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OUR LIVES DIGITISED

AUSTRALIAN ACADEMY OF
TECHNOLOGY AND ENGINEERING

ATSE

2018 ATSE Innovation Dinner

ATSE cordially invites you, your staff, guests and partners to attend the ATSE Innovation Dinner where the Clunies Ross Awards will be presented at the Sofitel Hotel, Melbourne on 13 June 2018.

The Dinner provides a valuable networking opportunity and a chance to be part of the nation's premier annual awards for innovation commercialisation.

The **Clunies Ross Awards** are presented in three separate categories;

- **Entrepreneur of the Year**
- **Knowledge and Commercialisation**
- **Innovation**

Now in its 28th year of being presented, the Clunies Ross Awards will again recognise the outstanding applications of science and technology that provide economic, social and/or environmental benefit to Australia.

Various sponsorship packages are available. If you know your organisation could benefit from highly targeted brand awareness and strategic networking opportunities with key decision makers across industry, government and research then lock in your sponsorship position now. For details on the packages available contact Sue Wickham, Executive Director Operations and Events via **sue.wickham@atse.org.au**

Registrations will open at the end of February.
Email **atse.events@atse.org.au** with any enquiries.

CluniesRossAwards

DETAILS

Wednesday 13 June 2018
Sofitel Hotel, Melbourne
The Grand Ballroom
25 Collins Street, Melbourne

$160 per person or $1,440 for a table of 10

6.15pm Pre-dinner drinks
7.00pm Official proceedings
Black tie optional

Registrations open end of February at www.atse.org.au/events.

Mr Darryn Smart, Clunies Ross Knowledge Commercialisation Award 2017, recipient, congratulated by Dr Leanna Read FTSE, Chief Scientist for South Australia.

AUSTRALIAN ACADEMY OF TECHNOLOGY AND ENGINEERING

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ATSE

Front cover photo: Pepper is the first robot designed to live with humans. (© Softbank Robotics)

FOCUS

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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NEWS

Wheat crops have better defence against dangerous rust disease

As climate change looms and the population booms, staying one step ahead of crop diseases and pests is essential to keep food security robust.

ATSE Fellow Professor Robert Park is among scientists from Australia, the US and the UK who have developed a rapid test that may curb a rust disease from devastating wheat crops. Their findings were published in *Science*.

Robert Park inspects wheat.

Wheat is one of the world's most important food crops, feeding about one-fifth of humanity.

But the crop is susceptible to stem rust, historically the most dangerous wheat pathogen, which has recently re-emerged.

"It's like an ongoing arms race – we've got to keep one step ahead of this changing pathogen," the University of Sydney's Professor Park says.

"The last major epidemic of wheat stem rust in Australia alone, in 1973, caused $300 million in damage – imagine what that would be today."

A rust disease epidemic is causing widespread damage in East Africa, and rust is making a comeback in Europe.

The new diagnostic test can analyse wheat samples in a matter of hours, rather than weeks, potentially saving crops from being entirely destroyed.

NEW DNA TEST

A DNA test will identify whether a rust in a wheat crop anywhere in the world can overcome a rust-resistance gene in wheat called *Sr50*, Professor Park says.

"This will indicate whether or not a given wheat crop needs to be sprayed with expensive fungicide quickly to protect against rust, which would otherwise devastate the crop in a matter of weeks."

Professor Park is an international leader in the pathology and genetics of cereal rust pathogens.

Through his personal research and leadership of the world-renowned Australian Cereal Rust Control Program, he has made major contributions to the national effort to control these diseases.

"It's like an ongoing arms race – we've got to keep one step ahead of this changing pathogen."

SYNCHROTRON'S SILK SOLUTION

A specialised technique on the infrared microspectroscopy (IRM) beamline at the Australian Synchrotron in Melbourne can determine the structure of proteins in individual silk fibres, thanks to a large international collaboration.

The technique, hyper-spectral infrared imaging, has the potential to influence the design of new materials. It's a powerful analytical tool because it can establish the link between micro- and nano-structures and the specific material properties of biomaterials.

