without a commitment to greater gender equality, the building and construction sector is missing out on attracting and retaining the best talent, the Government says. Diverse workplaces have been proven to be more productive and deliver better returns to the bottom line.

The mentoring program will match female senior industry leaders with female industry newcomers to support them in their pursuit of long-term and rewarding careers in building and construction.

Delivered by Master Builders Australia, the program will run over 12 months in New South Wales and Tasmania.

Master Builders Australia will be provided with \$250,000 in grant funding to deliver the pilot as part of the Australian Government's Women's Leadership and Development Strategy. The program involves mentoring activities, an ambassador program to engage young women in schools and local communities, and an annual award recognising excellence and women in leadership.

GENDER EQUITY STRATEGY FOR APS

The Government has released a gender equity strategy for the Australian Public Service (APS).

Balancing the Future: The Australian Public Service Gender Equity Strategy 2016-2019 aims to position the APS to lead the way in gender equality for the broader Australian workforce.

"A key output of this Strategy is to consider practices that hinder workforce participation and career progression of women, and to develop and implement solutions to counter these practices," said Senator Michaelia Cash, Minister Assisting the Prime Minister for the Public Service.

"Importantly, this Strategy recognises that gender equality applies to both men and women and that supportive and enabling organisational culture drives the success of this," she said.

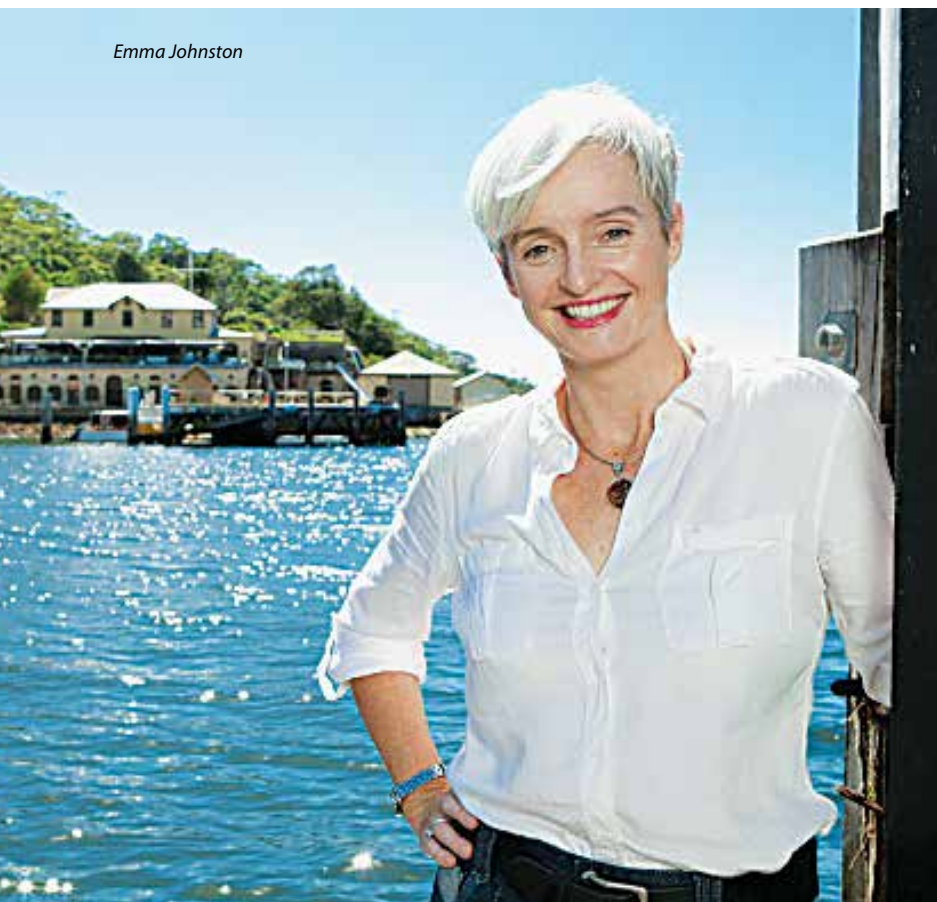
"Gender equality is a priority in the APS. The targets and actions outlined in this Strategy, coupled with the accountability that all APS departments and agencies have to deliver on these, sets the APS in the right direction to once again be a leader in gender equality.

It was released at Parliament House, Canberra, by Senator Cash, the Secretary of the Department of the Prime Minister and Cabinet, Dr Martin Parkinson, and the Acting Public Service Commissioner, Ms Stephanie Foster.



WOMEN IN TECHNOLOGY

Emma Johnston



Emma Johnston gets UNSW boost

The University of NSW has announced the appointment of Professor Emma Johnston as Pro-Vice-Chancellor (Research), replacing Professor Brian Boyle who is acting Deputy Vice-Chancellor (Research).

A leading authority in marine ecology, Professor Johnston comes to the role with an exceptional research career. As well as heading up the Applied Marine and Estuarine Ecology Lab at UNSW, Professor Johnston has led more than 20 major research projects for industry, government, the Australian Research Council and the Australian Antarctic Science Program.

In 2012, Professor Johnston was appointed the inaugural director of the Sydney Harbour Research Program at the Sydney Institute of Marine Science, where she works with 35 scientists to better understand the threats to Sydney's prized natural harbour, and helps devise more sustainable management practices.

Professor Johnston is a high-profile science communicator, winning the 2015 Eureka Prize for Promoting Understanding of Australian Science Research. She is a regular media commentator and, as co-presenter for the Foxtel/BBC television series *Coast Australia*, has helped take Australian marine science to an international audience.

An Australia Research Fellow (2010–14), Professor Johnston studied science at the University of Melbourne, graduating with a PhD in 2002. Her research has been recognised with numerous awards, including the inaugural 2014 Australian Academy of Science Nancy Millis Medal for Women in Science, the 2012 NSW Science and Engineering Award for Excellence in Biological Sciences and the Hynes Award from the Canadian Rivers Institute (2016). She is currently Vice-President of Science & Technology Australia.

MATHS GENDER GAP "NOT HARDWIRED"

While Australian girls are less likely to participate and engage in mathematics, and more likely to achieve at a significantly lower level than boys, this is not evidence of biological or 'hardwired' differences between girls and boys, or even indicative of learning differences, according to a new report from the Australian Council for Educational Research (ACER).

The ACER report, *Gender and sex differences in student participation, achievement and engagement in mathematics*, concludes that research does not support the idea of structural differences in the brain between girls and boys.

Results from the 2012 cycle of the Program for International Student Assessment (PISA) reveal that 15-year-old Australian girls achieved at a significantly lower level than boys, by a difference of approximately one-third of a school year. Girls are also more likely to opt out of maths and science subjects than boys.

"The participation of girls in any maths and science subjects in senior school is declining but more worrying is that the participation of girls in advanced maths and science subjects – which are prerequisites for further study and careers in science, technology, engineering and mathematics fields – is also declining," said ACER Research Fellow Dr Sarah Buckley.

The good news, according to the report, is that neuroscience does not suggest that there are hardwired brain differences but rather shows the brain is highly plastic. And according to neuroscience, psychology and education research, that means girls' – and boys' – attitudes, engagement, participation and achievement in maths can be changed by what they think and do, how their teachers teach, and by the messages they receive from society.

Boys and girls may have certain preferences for learning – likely encouraged through socialisation – but according to Dr Buckley this does not mean they cannot learn in other ways. It is also a generalisation to say that all girls or boys will have a preference for a particular learning style or environment.

"Rather, the message from neuroscience and psychological research is that given new environmental opportunities there is the potential for change and growth," Dr Buckley said.

"The more mathematics is perceived in our society as a subject that is useful, enjoyable and attainable by all, irrespective of gender, the more likely the gender gap will start to close."

ATSE IN ACTION

Global Connections Fund launched

The Australian Government and ATSE have launched a new initiative to build sustainable global linkages for Australian SMEs and researchers in the area of science and technology.

On behalf of the Government's Global Connections Fund, ATSE has run its first call for Priming Grants – a new vehicle for driving collaboration between Australian researchers and overseas small to medium enterprises (SMEs) and between Australian SMEs and overseas researchers.

Industry, Innovation and Science Minister Christopher Pyne announced the first round of grants under the Global Connections Fund, at the APEC Science Prize for Innovation, Research and Education (ASPIRE) awards ceremony in Adelaide.

Collaborative relationships are proven to produce better research quality and optimise the environment for innovation breakthroughs. Leveraging one another's strengths in a cooperative way will have benefits for both Australia and partner economies and assist in their development as technology leaders. Cooperation in science, technology and innovation at the international level is vital to support economic growth in Australia.

Priming Grants of \$7000 will contribute to more effective and strategic network formation. They will support collaborations that focus on national industry and research and science priorities: advanced



Christopher Pyne launches the Fund.

manufacturing; food and agribusiness; medical technology and pharmaceuticals; mining equipment, technology and services; and oil, gas and energy resources.

The Global Connections Fund supports linkages with 17 priority economies – Brazil, China, EU member states, India, Israel, Japan, Korea, New Zealand, Singapore, Switzerland, Taiwan, the US and Vietnam.

The program will: enhance access

to international expertise and networks of researchers; provide a stimulating environment which triggers new ideas, technologies and innovations; and provide opportunities for SMEs to add value to products or services through access to and adoption of innovative research.

[Details at the Global Connections Fund website, globalconnectionsfund.org.au](http://globalconnectionsfund.org.au)

ENTREPRENEUR DELEGATION VISITS CHINESE CENTRES

In early May ATSE launched the Australia China Entrepreneurs Program, sending a delegation to China for a three-day visit to highlight entrepreneurship programs and opportunities in China. Developed with funding assistance from the Department of Education and Training, the program aims to ensure that postgraduate training prepares young researchers to work with industry and brings their ideas to market.

Dr Paul Wood FTSE, who has extensive experience in innovation and entrepreneurship, led the delegation of educators and students from four universities to Shanghai and Suzhou entrepreneurship centres and incubators.

Some of Australia's brightest postgraduates and early career researchers in advanced manufacturing and related fields visited start-ups in the rapidly developing innovation hub of Shanghai over the first two days of the program, which culminated in a forum hosted by

Monash University in Suzhou to address the successful development of entrepreneurship skills in a globalised environment.

Four institutions participated: Monash University, Queensland University of Technology, the University of Melbourne and the University of Technology Sydney. Each sent one academic/educator from their leading entrepreneurship education program/centre and two postgraduate entrepreneurship students associated with the program/centre.

The Suzhou workshop will be facilitated by Dr Buzz Palmer, CEO of STC Australia and Director of Entrepreneurship at Monash University.

The team visited the Fudan University Youth Entrepreneurship and Science and Technology Incubator, the Public Practicing Base for Entrepreneurs and the FabLab O Shanghai at Tongji University – all in Shanghai.

ATSE IN ACTION

COP21 a 'step-change' in global climate action

The outcome of the Paris climate conference last December (COP21) represented a step-change in global action to address greenhouse gas (GHG) emissions, Dr Gordon de Brouwer PSM, Secretary of the Commonwealth Department of the Environment, told the NSW Division's 'Luncheon in the City' event in April.

The Paris Agreement set a framework for the net decarbonisation of the global economy over the course of this century and had profound implications for Australia as it transitioned away from a resource-based and carbon-intensive economy, Dr de Brouwer said.

He told an audience of 70 Fellows and guests at the lunch – the first in the 'Climate Change and its Consequences' series – that Australia had strategies in place to meet its 2030 target, including further auctions under the Emissions Reduction Fund, investment in

the development and commercialisation of renewable and clean energy technologies, and the examination of emission reduction schemes to focus on specific sectors where gains may provide greatest benefit to the nation.

Dr de Brouwer, a senior member of the Australian delegation to the conference, noted that a business-as-usual approach was not likely to lead to rapid reductions in GHG emissions.

Similarly, an internationally acceptable solution to this problem would not come from a traditional legal framework, but instead would require each country to be committed, and to use strategies that were acceptable within their community.

Dr Alan Finkel AO FAA FTSE, Australia's Chief Scientist, will present the second talk in the series on August 3, highlighting the role that science and technology will play in climate change mitigation.

CLUNIES ROSS WINNERS FROM THREE STATES

The 2016 Clunies Ross Awards will be announced on 15 June and three leaders in Australian innovation will be honoured at the Academy of Technology and Engineering's Innovation Dinner.

In the first year of a new format, ATSE will make awards to winners in three categories:

- Entrepreneur of the Year;
- Knowledge Commercialisation; and
- Innovation.

The Chief Scientists of Queensland, Victoria and South Australia – Dr Geoff Garrett AO FTSE (Queensland), Dr Leonie Walsh FTSE (Victoria) and Dr Leanna Read FTSE (South Australia) – will make the Award presentations to the three winners – one from each state.

The names of the winners will be released on an embargoed basis ahead of the ATSE Innovation Dinner at the Sofitel Sydney Wentworth Hotel on 15 June.

Australia's Chief Scientist Dr Alan Finkel AO FAA FTSE will attend the Innovation dinner, at which the CEO of CSIRO, Dr Larry Marshall, will be the keynote speaker. The Academy anticipates the Innovation Dinner will be attended by more than 200 eminent entrepreneurs, decision-makers, government officials, researchers, academics and business leaders.

The Awards have been running since 1991 and winners have included many Australians who have become household names through their achievements.

The Clunies Ross Awards are given in recognition of the outstanding application of science and technology that provides economic, social and/or environmental benefit to Australia. They have become one of the pre-eminent awards for scientists, technologists and innovators across Australia, recognising the achievements of many special people. They commemorate Sir Ian Clunies Ross, a giant of Australian science and former Chair of CSIRO.



(From left) Richard Sheldrake, Gordon de Brouwer, Peter Tyree and Brian Spies at the lunch.

OUR ASIAN COMMUNITIES A POTENT ECONOMIC FORCE

Australia's Asian communities – the diasporas – are a potent economic force but are under-utilised and under-represented in helping Australia forge greater trade, investment and innovation links with Asia.

Australian governments, institutions and industry need to increase the representation and participation of the Asian diasporas in the development of policies and programs aimed at strengthening economic, political and cultural relations with Asia.

These are two key findings of the latest report issued by ACOLA in the Securing Australia's Future program. Titled *Australia's Diaspora Advantage: Realising the potential for building transnational business networks with*

Asia, it was launched in Canberra in May by Australia's Chief Scientist, Dr Alan Finkel AO FAA FTSE.

It noted that the diasporas used their language skills, cultural understanding and global networks to accelerate the circulation of ideas, opportunities, people and capital for business purposes around the world. This is the diaspora advantage.

Australia had an opportunity to lead the world in developing a national diaspora policy to realise the advantages Australia's diasporas possess, the report said.

Dr Marlene Kanga AM FTSE and Professor Aibing Yu FAA FTSE were members of the project Expert Working Group.

ATSE IN ACTION

National leaders to address 'Agribusiness 2030'

The 2016 ATSE National Technology Challenges Dialogue 'Agribusiness 2030' will bring together Australia's top agriculture and agribusiness leaders with innovators from research, industry and government to explore the opportunities and challenges for agribusiness in the digital age.

Agribusiness 2030 will be held on 15 and 16 June at the Sofitel Sydney Wentworth Hotel and offers an unparalleled opportunity to discuss technology and innovation in the future of Australian food and agribusiness, and chart a course to realise its potential in a challenging environment.

Sessions will focus on: winning community support; profiting from the technology revolution; case studies on new technologies; farming the future; working with climate change; and grasping

agricultural biotechnology.

Agribusiness 2030 has attracted a top-flight list of speakers.

Ms Alison Watkins, Group Managing Director, Coca-Cola Amatil, will address 'The vision: Australian agribusiness in 2030' and Dr John Manners, Director, CSIRO Agriculture, will discuss 'The challenges: how science and technology will help us reach this vision'.

Mr David Williams, Kidder Williams Ltd, will discuss 'Investment and finance in technology and R&D'; Professor Andrew Campbell, Director, Research Institute for the Environment and Livelihoods, Centre for Renewable Energy, Charles Darwin University, will focus on 'Can technology turn the tide in Northern Australia?'; and Professor Mark Howden, Director, Climate Change Institute, Australian National University, will address 'Climate change and global agriculture'.

Other speakers include: Mr Rob Webb, Deputy Director Hazards, Warnings and Forecasts, Bureau of Meteorology – 'Weather and climate forecasting'; Dr Fyodor Urnov, Vice President, Discovery and Translational Research, Sangamo BioSciences – 'Genome editing in agriculture'; and Professor Steve Swain, Research Director, Breakthrough Genetic Technologies, CSIRO – 'The importance of bioinformatics'.

Major sponsors for the Dialogue and the National Innovation Dinner include: the Department of Industry, Innovation and Science, the University of Newcastle, Monash University, the University of Queensland, the University of NSW, Queensland University of Technology, Defence Science and Technology Group, CSIRO, the University of Melbourne, the University of SA and the NSW Department of Primary Industries.



EXCELLENCE AND IMPACT

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Liz Forsyth, Executive Director, Northcott Innovation

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ATSE IN ACTION

IMNIS expands to South Australia

South Australia has become the next home for ATSE's Industry Mentoring Network in STEM (IMNIS) initiative, with the creation of a pilot program for the state – the third in Australia.

The program, being hosted in SA by the State Government agency BioSA, seeks to partner industry mentors with PhD students to develop mentees' commercial knowledge and business skills to better prepare them for careers in industry and collaboration with industry partners.

Through linking PhD students in STEM with qualified industry mentors who can provide mentees with advice and guidance, IMNIS aims to narrow the cultural gap that exists in Australia between business and academia.

"Australia is very highly ranked for the quality of research we produce here. However, preparing our students for careers outside of academia is one area where we can improve substantially," said Dr Meera Verma FTSE, Chief Executive of BioSA and ATSE SA Division Chair.

"The establishment of a program here in Adelaide such as IMNIS will help round out our students' skill sets. The ultimate goal of the program is to produce industry-savvy PhD graduates in STEM who can work effectively at the research/industry interface, and lead the companies they work for or have founded," Dr Verma said.

Ms Sarah Mortellaro, Director Industry



Attending the IMNIS launch in Adelaide are (from left) Ms Sarah Mortellaro, Professor Pat Buckley (UniSA), Emeritus Professor Mike Miller, Dr Meera Verma, Professor John Williams (University of Adelaide), SA Health Minister Mr Jack Snelling, Dr Steven Rodda (UniSA Ventures Pty Ltd) and Mr Marco Baccanti (CEO, Health Industries SA).

Liaison at BioSA is leading the initiative in SA, together with the support of former ATSE Director Professor Mike Miller AO FTSE and Ms Ronnie Wood, a Director of IMNIS. Three SA universities have partnered with BioSA in this initiative – the University of South Australia, Flinders University and the University of Adelaide.

BioSA and ATSE have established an IMNIS Steering Committee to provide program oversight and expert guidance to

the SA IMNIS project. The Academy is also facilitating access to its networks and Fellows to help IMNIS achieve its objectives.

The first two pilot programs, in Victoria and WA, were launched in mid-2015. The Victorian program focuses on biotechnology, with support from AusBiotech CEO Dr Anna Lavelle FTSE. The WA program, overseen by Dr Peter Lilly FTSE, who has broad experience in the resources industry and research, focuses on energy and mineral resources.

TECHNOLOGY WORKSHOP ON FOOD SAFETY IN BEIJING

ATSE engaged in a two-day workshop in China in April, on safety in the food supply system. An ATSE delegation, led by Vice President Professor Kaye Basford FTSE, travelled to Beijing for a joint workshop with the Chinese Academy of Engineering on advances in technology for food safety.

The delegation participated in a two-day workshop and roundtable with CAE, which also included representatives from various sectors in China – research, food production and processing, and government.

Australian and Chinese participants made presentations on the systems, regulations and technologies that are used in the two countries to ensure that the food supply system is safe, from 'farm to fork'.

These included examples from the dairy, horticulture, grain and meat industries of the two countries, and touched on issues around

rapid testing, soil health, the use of ICT, antibiotic use and social acceptance.

Following the workshop, participants undertook technical visits to Beijing Sanyuan Foods, a large Chinese food and dairy producer, and the COFCO Corporation Nutrition and Health Research Institute.

The Australian delegation accompanying Professor Basford comprised Professor Snow Barlow FTSE, Dr Tony Gregson AM FTSE, Dr Joanne Daly PSM FTSE, Dr Mary-Ann Augustin FTSE, Professor Deli Chen, University of Melbourne, Associate Professor Alice Lee, University of NSW, Mr Richard Bennett, Produce Marketing Association Australia–New Zealand/Fresh Produce Safety Centre and Dr Matt Wenham, from ATSE.

Representatives of the Australian Embassy in Beijing also attended the workshop.

ATSE IN ACTION

This article first appeared on The Conversation website. It was written by Professor Helen Marsh FTSE, Dean, Graduate Research, James Cook University, and Professor Mark Western FASSA, Director, Institute for Social Science Research, The University of Queensland – both Deputy Chairs of the SAF 13 Expert Working Group – and co-authored by Mr John McGagh FTSE, an adjunct professor at the University of Queensland and Chair of the EWG.

Skilled graduates the key outcome

The skilled graduate must become the most important outcome of research training in Australia – as it is in many other parts of the world – urges a new report by the Australian Council of Learned Academies (ACOLA).

The findings from the ACOLA *Review of Australia's Research Training System* suggest that universities need to better serve the needs of doctoral graduates. The report provides recommendations for how to help better connect research students and graduates with industry.

With fewer than 50 per cent of Australian doctoral graduates being employed in the university sector, industry experience and training that better equips graduates for jobs beyond universities is essential.

The report calls for transferable skills to be central to the training of doctoral candidates. Such skills development must be flexible and candidate-directed, and build on the diverse backgrounds and experience of candidates.

COLLABORATION

Industry placements are at the heart of this model. Industry is defined broadly as: businesses, governments, government business enterprises, non-government organisations, not-for-profit organisations and community organisations. This needs to include research students in the social sciences and humanities as well as those in science, technology, engineering and mathematics (STEM) disciplines.

Australia has been slow to adopt such initiatives. This failure is likely to have contributed to our lacklustre performance



Helene Marsh



John McGagh

in research collaborations between higher education providers and industry. Our poor performance is illustrated by several indicators. For example, Australia ranks last out of 30 OECD countries on the proportion of small and medium enterprises collaborating with higher education and public sector institutions on innovation. It is second last on the same indicator for large businesses.

Encouraging PhD students to form a bridge between academia and industry will bolster collaborations and be a win-win for all.

The review also calls for more professional supervision through recognising excellence, driving metrics and providing high-quality training and ongoing professional development for supervisors.

While rates of satisfaction with supervisory experience for research students have steadily increased over the past 14 years, surveys reveal that one in five research graduates is dissatisfied with the supervision they received. Negative expectations of cloning (creating graduates in the image of

the supervisor) and cheap labour still linger.

Research training needs to be valued as the human capital development required to build our innovation economy as well as for the research that research students produce. Increased emphasis on the skilled graduate as the major outcome of research training will require cultural change in supervisory practice.

OTHER COUNTRIES

In 2002 in the UK, the Roberts Review catalysed a policy initiative that provided £120 million in new government funding for skills development of research higher degree candidates and postdoctoral research staff in STEM disciplines.

This program was a major cultural change in the provision of skills and career support for researchers in UK higher education institutions. It championed the value of investing in the development of individual researchers.

A review of the program in 2010 confirmed that it had resulted in major

Research training needs to be valued as the human capital development required to build our innovation economy as well as for the research that research students produce.

ATSE IN ACTION

improvement in the way career development and transferable skills training were provided for researchers. It was unable, however, to provide quantitative metrics of success because of the absence of baseline data.

Although no such dedicated funding has been available in Australia, many universities have invested in the delivery of transferable skills training to higher degree by research (HDR) candidates. However, transferable skills development is not as strongly embedded in our research training system as in the UK and some other similar countries.

In 1999, Canada established Mitacs as a part of its Network Centre of Excellence Program. Mitacs started as an initiative in mathematics, prompted by the loss of Canadian mathematics PhD graduates to the US. The program expanded from 17 internships in 2003 to almost 3200 in 2014-15. By 2020, 10,000 internships are expected to be delivered per year.

Although Australia has several small internship schemes for research students, we estimate that fewer than 120 of more than 20,000 HDR candidates undertook an internship in 2015. A Canadian HDR candidate is 16 times more likely to undertake a placement than their Australian counterpart.

Mitacs has 14 government partners including the Canadian Government, most provincial governments and more than 60 universities. In 2014-15, Mitacs collaborated with 1065 partners in Canada and 23 partners outside Canada; 79 per cent were small-to-medium enterprises.

In 2014-15, it enabled two million hours of research work by interns for industry and not-for-profit partners, underpinned by an investment of C\$22 million (A\$23.4 million).

Mitacs surveys of their partners indicate that 82 per cent have continued collaborations with the academic supervisor, 66 per cent of the products of the collaborations have been commercialised and 47 per cent have hired at least one intern. The majority of participating interns feel more employable as a result of their internship.

The 2015 *Review of Research Policies and Funding* recommended that Australian government funding of \$12.5 million per year be provided to create a program to support universities to increase numbers of industry placements for PhD students.

The ACOLA review recommends that

this funding be used to seed a national program of placements for research doctoral candidates, along the lines of Mitacs.

Certainly, some Australian research students already obtain experience by working on externally defined research problems, in non-academic settings with non-academic supervisors, especially as part of the Cooperative Research Centre system. However, the review did not have enough data to evaluate the significance of such partnerships at a comprehensive national scale.

This is an example of the inadequacy

of the data available to determine the performance of the research training system and its value to Australia's economic and social well-being.

The review calls for a longitudinal national data-collection exercise to monitor course satisfaction, course completions and career outcomes for HDR training.

Without such data, it is impossible to determine the return on this almost \$1 billion annual government investment in the development of the human capital required for the innovation economy.

RESEARCH TRAINING REVIEW SEEKS BETTER ENGAGEMENT

The final Review of Australia's Research Training System report, launched by the Minister for Education and Training, Senator Simon Birmingham, at the Knowledge Nation Summit, has joined the chorus of calls for better research-industry collaboration.

It notes Australia's industry-university collaboration performance lies close to last among international competitors – a situation it says is unacceptable for a nation striving to transition to an innovation-driven economy.

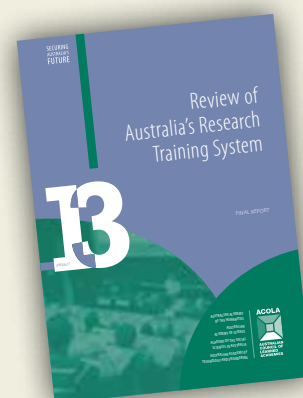
"There is an urgent need for Australia to address this issue," the report says.

"We encourage the university sector to develop a range of industry-engagement models in research training to drive proactive industry-university collaboration. We encourage industry to engage with universities in order to benefit from the skills and expertise of researchers."

The report, published by the Australian Council of Learned Academies (ACOLA), was commissioned in May 2015 by the previous Minister for Education and Training, Christopher Pyne. It required ACOLA, as part of the Securing Australia's Future program, to conduct a comprehensive review of Higher Degree by Research (HDR) training in Australia.

This project was undertaken by an Expert Working Group (EWG) consisting of Fellows from the four Learned Academies, with expertise in research, higher education and industry. It was chaired by Mr John McGagh FTSE, former Head of Innovation at Rio Tinto.

The report made six recommendations, primarily directed to the Australian Government, which focused on:



- 1 Implementing the recommendations flowing from its key findings.
- 2 Reducing red tape.
- 3 Incentivising industry-university collaboration.
- 4 Developing a national program to support industry placements for research doctorate candidates.
- 5 Monitoring results.
- 6 Increasing encouragement for Indigenous participation.

"Government clearly has a regulatory and financial role in improving the system, but many of the actions required fall under the remit of universities working in close collaboration with other stakeholders, especially industry, communities, and other parts of the innovation sector," the report said.

Many of the actions needed would require implementation by the higher education sector, industry and community stakeholders, it said.

Review of Australia's Research Training System is on the ACOLA website.



BY TREVOR DANOS
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A different perspective on science funding

The current disconnect with science discourages children from pursuing careers in STEM, dries up the job opportunities in STEM and fails to honour and encourage the brightest students.

In the 1960s and 1970s, when Julius Sumner Miller appeared on Australian television, he and Harry Messel had no difficulty in securing substantial funding from the corporate world for the promotion of science including elite science. This funding came not just from companies involved in science and engineering, but from a broad collection of 'industrial' companies such as Westpac and Consolidated Press.

At that time, the mention of science was predominantly about the betterment of society and about capturing and responding to science's sheer wonderment, rather than 'innovation' or its impact on GDP.

Sadly, that wise corporate investment is generally no longer forthcoming, despite the Federal Government's National Innovation and Science Agenda and talk about the "ideas boom" and the importance of STEM.

In the words of Julius Sumner Miller, 'Why is it so?'

First, science has come to be viewed by the industrial companies as yet another investment decision, with the usual focus on the need for short-term returns and immediately 'translational' outcomes. There is probably not much that can be done about this, except for pointing out to boards the hidden relevance of science to our daily lives – both the algorithms that allow

dealing rooms at banks to function and the encryption software used by banks would not exist without science.

Second, science has come to be seen by the industrial companies as the responsibility of government, supported by the tech, telco, engineering and defence sectors. For industrial companies, this means that requests for STEM funding tend to be directed to marketing and sponsorship departments (responsible for sport) or personnel who are charged with administering narrowly scoped corporate social responsibility (CSR) charters. These are not the places where there is much understanding about the central role of science at those companies and in the broader world.

MATHS A 'MUST' TO YEAR 12

Former WA Chief Scientist and prominent science advocate Professor Lyn Beazley AO FTSE has called for more attention to maths in schools, saying that mathematics to Year 12 should be compulsory.

Addressing a recent Curtin University productivity conference, she said people needed to realise three-quarters of future jobs would require science, technology, engineering and mathematics (STEM) skills.

Professor Beazley, 2015 WA Australian of the Year, said most innovations in Australia were happening in professional, scientific and technical services, and the economy would suffer without people skilled in maths.

"Insurance and construction are top of the list in [Australian] innovations – my gosh, you need maths for those, but you need maths just to run any company, even to run your own household," she said.

Professor Beazley also said it was vital to increase gender diversity in the sector.

University of WA Deputy Vice-Chancellor Professor Alec Cameron said universities acknowledged an "urgent need to put in place clear and reasonable incentives for students to choose the highest level of mathematics appropriate", not only to maximise study opportunities,



Lyn Beazley

but to boost job options.

He said business groups consistently identified poor numeracy as a barrier to employment and general productivity growth, pointing to a recent Productivity Commission report that found almost a quarter of Australians were capable of only basic mathematics "such as counting".

Professor Cameron said recent research found 60 per cent of jobs linked to

current study courses would not exist in future.

"All aspects of the education system need to be ready for change," he said.

Third, the need for carefully planned action and follow-through has been replaced by a delusional belief in the mantra of 'innovation'. The repeated recitation of 'innovation' is not a plan. Nothing worthwhile is ever accomplished without hard work and the commitment of resources.