The investigation included researchers from Swinburne University, the Tokyo Institute of Technology, Deakin University, the Australian Nanofabrication Facility, the Lithuanian Centre for Physical Sciences and Technology, and Dr Mark Tobin and Dr Pimm Vongsvivut from the Australian Synchrotron.

Molecular orientation is responsible for the optical, mechanical and thermal properties of biomaterials. Infrared imaging at the Australian Synchrotron can access the molecular orientation of the protein structure directly from a single silk fibre.

"The goal was to identify the orientation of proteins in different parts of the fibre and to look at how laser treatment can alter the protein structure in the silk fibre," says Dr Tobin, Principal Scientist, IR beamline at the Australian Synchrotron.

"Because the silk fibres are only 10 microns across and the synchrotron infrared beam is about half the size of that, we developed an optical device using a germanium crystal that allowed the beam to pass through the fibre's cross-section at four times higher resolution.

"Although the bulk information of silk fibres has probably been known, it has not been possible to measure molecular orientation on single fibres before," Dr Tobin says.

NEWS

Harvey picks capsicums

The Australian Centre for Robotic Vision has built a capsicum-picking robot, named 'Harvey', and will be designing and programming another robot for picking asparagus.

Harvey can not only "see" ripe capsicums on the bush, but gently grab and harvest them.

Given the size of the capsicum industry in Australia – the Australian Bureau of Statistics reported the 2015 annual harvest as 43,000 tonnes – this is big news for Australian agriculture.

Harvey, which is essentially a robotic arm that trundles along on wheels, uses deep learning. On the end of its arm is a camera – its 'eyes' – plus a suction cup and a stalk snipper.

Its 'brain' is a neural network, which was trained with thousands of images of capsicums and thousands of images of objects other than capsicums. It uses the geometry of the capsicum to differentiate it from other shapes such as leaves.

Once a capsicum is spotted, Harvey grips the fruit with the suction cup and harvests it with his stalk snipper.

Building on Harvey's 90 per cent success rate in initial trials, the asparagus-picking robot will similarly use advanced 3D computer vision and deep learning to distinguish when and how the produce needs to be picked.

The Australian Centre for Robotic Vision, based at Queensland University of Technology, involves QUT, the University of Adelaide, the Australian National University and Monash University, as well as CSIRO's Data61.

UNSW LINKS WITH RAAF, FRANCE AND ANU ON SATELLITES

The University of NSW Canberra and the Royal Australian Air Force (RAAF) will develop three Cubesats for maritime surveillance, with the first lifting off in early 2018. UNSW Canberra has signed a $9.96 million contract with the RAAF under which engineers and scientists from UNSW Canberra Space will design and build three Cubesat spacecraft for two space missions, to be launched into Low Earth Orbit.

Director of UNSW Canberra Space, Professor Russell Boyce says the Cubesats will be used for maritime surveillance. The space missions will also deliver research and educational outcomes for Defence and civilian students studying engineering at UNSW Canberra. UNSW Canberra Rector, Professor Michael Frater FTSE, says the space program leverages the university's core strengths in satellite and sensor R&D.

"UNSW Canberra has invested significantly to build a very large, world-class team of space scientists and engineers. We look forward to having a leading role in the space industry, both through education and research," Professor Frater says.

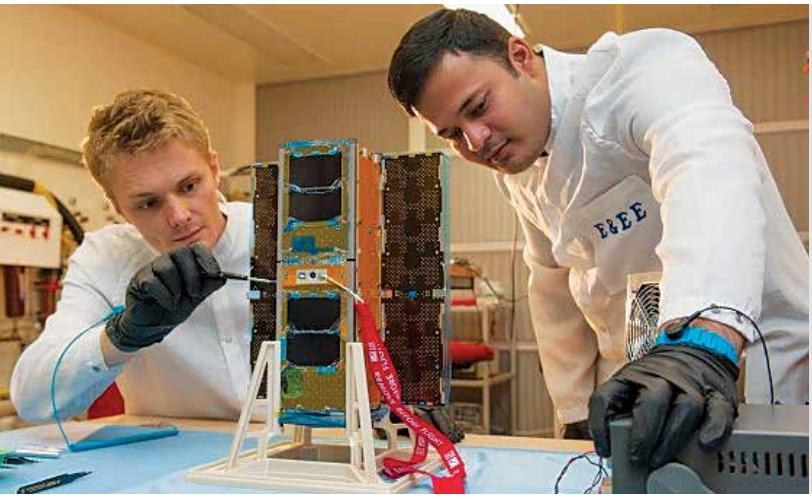
UNSW Canberra has also announced it will host a new facility in partnership with France's space agency, CNES, to fast-track Australia's ability to deliver world-class space technology and innovation.