The Australian Government and the Business Council of Australia are to be applauded for putting innovation and agility on the national agenda but an agenda item should be the starting point, not the end point.

This current disconnect with science by a very large number of industrial companies is devastating – it discourages children from pursuing careers in STEM, it dries up the job opportunities in STEM and it fails to honour and encourage the brightest students.

The underlying problem is one of culture. As a community, we are not committing to and not valuing science, including science excellence and elite science. This stands in such strong contrast to sport, where as a nation we commit hundreds of millions of dollars each year to the Australian Institute of Sport (AIS) to improve community participation in sport (Outcome 1) and to achieve excellence in sporting performance and international sporting success (Outcome 2).

Outcomes 1 and 2 could so easily be rewritten to refer to public participation in science and attaining international excellence in science.

In Australia, the commitment to elite student science is rather limited, principally the Australian and International Science Olympiads in physics, chemistry, biology, earth sciences and mathematics, the Professor Harry Messel International Science Schools and the National Youth Science Forum.

Australia wants, and the world needs, more super-bright students who can solve the world's grand challenges. Nobody ever regretted their country winning another Olympic Medal and the same logic and aspiration should apply to Nobel Prizes.

The AIS was formed after Australia's failure to win a gold medal at the 1976 Montreal Olympic Games, regarded at the time as a national embarrassment. Yet, when Australia's standing in OECD international maths and science league tables slides downward, there is stasis, with occasional but ineffectual grumblings about the national science curriculum.

There is no outcry from the industrial companies.

Not surprisingly, the countries that do well in those league tables are those where all sections of society value STEM and education. If Montreal was the clarion call for the creation of the AIS, then the league table results should now trigger the development of a comprehensive strategy for STEM Outcomes 1 and 2.

It must be time for all Australian

companies to commit meaningfully to STEM and STEM funding. This funding should not be seen as some component of a marketing budget nor should it be conflated with CSR.

Our nation's goal should be nothing less than a commitment to make STEM and research and development a centrally important and essential part of each company's business-as-usual activities.

This journey on STEM is not unlike the conversations about diversity that first presented themselves to the corporate world 10 or more years ago. We need to learn from that experience and inject STEM into the boardrooms of the nation so that boards drive change top-down and make measurable success in STEM part of the business culture of the organisation.

Just imagine what could be achieved by the ideas boom if every Australian public company had to report on its STEM activities and its research and goals and achievements in its annual report, as is now the case with sustainability and diversity. ☺

Mr Trevor Danos AM is a company director and a strategic adviser. He is on the board of Sydney Local Health District, he chairs the NSW Treasury Social Investment Expert Advisory Group and is a member of the ANZ Coordination Committee for the SKA telescope. He was previously a director of CASA and TransGrid and was a member of the CRC Committee. He recently wrote The Pursuit of Excellence: A History of the Professor Harry Messel International Science School and is an Adjunct Professor at UNSW.

GOVERNMENT BACKS AMSI PROGRAMS

The Department of Education and Training will co-fund the expansion of the Australian Mathematical Sciences Institute's (AMSI) research and higher education training programs.

Welcoming the \$2 million investment, AMSI Director Professor Geoff Prince said AMSI looked forward to closely engaging over the next four years with the Government's National Science and Innovation Agenda (NISA) to strengthen Australia's mathematical capability.

AMSI will strengthen industry pathways by linking its key events such as BioInfoSummer and AMSI Optimise to industry placement opportunities to foster work readiness.

Retention of senior undergraduate students, particularly women and Indigenous students, will also be a priority.

The key to AMSI's success, according to Professor Prince, is its position as the national peak body with access to both academic and industry networks.

"AMSI is uniquely placed to secure Australia's mathematical workforce into the 21st century," he said.

PHOTO: DAMIEN PLEMING

Stephen Taylor



BUSINESS DEANS FOCUS ON COLLABORATION

The Australian Business Deans Council (ABDC) has appointed Professor Stephen Taylor from the University of Technology Sydney (UTS) as its inaugural Research Scholar – a new role that has the goal of expanding collaboration between universities and industry.

The ABDC Research Scholar will support the development and implementation of an ABDC research engagement strategy that highlights the role business schools can play in supporting Australia's long-term competitiveness and productivity through their research and education.

Professor Taylor will take a leadership role in expanding collaboration across business schools and with key stakeholders, and in improving the connection between the needs of business and government and business school research.

Until recently he was Associate Dean Research at UTS Business School and is a former Chair of ABDC's Business Academic Research Directors' Network.

NEWS

STEM horizons are unlimited

Australians with qualifications in science, technology, engineering and mathematics (STEM) are working across the economy in many roles from wine-makers to financial analysts, according to a new report from the Office of the Chief Scientist.

Australia's Chief Scientist Dr Alan Finkel AO FAA FTSE said *Australia's STEM Workforce* was the first comprehensive analysis of the STEM-qualified population and was a valuable resource for students, parents, teachers and policy-makers.

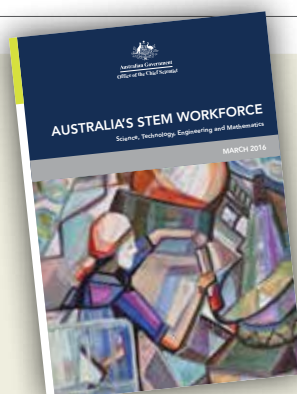
The report is based on data from the 2011 Census, the most recent comprehensive and detailed data set of this type of information. The report will serve as a benchmark for future studies.

"This report provides a wealth of information on where STEM qualifications – from both the university and the vocational education and training (VET) sectors – may take you, what jobs you may have and what salary you may earn," Dr Finkel said.

"Studying STEM opens up countless job options and this report shows that Australians are taking diverse career paths."

The report investigates the workforce destinations of people with qualifications in STEM fields, looking at the demographics, industries, occupations and salaries that students studying for those qualifications can expect in the workforce.

The report found that fewer than one-third of STEM university graduates were female, with physics, astronomy and engineering



having even lower proportions of female graduates. Biological sciences and environmental studies graduates were evenly split between the genders. In the VET sector, only nine per cent of those with STEM qualifications were women.

Dr Finkel said that even more worrying than the gender imbalance in some STEM fields was the pay gap between men and women in all STEM fields revealed in the report. These differences cannot be fully explained by having children or by the increased proportion of women working part-time.

The report found that gaining a doctorate is a sound investment, with more STEM PhD graduates in the top income bracket than their bachelor-degree-qualified counterparts. However, STEM PhD holders are less likely to own their own business or work in the private sector.

Dr Finkel said that preparing students for a variety of jobs and industries was vital to sustaining the future workforce.

"This report shows that STEM-qualified Australians are working across the economy. It is critical that qualifications at all levels prepare students for the breadth of roles and industries they might pursue.

"The most striking finding in my mind is the range of occupations that people with STEM qualifications have pursued. We have people with physics doctorates working as financial analysts.

"We have chemistry graduates running farms and making wine. We have ICT graduates planning cities. There are no limits on what a STEM graduate can do, and we shouldn't impose them.

"Do we impose them? I suspect we do, perhaps particularly on women with the talent and passion for STEM. The pay gap between men and women revealed in this report is significant, it is longstanding and it is unacceptable. No 'clever country' under-serves half its people.

GO8 TOPS THE AUSTRALIAN LIST IN NATURE INDEX

Australia is listed at number 12 in high-quality global research by *Nature Index*, just ahead of India and three places behind South Korea. The US leads the index, followed by China, Germany, the UK and Japan.

Between 2012 and 2015, China's contribution to the *Nature Index* grew by an annual average of 12.8 per cent. Australia's grew by an average 3.3 per cent a year over the same period.

Australia's Group of Eight universities fill the top eight positions by Australian universities, with The University of Queensland leading at 89 on the global university list. Monash University is 93 globally, ANU is 100 and The University of Melbourne at 130.

Australia has 11 universities in the top 500 institutions in the index, which tracks more than 8000 institutions worldwide.

Globally, Harvard University was listed as

the leading university, followed by Stanford University, The University of Tokyo and MIT.

The *Nature Index* is built on an institution's contributions to about 60,000 high-quality papers each year and counts both the number of papers and the relative contribution of the authors.

Melbourne researchers were listed as authors on 164 more papers than their UQ peers, but UQ had greater ownership of their papers – fewer authors from other institutions – bringing them to the top of the index in terms of contribution to the articles.

The index indicates that Curtin University is the most collaborative Australian university in the top 500 of the index, as shown by its article count being much higher than the relative contribution from its authors. It was also the biggest Australian mover in the index, improving by a compound annual average of 22.2 per cent between 2012 and 2015.

YOUNG UNIVERSITIES RATE WELL

Sixteen Australian universities have been named in the top 100 of the Times Higher Education World University Rankings of the 150 world universities younger than 50 years of age.

Top-ranked was the University of Technology Sydney (21), followed by Queensland University of Technology (equal 28), Charles Darwin University (equal 31), the University of Wollongong (37), James Cook University (38), Flinders University (46), Griffith University (48) and Deakin University (50).

The next group was led by the University of SA (57), La Trobe University (58), Swinburne University (74), Murdoch University (82), Western Sydney University (equal 86), Curtin University (equal 92), Southern Cross University (94) and RMIT University (98).

The University of Canberra, Central Queensland University and Edith Cowan University were ranked within 101 to 150.

"And no clever country would encourage its most STEM-literate people to pursue only traditional research paths, in universities or public-sector research agencies. I know from my own experience that the opportunities rarely lie in the expected places.

"Our STEM community, and most of all our young people, should be given every encouragement to find new applications for their skills across the economy.

"Our best future is a future that builds on technology, innovation, ideas and imagination. It is a future with STEM. And it is a future that is ours to build," he added.

Professionals Australia, which positions itself as the professional association representing Australia's STEM workforce, said the report data correlated with its own reporting, noting that STEM employees undoubtedly drive productivity across the economy.

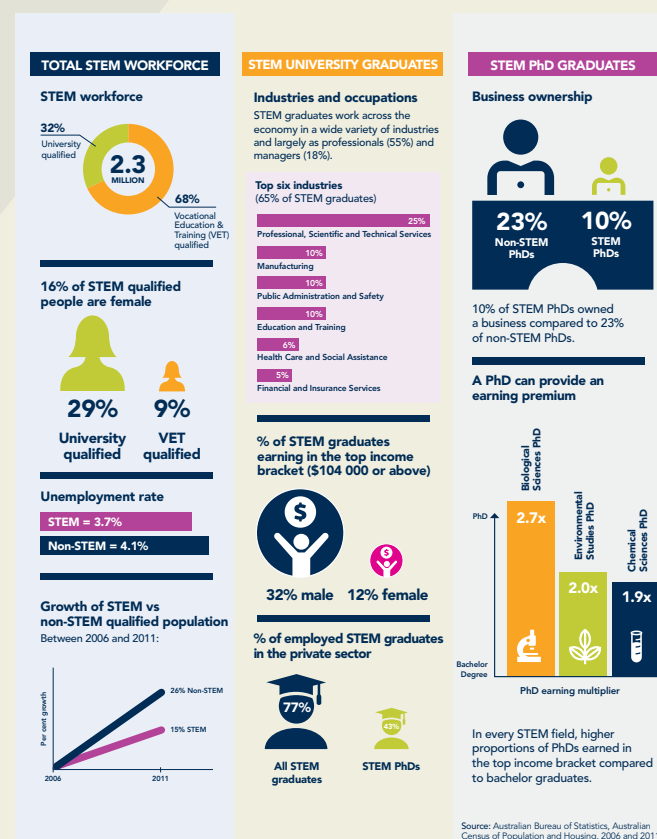
"This report shows businesses that employ STEM-skilled workers are 33 per cent more productive than those who do not. It is no coincidence that the most innovative companies in the marketplace are also the biggest employers of STEM workers," CEO Mr Chris Walton said.

"Barriers that prevent Australia from fully realising the benefits of a strong STEM workforce must be removed immediately. Long-term workforce development must be at the core of all government planning.

"Investing in engineering, science and IT professionals in decision-making and management positions within government translates directly to reduced waste of taxpayer dollars. Yet successive governments have shed in-house engineering and science capacity. It is a dangerous false economy.

"We need to not only ensure a strong pipeline to attract our best and brightest into the STEM professions but a sustainable workforce in the long-term. There is no ideas boom without the experienced STEM professionals to develop and drive it."

Figure 1 Key findings of Australia's STEM Workforce.



AUSTRALIA'S STEM WORKFORCE IS AVAILABLE ON THE CHIEF SCIENTIST'S WEBSITE

\$163 MILLION ARC GRANTS FOR 258 PROJECTS

The 258 new research projects to be funded by \$163 million in ARC grants will permit researchers from 31 universities to collaborate with industry and business to address pressing issues as diverse as identity theft, different disease strains and farming crop yields.

Education and Training Minister Senator Simon Birmingham said the impacts and benefits from the projects would be felt in hospitals and schools, on farms and in homes across the country.

The latest round of grants includes:

- 16 new Australian Laureate Fellowships worth \$44.1 million;
- 231 new Linkage Projects (\$81.2 million);
- 5 new Industrial Transformation Research Hubs (\$15.7 million); and
- 6 new Industrial Transformation Training Centres (\$22 million).

"The new research projects under the Linkage Projects scheme are also supported by

477 partner organisations where researchers team up with businesses and corporate Australia, think-tanks and other institutions to deliver breakthroughs that solve real-world problems," Minister Birmingham said.

"Those partners have pledged support – cash and in-kind – of \$162.9 million. That represents \$2.01 for every dollar from the Commonwealth and highlights the value of research done at Australian universities and laboratories."

The 16 Laureate Fellows include two Australians returning from overseas and four international researchers.

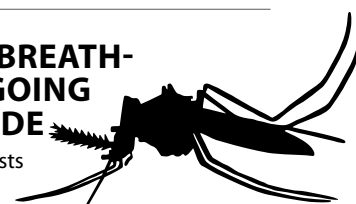
The University of Melbourne was the principal beneficiary of the Linkage Projects grants, being awarded \$11.2 million, followed by UQ (\$9.9 million), UNSW (\$7.6 million), Monash University (\$6.4 million), UWA (\$5.2 million), the University of Sydney (\$4.7 million) and ANU (\$3.7 million).

MALARIA BREATH-TESTING GOING WORLDWIDE

Australian scientists will soon be field-testing their ground-breaking breath markers for malaria, thanks to a \$1.4 million research grant from the Bill & Melinda Gates Foundation.

Over the next 18 months, a CSIRO research team will be leading collaborative validation trials in locations with high malaria incidence including Malawi, Bangladesh, Malaysia and Sudan.

This next stage of development follows on from the exciting discovery last year by scientists at CSIRO, QIMR Berghofer Medical Research Institute and the Australian National University, where the research identified distinctive chemicals that can be detected in the breath of patients infected with malaria.



NEWS

Sydney launches its Nanoscience Hub

The University of Sydney has launched the Australian Institute for Nanoscale Science and Technology (AINST) – and its \$150 million Sydney Nanoscience Hub – which it claims is the most advanced facility for nanoscience in the region – where design, fabrication and testing of devices can occur under one roof.

More than six years in the making, the Sydney Nanoscience Hub was co-funded with \$40 million from the Australian Government and includes teaching spaces alongside publicly available core research facilities that will support fundamental research as well as the work of start-ups and established industry.

The Institute hosts some of the capabilities of the Australian National Fabrication Facility and of the Australian Microscopy and Microanalysis Research Facility – both co-funded by the National Collaborative Research Infrastructure Strategy (NCRIS). Researchers at the Institute contribute to two Australian Council Centres of Excellence: CUDOS, the Centre for Ultrahigh bandwidth Devices for Optical Systems; and EQuS, the Centre for Engineered Quantum Systems.