"Thanks to our partnership with CNES, UNSW Canberra will host Australia's first Concurrent Design Facility by the end of the year," he says.

"Having this top-level agreement means that UNSW Canberra is highly regarded internationally, and will see us leading Australia's space economy," he says.

The UNSW Canberra and CNES agreement complements another UNSW Canberra agreement to utilise spacecraft test facilities at the ANU's Advanced Instrumentation Technology Centre (AITC).

UNSW says cooperation between all three institutes means that Australia can provide a complete suite of end-to-end capability in conceiving, designing, building, testing and operating space missions.



UNSW Canberra scientists working on a Cubesat.

CUBESATS

Cubesats are miniaturised satellites with a standardised form that fits into the 'piggy-back' dispensers on most commercial rocket launch services. They are made up of units that are 10 cubic centimetres in size, and use a variety of off-the-shelf and bespoke electronic components and sensors. They are economical, can be applied to a wide array of space-based purposes (particularly for space research, Earth observations and communications), and can be rapidly designed and built to high standards. A three-unit (3U) Cubesat is roughly the size of a loaf of bread and weighs about four kilograms.

NEWS

American mines are safer and more efficient, thanks to Australian technologies

By Lydia Hales, *Science in Public*

Mining companies across America are increasing the reliability of their trucks, diggers and other big machines, and saving hundreds of millions of dollars in the process. They're giving these big machines regular health tests and comparing the results with a global database for that machine.

The result? They're fixing machines before they break. This preventative health system was developed by an Australian company, Dingo, which now has 40 people working at its bases in Denver, Brisbane and Calgary.

The results can be dramatic. For example, Dingo maintenance support has improved the engine life of a widely used CAT mining truck by an average of 61 per cent. And they've more than doubled the life of certain Cummins diesel engines working underground.

Dingo was founded in 1991 by Paul Higgins when he realised that, just like blood tests, oil samples from machinery could reveal the health of the machine.

"I thought: that's brilliant, that's the future right there – doing maintenance by using what the machine is actually telling you about itself," he says.

Dingo now leads the world in predictive maintenance for companies with big, expensive assets that they need to work hard. Mining companies, train operators, wind turbine operators, and many other companies are asset-intensive. They need to keep their machines in peak condition to maximise production and avoid expensive and potentially dangerous failures.

How does Dingo work? As a technician inspects, tests and photographs a machine, the data they collect goes via the cloud to Dingo, where an expert can instantly compare the results with industry standards and advise on the appropriate maintenance or repairs.

CLEAN AIR UNDERGROUND

The air is cleaner in mines around the world, thanks to filters developed by a Melbourne company working with 3M and BHP Billiton. Micro Fresh Filters developed their first disposable diesel exhaust filters for underground mines back in 1995 and now makes filters for most mining vehicles. Using these filters removes up to 90 per cent of carcinogenic particles in diesel fumes. The filters use advanced polymers that also help to reduce the risk of fires by being non-flammable. The filters are also unaffected by water and by low engine back pressure. Micro Fresh Filters is now Freudenberg Filtration Technologies (Australia).

FURTHER AUSTRALIAN INNOVATIONS

Coal companies in Virginia and Indiana are using Australian Jameson Cells to capture and sell coal dust. Miners are talking using secure communication systems developed by Melbourne's Excelis C4i as a spin-out of their work with US defence organisations. Pythons are at work in Alaska to reduce the cost and impact of mining. The Python is a modular ore-concentration plant in the Arctic developed by Gekko Solutions. Australia's Steve Durkin has reinvented the ladder for mines. Laddertube is making mines safer in Idaho, Nevada and Alaska. The fully enclosed plastic tube keeps out rocks, water, and salt build-up that might slow escape from a mine.