Professor Benjamin Eggleton FTSE, the Director of CUDOS who also heads the photonics flagship at AINST, said photonics (the study of photons – the building blocks of light) was already delivering real-world solutions.

“Photonics is the backbone of the internet and underpins a \$7 trillion industry,” Professor Eggleton said. “Our team has led the world in photonic-based chip processing and we are now working on building a photonic chip – or a lab on a chip – that may one day be compatible with mobile phones, enabling them to sense environmental pollution or be used for testing blood samples to diagnose health issues.”

AINST Director, Professor Thomas Maschmeyer FAA FTSE, will also head one of five initiating flagships – in Energy and Environment.

PHOTO: UNIVERSITY OF SYDNEY



Inside the Sydney Nanoscience Hub.



Thomas Maschmeyer



Ben Eggleton

DATA61 AND AICD LINK ON CYBER SECURITY

CSIRO's Data61, the largest data innovation group in Australia, and the Australian Institute of Company Directors (AICD) have finalised a joint commitment to collaborate on lifting the digital and cyber literacy of directors and boards across Australia.

The parties have entered a Memorandum of Understanding (MoU) that aims to create stronger and more secure organisations by facilitating a better understanding of cyber security by boards, appropriate risk management, the required investment and the opportunities for innovation that come with it.

Over the coming months Data61 and AICD will develop a cyber security education

and training program to enable directors and their organisations to grow and innovate with confidence based upon the information principles of confidentiality, integrity and availability of data. The program will focus on corporate governance and its application to the way people interact with technology and each other in a quantifiable and repeatable manner.

This collaboration will enhance the creation of highly skilled company directors equipped to influence economic growth and community prosperity, while protecting enterprise assets from intentional theft or accidental loss.

It is anticipated that, as a result of the

program, directors will have the opportunity to:

- identify implied and express obligations as directors or officeholders of an organisation;
- identify the value of information to the organisation in terms of business opportunity and risk;
- identify a target state of assurance to address business risk and opportunity;
- identify the current capability of the organisation to protect and leverage its valuable information and determine an appropriate path to sustainability; and
- develop a quantifiable program for continuous organisational improvement.



BY IAN RAE
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A new look at south-east Asia

In his 19th book, Professor Lindsay Falvey FTSE continues his career as a writer on social, technological and esoteric themes. This time he has given us a primer for understanding the states and language groups that lie one overnight flight away from our south-eastern capitals. Books about south-east Asia seldom include the word 'understanding' in their titles, although it's common in the blogosphere and in the titles of university courses.

Understanding Southeast Asia: Syncretism in Commonalities by Lindsay Falvey (TSU Press (Thailand), 2015, xx + 166 pp).

Starting from prehistoric times, he describes developments in the region in terms of agriculture, trade, language and religion, cronyism and corruption, colonialism, statehood and leadership.


Each is impacted by the continuing influence of China to the north and India to the west. Rice, of course, as we know from others of Falvey's writings, is the glue that binds many of these strands together.

More philosophically, and alluding to the book's subtitle, he uses the concept of syncretism (the amalgamation or attempted amalgamation of different religions, cultures or schools of thought) to describe how "merged belief systems spanning all aspects of life provide psychological resilience" and promotion of environmental morality ensures "the protection of resources essential to life".

Lest we fall into the trap of thinking that syncretism is a dressed up version of the Asian Values debate of the 1980s and 1990s, the book ends with a discussion of "the regional concept of harmony" or avoidance of the risk of "personal harm from taking a contentious position".

These can properly be seen as deriving from a broad range of commonalities and so they contrast with more instrumentalist models of society that he characterises as "hegemonic, nation-building and academic", dominated by statutory law.

And this is not just "the nostalgic view of an old Asia hand" – the syncretism he describes can move us beyond rice and religion to a deeper understanding of our neighbours.

The book's summary is rendered in 10 languages and the text includes a number of annotated maps, data tables, cartoons and colour photographs. 

Professor Ian Rae FTSE, an Honorary Professional Fellow at the University of Melbourne, is a former technical Director of ATSE. He was President of the Royal Australian Chemical Institute (2006–08) and served for a decade as a technical adviser to the UN Environment Programme. He is co-editor of the Australian Academy of Science journal Historical Records of Australian Science.

NEWS

PUTTING SOME LIGHT ON THE LAUNDRY

By magnifying this textile 200 times the total coverage of the nanostructures by the silver nanoparticles (red colour) is evident.

A spot of sunshine may be all it takes to get your washing done, if nano research into self-cleaning textiles at RMIT University delivers.

Researchers have developed a cheap and efficient new way to grow special nanostructures – that can degrade organic matter when exposed to light – directly on textiles, which paves the way towards nano-enhanced textiles that can spontaneously clean themselves of stains and grime simply by being put under a light bulb or worn out in the sun.

RMIT's Dr Rajesh Ramanathan said the process developed by the team had a variety of applications for catalysis-based industries such as agrochemicals, pharmaceuticals and natural products, and could be easily scaled-up to industrial levels.

The researchers worked with copper and silver-based nanostructures, which are known for their ability to absorb visible light. When the nanostructures are exposed to light, they receive an energy boost that creates 'hot electrons'. These hot electrons release a burst of energy that enables the nanostructures to degrade organic matter.

"The advantage of textiles is they already have a 3D structure so they are great at absorbing light, which in turn speeds up the process of degrading organic matter," he said.

"There's more work to do to before we can start throwing out our washing machines, but this advance lays a strong foundation for the future development of fully self-cleaning textiles."

The challenge for researchers has been to bring the concept out of the laboratory by working out how to build these nanostructures on an industrial scale and permanently attach them to textiles.

The RMIT team's approach was to grow the nanostructures directly on the textiles by dipping them into a few solutions, resulting in the development of stable nanostructures within 30 minutes.

When exposed to light, it took less than six minutes for some of the nano-enhanced textiles to spontaneously clean themselves.

"Our next step will be to test our nano-enhanced textiles with organic compounds that could be more relevant to consumers, to see how quickly they can handle common stains like tomato sauce or wine," Dr Ramanathan said.

NEWS

CSIRO's ON Accelerator drives collaboration

Eleven teams of scientists and researchers from CSIRO and Australian universities have been selected to take part in the current round of CSIRO's 'ON Accelerator', a program designed to boost Australia's innovation performance by accelerating big science and technology ideas into commercially viable opportunities.

The teams were selected on the potential of their ideas to have real positive impact on Australian industry, economy, environment and future, among other selection criteria. Some of the winning ideas include:

- a GPS-free, collision-avoidance sensor allowing unmanned aerial vehicles (UAVs) and drone devices to fly autonomously near infrastructure and in GPS-free environments, with the potential to rapidly advance the booming UAV and drone markets into new areas such as parcel delivery services;
- a natural feed additive for livestock that could improve productivity by 10 per cent and reduce methane emissions by up to 90 per cent; and
- a facial-recognition technology that could provide accurate, real-time pain assessment for health patients who cannot communicate verbally.

For the first time CSIRO welcomed Australian university applications into the ON Accelerator program, recognising the importance of collaboration and engagement between research sectors in driving Australia's innovation agenda.

"CSIRO is focused on helping Australia navigate the changes we face, from digital disruption to environmental impact. We need to translate more of our nation's excellent science into solutions that build a better future, and the ON Accelerator is the perfect way to teach researchers and teams how to do just that," said CSIRO Chief Executive Dr Larry Marshall.

Out of eight university applications Curtin University and a combined team from Macquarie University, the University of Adelaide and ANU were successful in securing two wildcard spots in the next current program.

"As a collaborative and industry-engaged university we are excited about continuing to build integration across CSIRO, industry and university sectors. The CSIRO ON Accelerator provides a framework through which we can extend previous collaborations," said Professor Sakkie Pretorius, Deputy Vice-Chancellor (Research), Macquarie University.

From July the ON Accelerator program will be expanded nationally to include all other publicly funded research organisations, as well as Australian universities, as part of the National Innovation and Science Agenda.



PICTURE: © CSIRO, KARL SCHWEDTTEGER

Jiaming Li, Lloyd Niccol and Kate Cavanagh, from *elimun8*, one of the successful CSIRO teams progressing to the ON Accelerator.

DATA61 AND CYBER LONDON JOIN FORCES

CSIRO's Data61 (formerly NICTA) is partnering with Cyber London (CyLon), Europe's first cyber security accelerator and business incubator, to strengthen cyber collaboration between Australia and Britain.

A Memorandum of Understanding (MoU) between the two parties aims to accelerate cyber innovation in both Australia and Britain by providing expertise, resources and capital to enhance the growth of this sector, an area of strategic priority for both governments.

The partnership will complement initiatives in the Australian Government's soon-to-be-released Cyber Security Strategy, including the recently announced Cyber Security Growth Centre.

The Growth Centre is a component of the National Innovation and Science Agenda and will bring together cyber security research and innovation to grow Australian business opportunities online.

NEW NORTHERN INFRASTRUCTURE FACILITY TO BE CAIRNS-BASED

Cairns has been chosen as the headquarters for the Northern Australia Infrastructure Facility (NAIF).

Mr Josh Frydenberg, Minister for Resources, Energy and Northern Australia, said the decision was an essential step towards implementing the \$5 billion facility, proposed in the Government's White Paper on Developing Northern Australia.

"We are implementing our plan to unlock the huge economic potential of northern Australia and the NAIF is a centrepiece of this plan. It will help deliver the infrastructure projects needed to drive economic and population growth in our north," Mr Frydenberg said.

The Federal Member for Leichhardt Mr Warren Entsch said the Cairns decision made sense.

"Our region is a hub for agriculture, tourism, education and energy resources, coupled with a sizeable population base. We also have outstanding connectivity – Cairns International Airport recently rated 13th in the world's top 20 best-performing small airports and we have direct flights to almost every capital city in Australia as well as excellent connections internationally."

'Best work in the world', says Turnbull

In the race to build the world's first super-powerful quantum computer, the University of NSW has opened new cutting-edge quantum computing laboratories at the Centre of Excellence for Quantum Computation and Communication Technology (CQC²T).

The new laboratories will double the productive capacity of the CQC²T at UNSW, helping Australian researchers remain global leaders by building a 10-qubit prototype quantum integrated circuit – the technology that will underpin the development of a commercial quantum computing device.

CQC²T's unique approach of using silicon has given researchers at UNSW a two to three-year lead over the rest of the world.

The new facility was opened by Prime Minister Malcolm Turnbull, accompanied by the Minister for Industry, Innovation and Science, Christopher Pyne.

There was no bolder idea than quantum computing, Prime Minister Turnbull said, hailing UNSW's research in the transformative technology as the "best work in the world".

He praised the leadership of Scientia Professor Michelle Simmons FAA FTSE, Director of CQC²T, and congratulated the Centre's team on their research breakthroughs.

The laboratories will double the productive capacity of the UNSW headquarters of the CQC²T.

They will also be used to advance development work to commercialise UNSW's ground-breaking quantum computing research and establish Australia as an international leader in the industries of the future. The work has attracted major investment from the Australian Government, Commonwealth Bank and Telstra.

CQC²T is leading the international race to build the world's first quantum computer in silicon.

The new laboratories, which have been funded by UNSW, will house six new scanning tunnelling microscopes, which can be used

to manipulate individual atoms, as well as six cryogenic dilution refrigerators that can reach ultra-low temperatures close to absolute zero.

"The international race to build a super-powerful quantum computer has been described as the space race of the computing era," Professor Simmons said.

"Our Australian centre's unique approach using silicon has given us a two to three-year lead over the rest of the world. These facilities will enable us to stay ahead of the competition."

The new laboratories will also be essential for UNSW researchers to capitalise on the commercial implications of their work.

"In addition to our fundamental research agenda, we now have an ambitious and targeted program to build a 10-qubit prototype quantum integrated circuit within five years," Professor Simmons said. "By mapping the evolution of classical computing devices over the past century we would expect commercial quantum computing devices to appear within five to 10 years of that milestone."



"No bolder idea" –
Malcolm Turnbull.

Michelle Simmons

Quantum computing has the potential to revolutionise computing. Today's digital computers have finite processing power whereas a commercial quantum computer will deliver a significant speed-up in power, including over a supercomputer. More jobs than ever before in Australia's modern 21st century economy are digital. The enormous power of quantum computing will create many more opportunities for new and higher wage jobs, particularly those involving analysis, forecasting and modelling.

\$6 MILLION FOR NEW CHINA RESEARCH LINKS

Six new Joint Research Centres will be funded for three years under the Australia-China Science and Research Fund (ACSRF).

"These grants, totalling \$5.95 million, support the objectives of the National Innovation and Science Agenda, and help Australian research institutions build links with China – a growing science power and important collaborative partner for Australia in science and research," Industry, Innovation and Science Minister Christopher Pyne said.

"This will build Australia's research capacity, forge strategic alliances and increase commercialisation and application of research outcomes, boosting innovation and international competitiveness."

The new Joint Research Centres grant winners are:

- Monash University and Soochow University – researching dairy industry manufacturing process efficiencies and new high-value products;
- the University of Adelaide and the Shanghai Jiao Tong University –

developing new cereal grains with long-term health benefits;

- the University of Melbourne and Chinese Agricultural University – investigating healthy soils for sustainable food production;
- Swinburne University and First Institute of Oceanography of the State Oceanic Administrations – developing a new generation of models to forecast and describe ocean and wave climatology;
- the Australian Institute of Marine Science and Institute of Oceanology, Chinese Academy of Science – exploring the translation of data into management solutions for coastal pollution and ecosystem safety; and
- the University of South Australia and Central South University – developing in-line chemical and mineral sensing for sustainable mineral processing.

The Joint Research Centres will also receive co-investment from the Chinese Government through the partnering Chinese institution.

NEWS



CSIRO's Dr Crispin Howitt and Dr Phil Larkin celebrating the launch.

CSIRO barley key to gluten-free beer

CSIRO's Kebari™ barley has been used to make the world's first commercially produced, full-flavoured, barley-based, gluten-free beer – Pionier – released by German beer-brewing company Radeberger.

While Pionier is only available in Germany, CSIRO is continuing to explore opportunities with Australian brewers to develop a local beer using Kebari™ barley. Once development of a hullless version of the barley is complete, there is a plan to work with manufacturers to bring a range of foods containing Kebari™ barley to Australian consumers.

While it is 'ultra-low' in gluten, Kebari™ grain cannot be called "gluten-free" in Australia or New Zealand under the current Food Standards Code. But the gluten level is well below 20 parts per million, the level recommended by the World Health Organization for classification as gluten-free, so in some other countries, such as Germany, products made with Kebari™ barley can be classified as gluten-free.

The Walter and Eliza Hall Institute of Medical Research and The Royal Melbourne Hospital were involved in the early stages of the ultra-low gluten barley project.

"Using conventional breeding we've reduced the gluten levels to 10,000 times less than regular barley, which more than meets the World Health Organization's recommendation for calling a grain gluten-free," CSIRO Principal Research Scientist Dr Crispin Howitt said.

"It's really exciting seeing the first product made with the malted version of our Kebari™ grain, we hope it's the first of many products."



Radeberger's 'Pionier' gluten-free beer.

EATING FOR THE ENVIRONMENT

A new CSIRO survey aims to examine the environmental impact of the nation's diet.

CSIRO will use data from the country's largest diet survey, the Healthy Diet Score, to look at the contribution of food consumption to our environmental footprint, as well as providing people with a score indicating the nutritional quality of their eating habits.

Improving the national diet could achieve both health and environmental benefits, such as minimising greenhouse gases by reducing processing, packaging and transport of food. CSIRO research has found that reducing overconsumption of kilojoules and eating whole foods at the levels recommended in the National Dietary Guidelines could cut the greenhouse gas contribution of the average diet by 25 per cent.

ROBOTS ORGANISE BEES IN ORCHARDS

Two Australian-made robots have uncovered the best locations to place beehives in orchards to get maximum fruit output in a new study commissioned by Horticulture Innovation Australia (Hort Innovation).

Delivered by the University of Sydney's Australian Centre for Field Robotics, the findings came from a four-year study that included the use of two unmanned vehicles.

The robots – trialled on almond, apple, lychee, custard apple, avocado and banana farms – worked concurrently on either side of tree rows using a group of cameras, lasers and software to create a series of algorithms that led to the identification of the fruit and patterns in yield variations consistent with a lack of pollination. This enabled growers to move hives to enhance pollination.

"This is a very exciting finding as this technology has the ability to help growers identify issues such as a lack of pollination and address them quickly," said Hort Innovation Chief Executive Mr John Lloyd.

"By monitoring the data patterns produced by these robots growers can effectively help ensure the best yield possible."

Mr Lloyd said the robots also showed the capacity to identify individual pieces of fruit and nuts, paving the way for fully autonomous tree fruit and nut-picking.

"This study has provided a real window into a not-too-distant future where labour-hire shortages and associated costs no longer need to be key concerns for tree crop growers."

Hort Innovation is currently investing more than \$15 million in autonomous-based projects on behalf of the nation's horticulture industries.



Robot working an almond orchard.

\$4 million investment to speed drug discovery

Melbourne start-up biotech company MecRx has secured a \$4 million investment from the Medical Research Commercialisation Fund (MRCF) to advance its breakthrough technology for accelerating drug discovery.

Under the agreement, CSIRO is assisting MecRx in validating its technology platform, which is being used to create promising starting points for new anti-cancer drugs. CSIRO shared the R&D costs in return for a mixture of milestone payments and shares in MecRx, based on their success. Today, CSIRO has a 14.6 per cent equity stake in the company.

The CSIRO risk-sharing agreement, combined with a Victorian Government Innovation Voucher, enabled MecRx to secure the significant MRCF investment.

"MecRx is a shining example of how the research and commercial sector can work together to accelerate Australian innovation and make a significant commercial impact," MecRx board director Dr Chris Smith said. "CSIRO and the Victorian Government were crucial in getting our technology off the ground – without their funding support and expertise the idea would never have been tested and the huge potential our platform offers for new drug discovery would have gone unrealised."

MecRx and CSIRO have joined forces with the world-leading

Peter MacCallum Cancer Centre in Melbourne to develop and test a promising drug lead for inhibiting the biological target cMyc – a key driver of destructive cell mutation in many cancers.

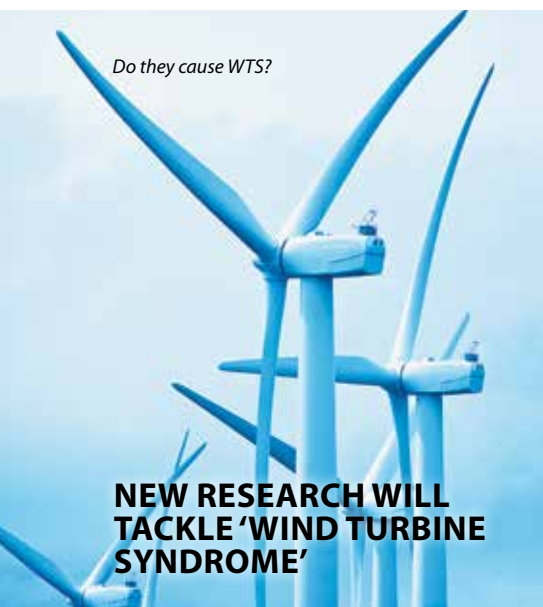
CSIRO's chemistry group leader, Dr Jack Ryan, said an effective way to successfully inhibit cMyc has eluded scientists across the world for the past 30 years.

"We're delighted to see this work translated to drug development, which we hope will ultimately lead to clinical trials through our partners at Peter Mac and commercialisation of the world's first cMyc drug," Dr Ryan said.

Established and managed by Brandon Capital Partners, MRCF brings together more than 50 of Australia's leading medical research institutes and research hospitals, the Australian Government and the state governments of Victoria, NSW, WA, Queensland and SA and has support from various superannuation funds and the Australian Government's Innovation Investment Fund (IIF).



(From left) CSIRO's biomedical research director Dr Paul Savage, MecRx founder Dr Joanne Alcindor, MecRx director Dr Chris Smith and CSIRO chemistry group leader Dr Jack Ryan.



Do they cause WTS?

NEW RESEARCH WILL TACKLE 'WIND TURBINE SYNDROME'

PHOTO: ISTOCK

Australians living near wind farms may soon know if 'wind turbine syndrome' actually exists or if the symptoms they report are the result of the 'nocebo effect'.

The National Health and Medical Research Council (NHMRC) has awarded two grants totalling \$3.3 million to enrich the evidence-based understanding of the effects of wind farms on human health.

Research led by University of NSW Professor Guy Marks will investigate the broader social and environmental circumstances that may influence the health of people living near wind farms.

The outcomes of this research will assist in developing policy and public health recommendations regarding wind turbine development and operations in Australia.

Australia is home to more than 75 wind farms running about 2000 turbines. AGL's Macarthur Wind Farm in western Victoria is the largest, followed by TrustPower's Snowtown project in South Australia, completed in 2014.

Wind power use is rapidly expanding in Australia, with multiple new projects in the pipeline. But with the growth has come a rise in complaints from residents living near wind farms who report experiencing headaches, dizziness and sleep disturbances that they attribute to the turbines. The symptoms, which also include nausea, tinnitus and irritability, are referred to collectively as wind turbine syndrome (WTS), a medical state they link to infrasound.

With a \$1.9 million NHMRC grant Professor Marks will lead two trials, one in

the laboratory and another in the study participants' homes, investigating the impact of infrasound – inaudible sound that emanates from turbines. Sleep quality, balance, mood and cardiovascular health will all be measured.

"As of yet, there's no proof that WTS actually exists, as all the research available is seriously flawed," Professor Marks said.

"Those who experience it are certain that it's affecting their health, and report convincingly that the problem disappears when they go on holiday and returns when they come home.

"On the other hand, there are several experts who firmly believe WTS symptoms are the result of a 'nocebo effect', where a person becomes certain something harmless is making them sick. In other words, their health problems are triggered by the individual's dislike of the turbines, rather than from any sound emanating from them."

Flinders University's Associate Professor Peter Catcheside's \$1.3 million NHMRC grant will evaluate the sleep and physiological disturbance characteristics of wind farm noise compared to traffic noise.

NEWS

Climate Science Centre underpins future research

CSIRO will establish a national climate research centre in Hobart that will focus on climate modelling and projections for Australia, drawing on both national and international research expertise.

Operating as part of CSIRO Oceans and Atmosphere, the new CSIRO Climate Science Centre has a guaranteed research capability for 10 years and will focus CSIRO's climate measurement and modelling researchers and resources.

Collaboration and partnership will be a cornerstone of this decadal commitment for Australia. In recognition of this, the Minister for Industry, Innovation and Science, Christopher Pyne, has agreed that an independent National Climate Science Advisory Committee will be established, with representation from CSIRO, the Bureau of Meteorology and other experts from Australia and overseas.

It will report at Ministerial level to inform the future direction of Australia's climate science capability and research priorities.

CSIRO Chief Executive Dr Larry Marshall said CSIRO's Strategy 2020 was focused on collaboration, global connection, excellent science and innovation.

"All four of these pillars are at work in this Centre," Dr Marshall said. "As I indicated at the start of CSIRO's current broader change process, it is critical that we retain the capability that underpins our national climate research effort.

"This announcement is a culmination of the ongoing consultation and feedback we've had from our staff and stakeholders, and this new Centre is a reflection of the strong collaboration and support right across our system and the global community.

"The Centre, with support from the Advisory Committee, will allow scientists across the nation to provide a decadal commitment to climate research in the nation's interest."

The foundation of the Centre will be 40 full-time CSIRO scientists. It will work closely with researchers from Australian universities and other stakeholders, including the BoM, and CSIRO is also planning to deepen its existing partnership with the UK Meteorology Office.

CSIRO will offer its unique Southern Hemisphere modelling capability and measurements to the UK's global model, helping to build a model that is even more relevant for Australia and other Southern Hemisphere nations.

All of CSIRO's critical measurement infrastructure, such as the ice and air libraries, ARGO float program and Cape Grim, will be guaranteed in the same manner as the other national facilities such as the *RV Investigator*, which is based in Hobart.

Welcoming CSIRO's announcement, Mr Pyne said the Centre's research would help guide decision-making around land use, where and how infrastructure is built, and the viability of new technologies and approaches to carbon abatement.

"Australia's whole research sector – supported by the Australian Government's annual investment in science, research and innovation of almost \$10 billion – contributes to this vital national capability," Mr Pyne said.

"It is critical that CSIRO continue to work in this space, and this announcement fulfils that commitment. It means that Australia's foremost research agency will continue to underpin and provide leadership in an area that impacts all of us.

"Throughout its history CSIRO has independently made decisions about how best to direct its efforts and resources to meet Australia's needs – this operational decision is another example of this."

Australia's Chief Scientist Dr Alan Finkel AO FAA FTSE welcomed the announcement. He said Australia had a rich history in world-class climate research and its future was now on a much firmer footing.

"This announcement recognises the importance of climate research, in particular modelling and observations, to our science and our community. The new centre is a stable building

block in this critical field, which will both inform national policy and meet our international obligations," Dr Finkel said.

"Australia has a central role to play in understanding the climate of the Southern Hemisphere."



The *RV Investigator*.

SCOTS GET HALF ENERGY FROM RENEWABLES

Scotland generated the equivalent of 57.7 per cent of its electricity consumption from renewable sources in 2015, according to statistics released by the UK Department of Energy and Climate Change.

This record figure beats the government's 2015 interim target to meet half the country's electricity demand from renewable sources, which means Scotland is more than halfway to its ultimate goal of fully renewable electricity.

The 2015 gains, with renewable electricity generation up by almost 16 per cent over 2014, came from increases in wind (up 21.2 per cent) and hydro (up 7.2 per cent) power generation.

This follows reports in January that Denmark produced 42 per cent of its electricity from wind turbines in 2015, up from 39 per cent in 2014.

The Danish Government aims to produce half of all its electricity from wind by 2020.

Some regions in Denmark's west produced more wind energy than they could consume for the equivalent of 60 days of last year. Government sources said that on one particularly windy day in July, Denmark produced 140 per cent of its electricity demands from its wind turbines and was able to sell the excess off to Germany, Norway and Sweden.

ARENA part of nine new R&D projects

The Australian Renewable Energy Agency (ARENA) has announced \$17 million in funding for nine new R&D projects through its latest collaboration R&D funding round.

ARENA CEO Mr Ivor Frischknecht said the funding would create clear pathways for renewable energy technologies to move from the laboratory to the field by fostering collaboration between research institutions and industry.

"ARENA's \$17 million funding is leveraging substantial contributions from private and public sectors, with combined project values totalling more than \$54 million. This will tap into our home-grown ingenuity and complement our existing portfolio of 144 R&D projects."

Mr Frischknecht said the projects would ultimately aim to benefit businesses and consumers by integrating more renewables into our energy networks and industrial processes.

"A range of renewable energy technologies are represented, including storage, biofuels, wave power, solar PV and solar thermal," Mr Frischknecht said.

"The Australian National University is leading three projects (totalling \$14.4 million). One will develop a system to estimate the

power produced by all the rooftop solar PV in a given area, another will look at how robots could capture data for solar installation diagnostics and the third will look at how battery storage and solar can solve network constraint problems on Bruny Island.

"The (\$2.6 million) project led by Curtin University of Technology aims to unlock the potential of renewables in medium-density strata developments, while the (\$10.6 million) University of Wollongong-led one aims to develop a low-cost, high-density sodium battery.

"The University of Adelaide will lead a (\$15.1 million) project to find out if solar thermal energy can be integrated into Alcoa's alumina refining process and Queensland University of Technology will work with industry (on a \$5.7 million project) to explore how to produce biogas from sugarcane to further reduce the sugar industry's fossil fuel use.

"The (\$3.6 million) project led by the University of Western Australia will determine the optimum size and location of wave energy arrays and the University of South Australia-led (\$2.1 million) project will develop low-cost phase-change materials, which can store solar power for the industrial refrigeration market."

CEFC BACKS WINDLAB

The Clean Energy Finance Corporation is providing \$8 million to a CSIRO spinout company, Windlab Ltd, which is commercialising CSIRO renewable energy research.

Windlab, established in 2003, has developed more than 550MW of wind energy projects and currently has a development portfolio in excess of 50 projects, totalling some 7000MW of potential capacity, including 10 projects in Australia. Windlab now operates in seven countries, including Australia, Canada, the US and across southern Africa.

"This CEFC finance will help Windlab continue its expansion from project development to investment and asset management, important to its growth plans," CEFC CEO Mr Oliver Yates said.

"Windlab's success to date is reflected in the breadth of its corporate activities, which now include wind and solar-farm project development, asset management and equity investment.

"Through our experience in the renewables sector, CEFC has been able to bring together the appropriate finance structure to support Windlab in securing the next phase in its business strategy. This is a great example of an Australian business using locally developed innovation to drive business success in the growing renewable energy market."

RESIDENTIAL BATTERY STORAGE UNDER TRIAL

Solar panels on an Alkimos Beach house.



A residential battery storage trial is now running in the suburb of Alkimos Beach, north of Perth, supported by \$3.3 million in funding from the Australian Renewable Energy Agency (ARENA).

ARENA CEO Mr Ivor Frischknecht said the Alkimos trial was set to prove an innovative energy retailing model suited to the 21st century and the lessons learned would address gaps in existing knowledge, potentially paving the way for similar projects.

"A central 1.1 megawatt-hour (MWh) of lithium-ion battery storage has been installed in two shipping containers in the suburb. It will store power from more than 100 rooftop solar photovoltaic (PV) systems," Mr Frischknecht said.

"Combining community-scale battery storage and rooftop solar presents a win-win for energy retailers, developers and consumers, and can provide households with the benefits of storage without on-site installation and maintenance.

"Solar will work alongside battery storage to lower Alkimos Beach's demand for electricity from the grid. This model has the potential to offer residents cheaper electricity bills and reduce grid connection costs for future new developments."

The \$6.7 million trial will run until 2020.



BY LACHLAN BLACKHALL
lachlan@repositpower.com

The personal power station is on the rise

Australia is a proving ground for residential energy storage and an overwhelming majority of global battery manufacturers are launching their products in Australia.

Australia has an amazing opportunity right now to lead the deployment and grid integration of residential energy storage globally. This storage rollout not only creates opportunities for related products and technologies but also creates the impetus for new businesses and business models around electricity distribution and retail.

If we get this right Australia will stand at the forefront of a revolution in how the electricity network of the future will operate.

Australia has two compelling reasons for adopting residential energy storage at the moment.