IMAGE VIA IPGGUTENBERGUK LTD

TESTING SUN PROTECTION

Technologies and products that promise to improve sun protection will be tested at a new research centre being established in Brisbane by QUT in partnership with clinical trial company Q-Pharm.

Funded by an Advance Queensland Fellowship awarded to QUT's Dr Elke Hacker, the Centre for Testing New Technology will analyse websites, apps, devices and wearables used by people in the prevention, detection and management of cancer to ensure they are safe and live up to their promises.

Dr Hacker, who will lead the research centre, says technology is playing an increasing role in the prevention of sunburn and skin cancer, with personal UV detectors, sunscreen indicator patches and software apps encouraging people to take responsibility for monitoring their own health.

"It is vital that we make sure these devices and health apps are regulated and tested, and there is evidence to substantiate the health claims being made," Dr Hacker says.

She says Q-Pharm's state-of-the-art facilities will ensure trials meet national and international standards and guidelines.

NEWS

The SKA's latest telescope

Where is the quietest place on Earth? To escape radio transmissions, you'll need to travel 315 kilometres north-east of Geraldton in Western Australia. This isolated, 'radio quiet' area is the prime spot to carry out radio astronomy, as transmissions are restricted and monitored.

A new telescope, The Murchison Widefield Array (MWA), is the first of four planned precursor facilities to be completed as part of the worldwide Square Kilometre Array (SKA) network. The amount of data it will collect is huge. Each year the MWA will produce three petabytes (three million gigabytes) of data. The SKA is a next-generation radio telescope project involving institutions from more than 20 countries. When completed, the SKA will be the largest and most capable radio telescope ever constructed.

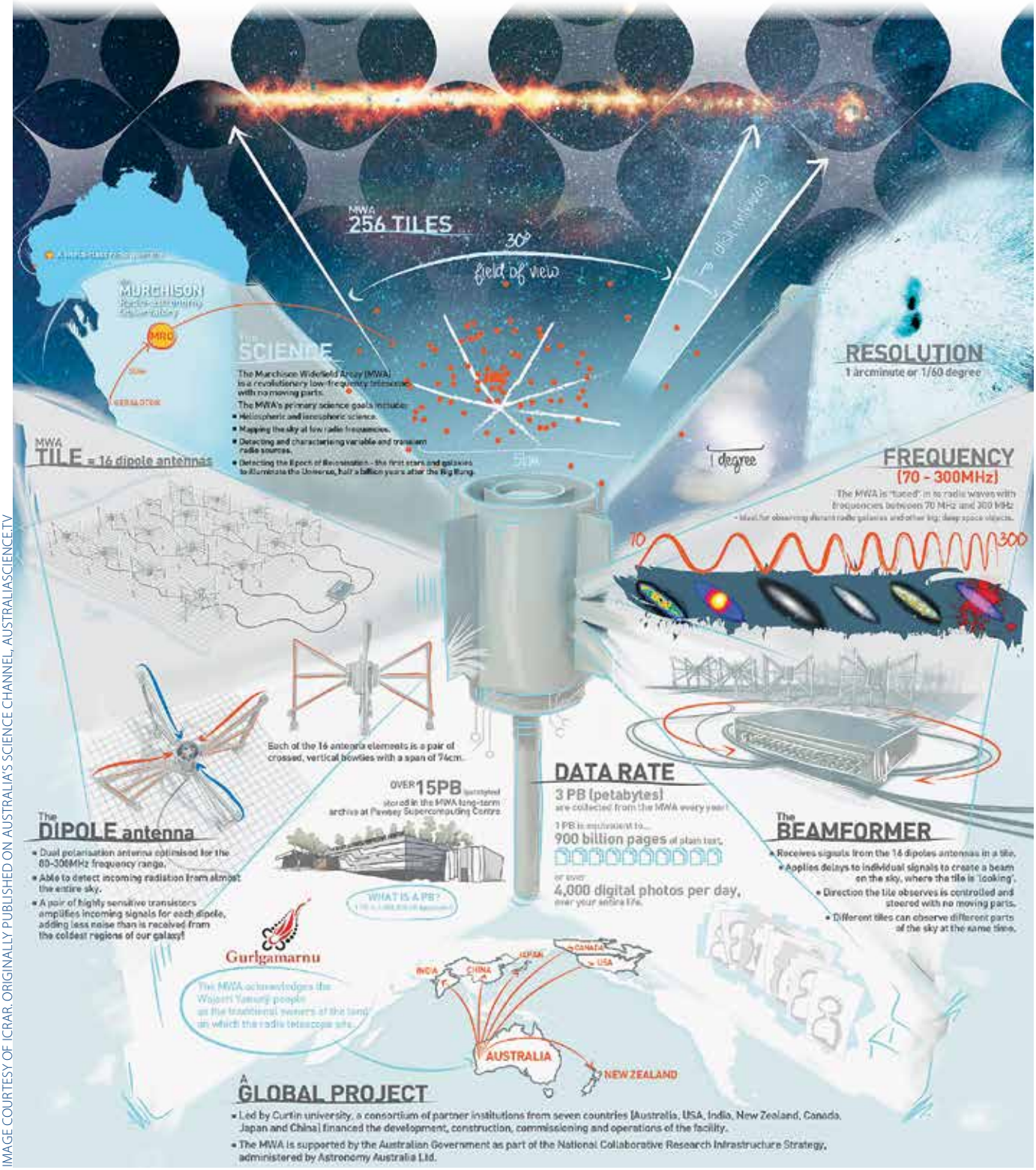


IMAGE COURTESY OF ICRAR ORIGINALLY PUBLISHED ON AUSTRALIA'S SCIENCE CHANNEL, AUSTRALIASCIENCE.TV

Better Today. Brighter Tomorrow.

Financing AES' battery-based energy storage project in California.

"Without the support of all of our stakeholders, including the Commonwealth Bank of Australia, it would not have been possible for AES to achieve this significant milestone. This transaction is one of the first project financings for battery-based energy storage, demonstrating once again AES' leadership in the energy storage industry"

Tom O'Flynn
Executive Vice President and Chief Financial Officer
The AES Corporation

Commonwealth Bank was a lead financier to the largest non-recourse loan for a battery-based energy storage project to date. The project comprises 1,284 MW of combined cycle gas capacity and 100 MW of battery-based energy storage under 20-year contracts with Southern California Edison.

In 2014, AES, a renowned developer and operator of power generation projects and regulated utilities around the world, won a competitive bidding process. It was awarded 20-year Power Purchase Agreements (PPAs) by Southern California Edison (SCE) to provide 1,284 MW of combined cycle gas-fired generation and 100 MW of four-hour duration, battery-based energy storage. The Southland Repowering Project will replace 3.9 GW of AES' existing gas-fired capacity.

A differentiating factor in AES' bid was the battery-based energy storage system. AES is one of the world leaders in battery-based energy storage. The technology sits well with California's commitment to source 100% of its power from renewable energy by 2045.

More bang for the carbon emissions buck

AES' existing power generation facilities in Los Angeles County were built in the 1950s. Due to new environmental regulations and demand for natural gas-generated electricity to balance California's extensive build-out of renewable generation, AES wanted to replace those facilities with new clean, low-cost gas-fired generation and battery storage. The Southland Repowering Project is an important step in AES' move towards clean energy generation.

The two combined cycle gas turbine facilities, each with capacity of around 650 MW, help conserve natural resources by using less natural gas and water to generate electricity relative to the older plants being replaced. The new turbines can respond quickly to smooth out the supply of electricity when renewable sources of power aren't operating. Aesthetically the new facilities are far better suited to their location in the urban areas of Long Beach and Huntington Beach.

An innovative answer

The zero-emission energy storage system, with capacity of 100 MW, will store energy for later use. Energy storage supports the build-out of intermittent renewables by providing greater reliability to the grid.

Energy storage is potentially an innovative answer to a number of energy supply needs beyond their instant energy response. Load management applications include peak shaving, frequency regulation and fast balancing serves to renewable energy.