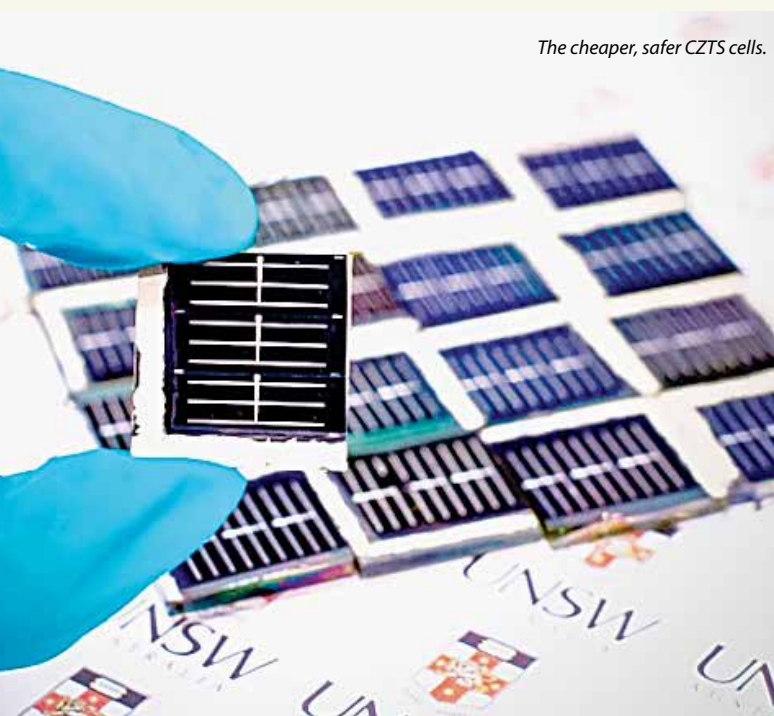
1 Australia has an incredible solar resource. More than 1.5 million homes across Queensland, NSW, ACT, Victoria, Tasmania and SA provide more than 4GW of residential solar generation capacity. Globally, Australia has one of the largest, if not the largest, per capita deployment of solar. Alongside this, more than 200,000 customers in NSW, SA and Victoria are about to lose generous solar feed-in tariffs (up to \$0.60/kWh).

2 Our electricity prices are amongst the highest in the world. Of the top 10 electricity prices globally, prices in SA, NSW, Victoria and WA occupy positions three to six.

For these reasons, consumers with solar are looking to energy storage as a mechanism to capture and use more of the energy they generate – reducing their grid consumption and ultimately lowering their electricity bill.

Globally, Australia is seen as a proving ground for residential energy storage, which means that an overwhelming majority of global battery manufacturers are launching

NSW LEADS RACE FOR NON-TOXIC, THIN-FILM CELLS



The cheaper, safer CZTS cells.

'Zero-energy' buildings – which generate as much power as they consume – appear closer after a UNSW team achieved the world's highest efficiency using flexible solar cells that are non-toxic and cheap to make.

Until now, the promise of zero-energy buildings has been held back by two hurdles: the cost of the thin-film solar cells (used in façades, roofs and windows), and the fact they're made from scarce and toxic materials.

But a University of NSW team, led by Dr Xioajing Hao from the Australian Centre for Advanced Photovoltaics at the UNSW School of Photovoltaic and Renewable Energy Engineering, has achieved the world's highest efficiency rating for a full-sized thin-film solar cell using a competing thin-film technology known as CZTS.

NREL, the US's National Renewable Energy Laboratory, has confirmed the world-leading 7.6 per cent efficiency in a 1cm² area CZTS cell.

"This is the first step on CZTS's road to beyond 20 per cent

Unlike its thin-film competitors, CZTS cells are made from abundant materials (copper, zinc, tin and sulfur) and CZTS has none of the toxicity problems of its two thin-film rivals, known as CdTe (cadmium-telluride) and CIGS (copper-indium-gallium-selenide). Cadmium and selenium are toxic at even tiny doses, while tellurium and indium are extremely rare.



A residential energy storage consumer using Reposit's technology.

their products in Australia first. This includes storage systems from Tesla, LG, Samsung and Enphase.

Many more energy storage systems from manufacturers in Japan, China, South Korea, Germany and the US will reach Australian shores in 2016 – and this doesn't include those being developed in Australia. This wide variety of storage systems will provide substantial choice for Australian consumers, hopefully driving prices down rapidly over the years ahead.

The primary reason that consumers are adopting residential energy storage is that it allows them to capture excess solar generation during the day and use it at night when peak energy prices are present. This is typically referred to as 'solar shifting'.

While shifting power using energy storage is one way to utilise solar and energy storage, it is not the only way. At Reposit Power, we are excited about all of the other ways that we can make solar and storage work for customers through the deployment of advanced real-time control and optimisation systems.

Advanced real-time control software can not only shift solar from when it is generated to when you need it but it can also pre-charge energy storage systems on cloudy days and take advantage of arbitrage opportunities in time of use (ToU) tariffs. Importantly, such software, when coupled with an energy storage system, can also be used to sell energy back to the grid when wholesale prices are high, or when the grid needs extra stability services. Allowing consumers to sell back to the grid is vital for supporting the rollout of other renewable energy generation such as wind and commercial solar.

Over the years ahead, stability services provided by residential energy storage will increase the stability of the grid in the presence of high renewable penetration from new renewable technologies such as geothermal and wave energy.

Residential energy storage is going to

drive a revolution which will ensure that customers can participate directly in the grid, not only saving money but also actively participating in keeping the grid stable and providing a steady supply of renewable energy for us all.

In years to come energy storage and smart software may allow consumers to trade energy peer-to-peer and, in the not-too-distant future, energy storage deployed throughout the grid may allow us to completely eliminate the fossil-fuel-fired power stations that we have today.

The time is right for the rise of the personal power station. A combination of residential solar and energy storage, powered by Reposit can underpin this revolutionary change in our electricity grid. ☺

Dr Lachlan Blackhall was the inaugural (2015) winner of the Batterham Medal, an award by ATSE on behalf of the Go8 Deans of Engineering and Associates that recognises an early career engineer who has achieved substantial peer and industry recognition for their work. Dr Blackhall graduated from the University of Sydney with a BE/BSc and the University Medal and has a PhD in control theory from ANU. He won two major prizes for his research before co-founding Reposit Power, a technology company designing advanced control systems for grid-deployed energy storage. As Chief Technology Officer, he has pioneered the use of distributed control schemes.

efficiency, and marks a milestone in its journey from the lab to commercial product," Dr Hao said. "There is still a lot of work needed to catch up with CdTe and CIGS, in both efficiency and cell size, but we are well on the way."

"In addition to its elements being more commonplace and environmentally benign, we're interested in these higher bandgap CZTS cells for two reasons," said Professor Martin Green AM FRS FAA FTSE, a mentor of Dr Hao.

"They can be deposited directly onto materials as thin layers that are 50 times thinner than a human hair, so there's no need to manufacture silicon 'wafer' cells and interconnect them separately. They also respond better than silicon to blue wavelengths of light, and can be stacked as a thin-film on top of silicon cells to ultimately improve the overall performance."

Dr Hao believes CZTS's cheapness, benign environmental profile and abundant elements may be the trigger that finally brings architects and builders onboard to using thin-film solar panels more widely in buildings.

Until now, most architects have used conventional solar panels made from crystalline silicon. While these are even cheaper than CZTS cells, they don't offer the same flexibility for curved surfaces and other awkward geometries needed to easily integrate into building designs.

\$1 BILLION FOR CLEAN ENERGY FUND

The Australian Government is establishing a \$1 billion Clean Energy Innovation Fund (CEIF) to support emerging technologies make the leap from demonstration to commercial deployment.

The Fund will be jointly managed by the Clean Energy Finance Corporation (CEFC) and the Australian Renewable Energy Agency (ARENA) and provide both debt and equity for clean energy projects.

Prime Minister Malcolm Turnbull said the Government would reinvigorate the Clean Energy Finance Corporation and the Australian Renewable Energy Agency, which would work together to provide capital investment in Australian businesses and emerging clean energy technologies.

The CEIF will target projects such as large-scale solar with storage, off-shore energy, biofuels and smart grids.

ARENA will continue to manage its existing portfolio of grants and deliver the announced \$100 million large-scale solar round, and will be given an expanded focus beyond renewable energy to enable energy efficiency and low-emissions technology, according to the announcement. Once the large-scale solar round is complete, ARENA will move from a grant-based role to predominantly a debt and equity basis under the CEIF.

The CEIF will be established from within the CEFC's \$10 billion allocation. This Fund will make available \$100 million a year for 10 years.

NEWS

Power Shift looks to 21st century

The Clean Energy Council has released *Power Shift: A blueprint for a 21st century power system*, which details a suite of strategic policy and regulatory measures to drive the transition from a high-emission power sector to an energy system powered by renewable energy, battery storage and efficient and smart technology.

Clean Energy Council Chief Executive Mr Kane Thornton said taking advantage of Australia's massive clean energy potential would allow the nation to modernise its energy system and cut emissions from the energy sector to zero by no later than 2050.

Ultimately this transformation would do much of the heavy lifting for Australia's commitments under

the global climate agreement reached in Paris last year.

He said *Power Shift* contained many actions that could be integrated by policymakers and regulators to pave the way for a modern energy system which created a more competitive market and empowered consumers to generate, store and manage their own electricity use.

POWER SHIFT CALLS FOR:

- transparent carbon reduction targets that apply to the energy sector, recognising the important interaction between energy policy and climate change policy;
- strong and long-term renewable energy targets that ensure the continued and steady deployment of renewable energy;
- innovation that delivers the next generation of clean energy solutions with appropriate institutions and support for R&D, demonstration, and innovative financing for the clean energy sector;
- smart regulation that creates a competitive market and empowers consumers and reforms energy market and regulatory frameworks to facilitate greater competition, empower consumers and overcome the barriers to unlock the commercial opportunities to transition to smarter, cleaner energy technologies; and
- public support achieved by unlocking the benefits of renewable energy for communities and consumers.

AUSTRALIA JOINS NUCLEAR RESEARCH FORUM

Australia has joined the Generation IV International Forum (GIF), a cooperative international endeavour, along with 12 other nations and the European Union to work together on long-term research on advanced nuclear technologies.

The Forum develops Generation IV technology and addresses not only the construction and operation of the next generation of nuclear power reactors, but also considers fuel efficiency, reducing waste production, and meeting stringent standards of safety and proliferation resistance.

Industry, Innovation and Science Minister Christopher Pyne said Australia's success in gaining membership was based on the landmark research infrastructure and world-class research capabilities and expertise of the Australian Nuclear Science and Technology Organisation (ANSTO) to contribute to the GIF's goals.

"Australia's invitation to join this important global project marks an exciting opportunity to be at the forefront of global innovation in the nuclear industry," Mr Pyne said. "Inclusion in the GIF further strengthens Australia's position as a nation that has the research muscle to deliver innovations on the global stage.

GIF research is focused on six reactor designs that will deliver safe, secure, sustainable, competitive and versatile nuclear technology. GIF expects that some of these reactor designs could be demonstrated and commercially rolled out in around 2030 to 2040, and current members are already developing and constructing prototype technologies.

Meanwhile the Government has shortlisted the voluntarily nominated site in Barndioota, South Australia, as a possible site for a National Radioactive Waste Management Facility. Last November the Government shortlisted six voluntarily nominated sites for community consultation, three in SA, and one in each of NSW, Queensland and the Northern Territory.

TRACKING CLOUDS TO BOOST PV PLANTS



PHOTO: ARENA

A cloud-tracking system that enables cheaper renewable energy by forecasting the power output of solar photovoltaic (PV) plants has entered the Australian market, with Fulcrum3D selling its CloudCAM technology to utility-scale solar customers.

Fulcrum3D Technical Director Mr Colin Bonner said three commercial solar sites across Australia had purchased CloudCAMs, including two sites operated by renewable energy company Epuron.

"The two sites, at Ti-Tree and Kalkarindji in the Northern Territory, are the first high-penetration PV power stations in Australia to use cloud forecasting to smooth solar power output," he said. "In addition to increasing revenue, the integration of CloudCAM at the Ti Tree site has seen a significantly lower demand for energy from its storage system, reducing cycling of the batteries and increasing battery life."

A pilot project received more than \$500,000 funding from the Australian Renewable Energy Agency.

ATSE PEOPLE

Two Fellows on ARENA Board

Mr Jonathan Jutsen FTSE and Dr Katherine Woodthorpe FTSE have been named among six new directors on the board of the Australian Renewable Energy Agency (ARENA).

Announcing the appointments, Environment Minister Greg Hunt said the board would, in collaboration with the Clean Energy Finance Corporation (CEFC), jointly manage the \$1 billion Clean Energy Innovation Fund to support emerging technologies make the leap from demonstration to commercial deployment.

Mr Jutsen is the Chair of the Australian Alliance to Save Energy and has been a leading figure in Australia and internationally in the energy efficiency and carbon management field for more than three decades.

Dr Woodthorpe is an experienced non-executive director, serving on boards ranging from ASX-listed companies to research institutions and government entities for nearly 20 years. An experienced venture capitalist, she was Chief Executive of the Australian Private Equity and Venture Capital Association Ltd 2006–13.

Mr Martijn Wilder AM will serve as the new Chair of ARENA. Head of Baker and McKenzie's



Katherine Woodthorpe

Global Environmental Markets Practice, his other roles include Adjunct Professor of Climate Change Law at the Australian National University and an Affiliate of the Cambridge Centre for Climate Change Mitigation Research at the University of Cambridge.

Other Directors are Ms Maria Atkinson AM, Ms Susan Jeanes and Ms Meg McDonald.



Jonathan Jutsen

CRAIG SIMMONS TAKES ON WATER QUALITY ROLE

South Australian 2105 Scientist of the Year Professor Craig Simmons FTSE has been appointed to a national advisory group on Australia's drinking water quality. The National Health and Medical Research Council (NHMRC) Water Quality Advisory Committee provides expert advice to the NHMRC on public health issues related to drinking water quality.

"Water quality is a profoundly important and fundamental issue for all aspects of public and environmental health nationally and internationally," Professor Simmons says.

A leading Australian hydro-geologist, Professor Simmons, the director of the National Centre for Groundwater Research and Training (NCGRT) at Flinders University, will join other leading authorities in the fields of microbiology, toxicology, regulation of water quality and operation of water utilities.

"I am honoured to be invited to join the committee, which is also responsible for targeted research areas relating to health and water, Australian public health epidemiology and World Health Organization systems and processes for drinking water quality," he says.

"The NHMRC Water Quality Advisory Committee will provide advice on current and emerging health issues relating to water quality in Australia, the Australian Drinking Water Guidelines, and identify gaps in the NHMRC water quality guidelines."



Craig Simmons

WA AANSTO CHIEF REAPPOINTED



Adi Paterson

Dr Adi Paterson FTSE has been reappointed for five years as the CEO of the Australian Nuclear Science and Technology Organisation (ANSTO), which is the home of Australia's nuclear science expertise and the custodian of some of the nation's most significant science and research infrastructure.

Dr Paterson commenced his tenure as CEO in March 2009. Under his leadership, ANSTO has significantly expanded its national and international impact.

Major programs and projects that are helping drive ANSTO's growth include:

- the \$168.8 million ANSTO nuclear medicine project, which will come online in coming months and see ANSTO more than triple its production of potentially life-saving nuclear medicines; and
- ANSTO's assumption of operational control of the Australian Synchrotron.

ANSTO Chair, Mr Jim McDowell, said Dr Paterson's leadership, achievements and strong vision for ANSTO's future had made the Board confident of Dr Paterson's continued leadership.

"Dr Paterson has led ANSTO exceptionally well, and will continue to do so. With Dr Paterson at the helm we are well positioned to continue to deliver strong outcomes for Australia," Mr McDowell said.

Dr Erica Smyth FTSE is ANSTO Deputy Chair.

ATSE PEOPLE

Frazer to head medical research board

Five Fellows have been named by Health Minister Sussan Ley as members of a new eight-member advisory board to advise the Government on investing proceeds from the \$20 billion Medical Research Future Fund.

The Board will be chaired by eminent scientist Professor Ian Frazer AC FRS FAA FTSE. Professor Frazer, who was integral in developing the HPV vaccine against cervical cancer, is also president of the Cancer Council Australia.

He will be joined on the Australian Medical Research Advisory Board by seven other directors, including four Fellows: Professor Doug Hilton FAA FTSE, President of the Association of Australian Medical Research Institutes; University of Queensland Vice Chancellor Professor Peter Høj FTSE; Chief Executive of ASX-listed biotech company Bionomics, Dr Deborah Rathjen FTSE; and Flinders University academic Professor Karen Reynolds FTSE.

The Board will develop the Australian Medical Research and Innovation Strategy every five years, and associated Australian Medical Research and Innovation Priorities every two years. It will also provide advice to the Health Minister on other matters that relate to use of funding from the MRFF.

"The MRFF is the single largest investment in medical research ever made in this country – and a core part of the Australian Government's health reform and innovation agenda," Ms Ley said.

"The Advisory Board will ensure that any expenditure from the MRFF will have a strong



Karen Reynolds



Ian Frazer



Peter Høj



Deborah Rathjen

business case, ensuring that the financial assistance provided from the MRFF delivers the greatest value for all Australians."

Professor Frazer is founding CEO and Director of Research of the Translational Research Institute in Brisbane. He has received more than 20 awards for science, including a Eureka Prize for Leadership in Science (2006), a Clunies Ross Award and Howard Florey Medal (2007), and the Prime Minister's Prize for Science and a Balzan Prize (2008).

Professor Hilton is a molecular biologist, Director of the Walter and Eliza Hall Institute of Medical Research and Head of the Department of Medical Biology at the University of Melbourne. Professor

Hilton, a member of ATSE's Gender Equity Working Group, is one of 20 inaugural 'Male Champions of Change', recognised for his work to improve the representation of women at senior levels of medical research.

Professor Høj was formerly the Vice Chancellor and President of the University of South Australia from June 2007 to October 2012. Prior to this, he was Chief Executive Officer of the Australian Research Council (2004–07) and Managing Director of the Australian Wine Research Institute, based in Adelaide (1997–2004). Professor Høj was educated at the University of Copenhagen, majoring in biochemistry and chemistry. He has a Master of Science in biochemistry and genetics and a PhD in photosynthesis.

Dr Rathjen has significant experience in company building and financing, mergers and acquisitions, therapeutic product research and development, business development, licensing and commercialisation. Dr Rathjen has been recognised both in Australia and internationally through awards and honours. In 2015 she was named in the Top 50 most influential Australia business women by *The Australian* newspaper.

Professor Reynolds is Deputy Dean, Computer Sciences, and a Matthew Flinders Distinguished Professor at Flinders University, a Director of ATSE and Chair of its Health Technology Forum, a member of the SA Science Council, Chair of the Biomedical Engineering College, Engineers Australia, and also Chair of EA's National Panel for Biomedical Engineering Education and Research.

CHARLIE SARTAIN WINS THE INSTITUTE MEDAL

Queensland Division stalwart Mr Charlie Sartain FTSE has been awarded the The Institute Medal – the most prestigious award and highest honour conferred by the AusIMM. It is awarded in recognition of eminent leadership services to the Australasian minerals sector.

Mr Sartain's commitment to the global minerals industry spans 35 years. He spent the early part of his career in a variety of mining engineering and management roles at the Mount Isa Mines complex in north Queensland. He then held several general



Charlie Sartain

manager and senior executive roles in Australia and overseas before being appointed Chief Executive of Xstrata Copper and a member of Xstrata plc's Executive Committee in January 2004. Over subsequent years Xstrata Copper grew to become the world's fourth largest copper producer. Mr Sartain left the Xstrata Group upon the completion of the merger with Glencore plc in May 2013.

As his career progressed, Mr Sartain became known for his philanthropic and corporate activities that enhanced research, promoted social responsibility and recognised the importance of the minerals industry in a global context.

ATSE PEOPLE

Fellows leading NSW data analytics

Three ATSE Fellows are playing a leading role in the NSW Government's Data Analytics Centre (DAC) as members of a new advisory board to hone the Government's data priorities.

Chaired by the chief information officer at the Australian Stock Exchange, Mr Tim Thurman, the board comprises nine other members from government, industry and academia.

The creation of the board follows the appointment of Dr Ian Oppermann FTSE as CEO and Chief Data Scientist of the NSW Data Analytics Centre. He is NSW's first Chief Data Scientist, having acted in the role in an interim capacity since the middle of last year.

Dr Oppermann has more than 20 years' experience in the ICT sector and has held senior management roles in Europe and Australia as Director for Radio Access Performance at Nokia, Global Head of Sales Partnering (network software) at Nokia Siemens Networks, and then Divisional Chief

and Flagship Director at CSIRO.

He is regarded as a thought leader in the area of the digital economy and is a regular speaker on 'Big Data', broadband enabled services and the impact of technology on society. He has an MBA from the University of London and a PhD in Mobile Telecommunications from the University of Sydney.

NSW Innovation Minister Mr Victor Dominello said the first-of-its-kind facility, which is presently co-located at the University of Technology Sydney, would better enable data sharing between agencies to inform more efficient, strategic, whole-of-government, evidence-based decision-making.

"The board will advise government on priorities and the key partnerships across industry, government and research sectors that should be forged to ensure outcomes are delivered," Mr Dominello said.

Professor Mary O'Kane AC FTSE, NSW Chief Scientist and Engineer, and Professor Hugh



Ian Oppermann

Durrant-Whyte FRS FAA FTSE, Director of the Centre for Translational Data Science at the University of Sydney, are on the new Board.

"With the calibre of Dr Ian Oppermann and Tim Thurman at the helm, I'm confident the DAC will deliver positive outcomes," Mr Dominello said.

SIDDIQUE TAKES THE PULSE

The University of Western Australia's Agriculture Chair, Professor Kadambot Siddique AM FTSE, has been named by the United Nations Food and Agriculture Organization (FAO) as Special Ambassador for Pulses 2016 at a ceremony in Marrakesh, Morocco.

Professor Siddique received the Special Ambassador designation at the 2016 International Conference on Pulses for Health, Nutrition and Sustainable Agriculture in Drylands, where world experts gathered to find a path forward to boost pulse production in developing countries using science, development investments, policy and markets.

As Special Ambassador, Professor Siddique will raise awareness of the important contribution of pulses to food security and nutrition, including the positive impact of pulses on climate change, human health and environmental sustainability.

"In the changing climate, the role of pulses in farming systems is important for crop diversification, nitrogen fixation and availability of nutrients in the system, as well as for human health, including cardiovascular disease, diabetes, obesity and dementia," Professor Siddique said.

"I am humbled and honoured to continue the FAO's mission of eradicating hunger, food insecurity and malnutrition. With declining arable land and water, now more than ever

we need to mobilise responsible governance of food production."

FAO Director General José Graziano da Silva said the appointment was made in recognition of Professor Siddique's outstanding contribution to Australian and international agriculture, leading innovative research in production agronomy, development and breeding of pulses and cereal crops for the benefit of the grains industry in Australia and overseas.

"Your many efforts have also promoted international collaboration by providing an extensive network of research connections to help farmers improve the quality and output of their crops," Dr Graziano da Silva said.

"I am confident that your knowledge, commitment and influence would amplify the message about the important role of pulses in

sustainable food production, and will send a strong signal to the international community on their benefits for soil fertility and climate change."

Professor Siddique has 30 years' experience in agricultural research, teaching and management in both Australia and overseas. As a result of his personal research and extensive collaborations, Australia has become one of the major grain legume exporting nations in the world. His pioneering research on chickpeas has contributed enormously to the Australian chickpea industry, currently valued at more than \$300 million a year.



Kadambot Siddique honoured in Marrakesh.

ATSE PEOPLE

Chris Roberts blazes the innovation trail

After 40 years at the frontier of ground-breaking medical device technology, former Cochlear CEO Professor Chris Roberts FTSE has built a career on being one step ahead of the curve.

As the inaugural joint Professor of the PLuS Alliance, a global collaboration between UNSW Australia, King's College London and Arizona State University, Professor Roberts hopes to take his passion for innovation to the next level, bringing together government, industry and academia across three continents to solve some of the world's most pressing problems.

"What are all these different countries, states and cities doing to drive innovation, to drive translation? What does the future look like and how do we participate in that?" he asks.

"It's about government policy, it's about industry and it's about universities, and how do these groups work collaboratively together – what are the settings that the government needs?"

Strategic thinking is second nature for Professor Roberts, a chemical engineer who started his professional life in the field of renal dialysis and went on to become chief of trailblazing hearing device company Cochlear – a position he held for 11 years.

"As a medical device company you're

trying to see the future of clinical practice. Asking how are you as a healthcare professional going to want to manage your patients down the track, given the doubling of medical knowledge every two to four years," he says. "And it is also about being able to see the future of technology."

In his new role with the PLuS Alliance, Professor Roberts' focus is to grow biomedical

engineering's footprint both locally and across the globe. It's an ambitious challenge, but one for which he's well equipped, having worked in fields ranging from orthopaedics and cardiology to sleep medicine, as well as serving on the executives of Cochlear and ventilation technology giant ResMed.

"The medical devices industry is characterised by technologic innovation and

Chris Roberts



PHOTO: QUENTIN JONES

TOM CALLCOTT A BHP RESEARCH STALWART

Dr Tom Callcott AM FTSE, a fuel technologist and pioneer of the Australian Institute of Energy, was widely known for his work as fuel research manager with BHP.

A University of Melbourne engineering graduate, he spent most of his working career at the BHP Central Research Laboratories in Newcastle (1956–82), following earlier employment with ICIANZ Ltd (now Orica).

He established Callcott Consulting in 1982 after he left BHP. He was named a Member of the Order of Australia in 2002 for his service to science, particularly in the field of particle science, coal carbonisation and coal technology. He joined ATSE as a Fellow in 1976.

ATSE has recently learned of his death in Newcastle in November 2014, aged 90.

This obituary was contributed by Emeritus Professor Dr Alban Lynch AO FTSE:

Tom Callcott was born in Melbourne and graduated BSc (1947) and DAppSc (1970) from the University of Melbourne. He had supervisory and research roles with ICIANZ Ltd in 1947–51, working on synthetic ammonia production, brown coal fluidised drying and carbonisation.

The composition and processing of coal became his principal research interest, beginning when he worked on the generation of fine coal particles with the British Coal Utilisation Research Association during 1951–55. BCURA was one of the early industry research groups established in Britain and fine coal was a problem in the domestic heating systems of the time because they were not designed to handle the fines that mining inevitably produced.

One outcome of Tom's research was the development of the Broadbent–Callcott technique, which tracked the movement of particles through size fractions as breakage occurred. The equation incorporating breakage, selection and classification that they used became the basis of models which are now used for optimising industrial comminution processes.

ATSE PEOPLE

research and development, and many are in niche markets so they have to be global. So I've spent my life in international, innovative businesses."

In addition to corporate boards, he has also had extensive experience in the government sector and is currently serving on three top advisory bodies – the NHMRC's Health Innovation Advisory Committee, Jobs NSW, and Innovation and Science Australia – a new independent body to help drive the Turnbull Government's \$1.1 billion National Innovation and Science Agenda.

He sees the PLuS Alliance as complementing these roles and says that, rather than simply swapping industry for academia, "I am actually creating something a little bit different".

Professor Roberts has long been a believer in the importance of universities to corporate innovation; he moved Cochlear back onto an academic campus at Macquarie University to bring it within a research environment.

Together, Cochlear and the university have built a 'hearing precinct', also housing not-for-profits and government statutory bodies – a "wonderful example" of top-down strategic collaboration Roberts says happens all too infrequently.

"A lot of collaboration, particularly in research, is bottom-up. But that's not strategic," he says.

"What I'm interested in is how do we

take these three leading, globally thinking universities and top-down form a strategic alliance. How do we make that work?"

Although it's early days – he started the position in February – Professor Roberts has hit the ground running, with fact-finding missions to London and the US.

Each PLuS Alliance university has different strengths, and his mission is to explore how new opportunities and advantages can be leveraged through collaboration, particularly in areas such as business and commercialisation or greater integration between and within faculties.

Plenty of things are exciting Professor Roberts in the engineering space, from new materials to UNSW's quantum computing research and developments in machine learning, which he says could have important applications in medicine and research.

His own journey into medical technology was one of "serendipity". Originally seeking a degree that would offer good employment prospects, he chose food technology, the logic being that "people are always going to need to eat".

He ultimately decided to enrol in chemical engineering, thinking it sounded a bit more challenging, but still took all the food-related subjects: brewing, dairy, cheese "and that got me into biology and microbiology".

While an undergraduate at UNSW, he studied under ResMed founder Dr Peter

Farrell AM FTSE, who had done his PhD with US dialysis pioneer Belding Scribner and returned to Sydney to set up a new nephrology research laboratory.

"I did my final-year experimental design thesis in his lab and got really excited about dialysis – I was blown away that you could keep people alive with just these very simple chemical engineering principles," Professor Roberts says.

Cochlear founder the late Paul Trainor gave him his first job out of university in 1976. He went on to do his MBA and a PhD in biomedical engineering, completing his thesis on plasma exchange therapy for autoimmune diseases – a technique he ultimately likened to "killing a mosquito with a sledgehammer", although it is used today to treat conditions such as Guillain-Barré syndrome.

He entertained the idea of going into medicine at some point but says he realised very early on that "if you could bring technology in and do some of these things you could probably influence just as many people, maybe a larger number of people".

"I think you've always got to be moving forward," he says. "If you get up every morning motivated and fired up, and actually just put one foot in front of the other, it's amazing what you can do."

Edited from an article that first appeared on the UNSW online Newsroom, written by Amy Coopes.

Tom worked with the BHP Central Research Laboratory in Newcastle from its establishment in 1956 to 1982, becoming Fuel Research Manager during the later part of this period. From 1982 until retirement in 2007, Tom was the Principal of Callcott Consulting PL.

His research and development projects were concerned with the physical and chemical properties of coals, cokes and other coal derivatives, resource characterisation and appraisal, comminution of fuels and minerals, coal preparation research and practices, Auscoke, Integrated Pipeline Transport and coal separation system, with special emphasis on coal conversion especially liquefaction through solvent refined coal.

Tom travelled widely and gained an international reputation. He was the first Australian to receive the Melchett Medal (1976), which is the highest award of the British Institute of Energy. It is awarded for



Tom Callcott

outstanding contributions to the science of fuel and energy. He was Foundation President of the Australian Institute of Energy and holder of numerous offices in the Australian membership of the Institute of Fuel, including National Chairman for two years.

He was inventor of patents granted in several countries concerning coking (Auscoke process), gasification (OXAR process), ball mill media, coal processing and transporting. He published more than 100 papers and patents

and was co-author with GB Smith of the book Solvent Refined Coal.

Tom was awarded the Institute Medal of the AusIMM in 1991 and the Joseph Becker Award of the Iron and Steel Society in 2001, and an Order of Australia in 2002.

He is survived by his wife, Mary, and his two daughters, Barbara and Ruth.

ATSE PEOPLE

Crozier has a clear vision of success

It was only when Professor Stuart Crozier FTSE and his colleagues shook hands on a licensing deal with global healthcare giant GE Healthcare that he realised the technology he'd co-invented was going to affect the lives of countless patients worldwide.

Professor Crozier, Director of the Biomedical Engineering and MedTeQ Centre at the University of Queensland, and his team developed a way to make images from magnetic resonance imaging (MRI) scanners clearer. This innovation vastly enhanced the value of MRI machines as diagnostic tools and helped clinicians detect diseases earlier.

The technology is now central to more than 65 per cent of all MRI scanners manufactured and has been used in billions of scans.

"We shook hands on the deal with GE Healthcare after protracted negotiations and then they told us the volume of their sales and the reach of the machines around the world. It was only then we realised we would be a part of the diagnosis of huge numbers of patients," Professor Crozier says. "That is such a wonderful feeling."

Along with GE Healthcare, another major manufacturer of MRI machines, Siemens Technology, has licensed the technology.

These deals have brought tens of millions of dollars to UQ.

"Our timing was really fabulous in terms of focusing on the technology of MRI and the engineering of it," Professor Crozier says.

This early success was the first of several medical technology breakthroughs he and his colleagues have made. He holds more than 20 patents for MRI-related technologies and his expertise in designing medical devices and developing new applications has had a significant global impact.

Professor Crozier migrated to Australia with his family from Newcastle-upon-Tyne, in the north of England, when he was six years old. He grew up in Brisbane, where his father was a motor mechanic.

A talent for maths and physics, and an interest in health and medicine, led him to study a Bachelor of Engineering, specialising in electrical engineering, at the Queensland University of Technology (QUT). Before he started his undergraduate degree, he undertook an internship at the biomedical engineering department of the Princess Alexandra Hospital in Brisbane. What he saw there sparked his interest in designing and developing medical devices.

"I saw engineers working on cool things.

But I also saw clinicians and allied health workers not being able to treat patients as effectively as they needed to because their diagnostic methods weren't up to it," he recalls. "Some of the treatments were also inadequate. They were quite clear about the things that they wanted to do but couldn't, and some of that was because of a lack of technology."

After completing his undergraduate degree, he joined the Princess Alexandra Hospital and the Queensland Government's medical physics department, and started on a part-time masters degree in medical physics at QUT. It established a pattern whereby he would undertake part-time higher education into areas that related to his day job.

"The work that I was doing motivated the study and the study helped to improve the work," says Professor Crozier, who also completed a PhD and a higher doctorate at UQ. This was followed by short stints working in laboratories in the UK, the US and Japan.

Following their success with clearer imaging, his team looked to reduce the size of the magnets MRI machines needed to operate. MRI machines use superconducting magnets cooled to minus 269°C. The large size of the magnets meant the machines were expensive and took up a lot of space

UWA HONOURS BERNARD BOWEN

WA science icon and long-time Fellow Dr Bernard Bowen AM FTSE has been awarded an honorary Doctor of Letters by the University of Western Australia (UWA).

Renowned as one of the country's finest science administrators and a passionate marine science and radio astronomy leader, he was

the founding chair of the International Centre for Radio Astronomy Research (ICRAR) in WA.

He was presented with the degree in recognition of his outstanding contribution to science in WA following a long and distinguished career spanning more than half a century.

Dr Bowen was WA's first government marine scientist, spent 23 years at the helm of the Department of Fisheries, was chair of the WA Environmental Protection Authority and helped develop the WA Marine Research Laboratories and the

WA Wildlife Research Centre. He guided the establishment of the WA Marine Science Institution (WAMSI) and was its founding chair.

He was instrumental in the establishment of ICRAR – a joint venture between Curtin University and UWA – and has chaired the ICRAR Board since 2009 and is a member of the WA Science Hall of Fame.

HARRY POULOS NAMED 'GEOLEGEND'

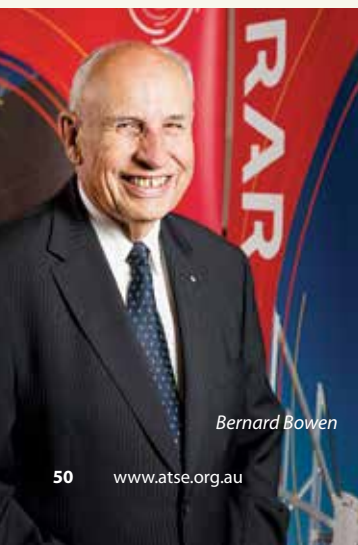


Harry Poulos

Professor Harry Poulos AM FAA FTSE, a world-leading authority on foundation engineering, has been named a 'GeoLegend' by the US Geo Institute (a part of the American Society of Civil Engineers) and been the subject of an in-depth interview in the latest issue of its *GeoStrata* publication.

GeoStrata says Professor Poulos' other areas of expertise include soil behaviour and piled foundations, marine geotechnics, and earthquake geotechnics. He has held dual roles in academia and industry and specialises in tall building foundation design.

In recent years he has been involved with foundation design for the Burj Khalifa (currently the world's tallest building) in Dubai,



Bernard Bowen

ATSE PEOPLE

Stuart Crozier with a radiofrequency coil.

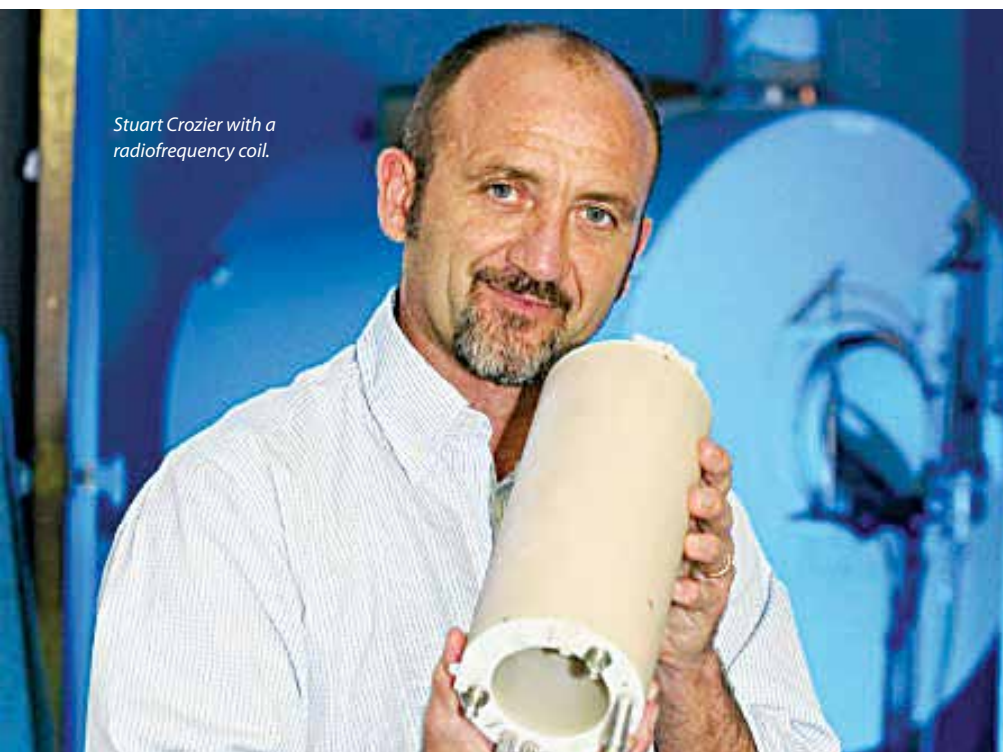


PHOTO: UQ

As one of the world's leading innovators in medical imaging technology, Professor Stuart Crozier FTSE is touching the lives of countless patients. His advancements in MRI scanner technology have been used in billions of scans and are helping doctors around the world make better and more timely diagnoses, improving patients' wellbeing and saving lives.

in hospitals. Their design also created discomfort for patients with claustrophobia, who had to enter the machine's tunnel-like entrance to be scanned.

The team developed smaller and more

portable magnets, which can now be found in a new range of mobile MRI machines.

When a knee or elbow needs to be scanned, there's no need for the patient to physically enter the machine. These smaller and cheaper

machines are now widely used in hospitals and clinics in developing nations.

There is also interest from sporting bodies, which see the benefits of being able to scan their players to assess if they can continue playing without aggravating or exacerbating an injury.

Professor Crozier's latest project is to develop an image-guided therapy to enable an MRI machine to locate and focus a radiation beam directly onto a tumour in real time, reducing the amount of healthy tissue that can be inadvertently irradiated using current methods.

This work is attracting considerable interest around the world. German scientific instrument maker Bruker is employing some of his developments in radiofrequency engineering. UQ's Magnetica, formed in 2005 to commercialise the magnets, is partnering with Japanese magnet maker Jastec and has also been holding talks with a Chinese company.

In 2012, Professor Crozier received a Clunies Ross Award for his 20 years of contributions to the field of magnetic resonance imaging.

Edited from an article that first appeared on the Australia Unlimited website written by Christopher Niesche. Australia Unlimited is a nation brand which is part of a broader Government-funded program called Building Brand Australia.

the proposed Incheon 151 Tower in Incheon, South Korea, and the Diamond Tower in Jeddah, Saudi Arabia.

Professor Poulos has been a Fellow for 20 years. In 1961 he earned a bachelor's degree in civil engineering from the University of Sydney, where he later obtained a PhD in 1965. Before transitioning into academia, he was an engineer at MacDonald Wagner & Priddle. He joined the Department of Civil Engineering at Sydney University in 1965 and was appointed professor in 1982, a position that he held until his retirement in 2001.

In 1989, he joined the consulting firm of Coffey Partners International, where he is currently a senior principal with Coffey Geotechnics. He is also an emeritus professor at the University of Sydney, and an adjunct professor at Hong Kong University of Science and Technology.

SURESH BHARGAVA WINS IRAN HONOUR

Professor Suresh Bhargava FTSE, Deputy Pro Vice-Chancellor (International) at RMIT, has been awarded the 29th Khwarizmi International Award, an initiative by the Iranian Ministry of Science, Research and Technology, with the support of major international

organisations such as UNESCO, to recognise the talent and achievements of scientists and engineers worldwide.

He was among nine international Laureates conferred in Tehran in March by the Iranian Minister of Science, Research and Technology.

This award recognises researchers, innovators and inventors from all over the world for their outstanding achievements and contributions to science and technology. The award is named after the 8th century Iranian mathematician and astronomer Abu Jafar Mohammad Ibn Mousa Khwarizmi.

Professor Bhargava was chosen from 628 nominations for his latest invention in the field of industrial chemistry – an ultrasensitive sensor for monitoring mercury emissions in alumina refineries using quartz crystal microbalances and a novel gold-based nanotechnology.



Suresh Bhargava

ATSE PEOPLE

Fellows prominent in research planning

Four Fellows are among the group of experts who will map out Australia's research priorities over the coming decade.

Education and Training Minister Senator Simon Birmingham said the new Expert Working Group (EWG) would help set the future direction of national research infrastructure, with \$150 million a year of indexed funding for the National Collaborative Research Infrastructure Strategy through the National Innovation and Science Agenda.

The eight-person EWG will be chaired by Chief Scientist Dr Alan Finkel AO FTSE and will include Professor Edwina Cornish AO FTSE, Provost of Monash University, Dr Andrew Cuthbertson FTSE, Chief Scientific Officer and R&D Director, CSL Ltd, and Dr Adi Paterson FTSE, CEO, ANSTO.

Minister Birmingham said the National Collaborative Research Infrastructure Strategy was critical to Australia's research community



Andrew Cuthbertson

Edwina Cornish

which, in turn, is critical to Australia's future.

"The work of this eminent group of Australians will develop a roadmap to maintaining and expanding Australia's world-class research capability," Minister Birmingham said. It was expected to be completed in late 2016.

"The Expert Working Group will consult widely with researchers, businesses and other stakeholders to develop a national 10-year plan to underpin research and innovation at

a national level and to identify future national research infrastructure priorities and areas for ongoing investment.

Minister Birmingham said the NCRIS supported national research infrastructure that provided services to more than 35,000 researchers, both domestically and internationally, through 27 projects and facilities delivered at 222 institutions.

"Combined with guaranteed funding for the National Collaborative Research Infrastructure Strategy, this Roadmap will help retain and attract the best researchers to position Australia amongst the world's other top research countries," Minister Birmingham said.

"This next phase for the National Collaborative Research Infrastructure Strategy is an important part of implementing our National Innovation and Science Agenda as our economy transitions from one reliant on mines to one focused on minds."

WENDY CRAIK TO HEAD BIOSECURITY REVIEW

Dr Wendy Craik AM FTSE will chair an independent review of the Intergovernmental Agreement on Biosecurity (IGAB), an essential component of the national biosecurity system.

Dr Craik will be joined by Dr Richard Sheldrake AM FTSE, ATSE NSW Division Chair and former Director-General of the NSW Department of Primary Industries Mr David Palmer.

The review was announced by Deputy Prime Minister and Minister for Agriculture and Water Resources Barnaby Joyce.

The IGAB was first introduced in 2012 to identify biosecurity roles and responsibilities across Australian governments, and outlines priorities for collaboration to minimise the impact of pests and disease on Australia's economy, environment and the community.

"Australia's biosecurity system is working well and our world-class credentials underpin the international market access enjoyed by our farmers and profits at the farmgate," Mr Joyce said. "Our biosecurity system protects the health of all Australians, plants and animals, but it is not something the Australian Government can deliver in isolation.

"Strong biosecurity relies on evidence-based processes and partnerships across all Australian governments and between industry, natural resource managers and the broader community.

"Strong biosecurity also requires sufficient resources and capability, which is why the Australian Government has committed an additional \$300 million to strengthen biosecurity efforts via the Agricultural Competitiveness White Paper. This review of IGAB will help ensure our nation's biosecurity system remains current, efficient and flexible."

Dr Craik holds a PhD in zoology and has previously served as a Commissioner of the Productivity Commission, Chair of the Australian Fisheries Management Authority, Chair of the National Rural Advisory Council and Executive Director of the National Farmers' Federation.



Wendy Craik



Richard Sheldrake

SHARING THEIR VISION FOR INNOVATION

Four Fellows were featured in the recent 'Thought Leadership Series' of articles promoted by Science Meets Business, an online publisher.

Chief scientist Dr Alan Finkel AO FAA FTSE wrote that all real-world problems were solvable from an engineering perspective.

CSIRO's Deputy Director and Science Director of Manufacturing Dr Cathy Foley PSM FTSE shared a four-step plan to ready Australia for the vastly different job scene of the future.

Ausbiotech CEO Dr Anna Lavelle FTSE wrote that cash-strapped life sciences had received a massive funding boost that would strengthen the role of biotech in our economic future.

Chief Defence Scientist, Dr Alex Zelinksky FTSE wrote that building a highly trained STEM workforce was critical to Australia's defence and national security.

Science Meets Business, backed by the CRC Association, positions itself as showcasing frontier research and the nexus, and opportunity, between science and business.

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Quantum leaps towards efficient, affordable renewable-energy devices

Meeting the world's growing demand for energy, while minimising impacts on the environment, is an endeavour that faces great technical challenges.

However, The University of Queensland's capabilities in innovative energies have received a major boost through significant infrastructure investments, which have attracted research leaders in the fields of solar energy, biofuel research and geothermal energy research.

Dr Ivan Kassal and his team from the ARC Centre of Excellence for Engineered Quantum Systems are using research into quantum coherence to design better organic solar cells, a type of cell which is easily made of inexpensive and abundant plastics.

Quantum coherence describes the wave-like properties of particles. It opens up a possibility that energy can flow faster as a wave than if it were jumping around randomly like a particle. Faster flow of energy would allow the organic solar cells to reach higher efficiencies and become competitive with other kinds of solar cells.

Dr Kassal's research into quantum coherence plays a fundamental role in the design of efficient, flexible and cheap renewable-energy devices for use in Australian homes and industry.

UQ's School of Mathematics and Physics is an international leader of quantum technology research based on the understanding, control, and engineering of quantum many-body systems. The School has a number of world-class research groups in a range of areas of Mathematics and Physics. Find out more at smp.uq.edu.au

The Federal Government's 2015 Excellence in Research for Australia exercise confirmed The University of Queensland as one of the nation's top three universities, measured by the quality of its comprehensive range of specialised research fields. UQ's outstanding critical mass offers researchers significant interdisciplinary capability.

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