A first for the banking market

The US$2.3 billion Southland Repowering Project is supported by US$2.0 billion of non-recourse debt, comprising a US$492 million syndicated bank loan for 10 ¼ years and US$1.475 billion of 22 ¼ -year bonds that were privately placed with institutional investors.

There are few battery-based energy storage projects of this scale around the world and even fewer that have been financed with non-recourse debt. As battery-based energy storage technology and applications continue to evolve so will its potential revenue sources and financeability.

The Southland Repowering Project required flexibility to structure an optimal financing for AES to incorporate battery technology. Our involvement in this innovative project, coupled with our knowledge and capabilities around versatile clean energy provision, position us well for clean energy projects around the world as we work with clients to make a lower carbon future a reality.

To learn more visit:

commbank.com.au/infrastructure

aescalifornia.com

CommonwealthBank of Australia

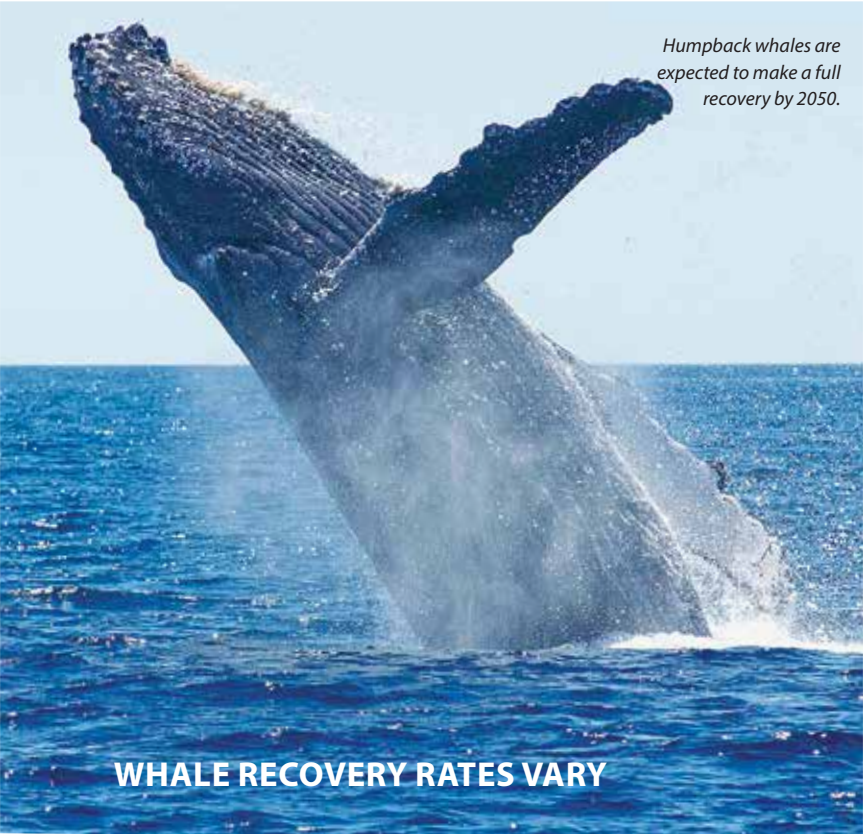
NEWS

Human trials for new prostate cancer weapon

Radiopharmaceutical company Clarity has licensed technology from the University of Melbourne to help combat prostate cancer.

The technology, used for imaging and treating the cancer, means a prostate-specific membrane antigen (PSMA) targeting agent will progress to human clinical trials. The targeting agent was developed over several years through a collaboration between the University of Melbourne and the Peter MacCallum Cancer Centre.

"This licensing agreement means we have the opportunity to translate this fundamental research with the goal of improving diagnostic and treatment options for prostate cancer," said University of Melbourne Associate Professor Paul Donnelly, who led the development of the PSMA targeting agent.



Humpback whales are expected to make a full recovery by 2050.

WHALE RECOVERY RATES VARY

CSIRO and University of Queensland research suggests that Antarctic whale numbers are recovering – but at different rates for different species – following the cessation of commercial whaling.

Humpbacks are reported to be currently at 33 per cent of their pre-whaling numbers, with a full recovery predicted by 2050.

But Antarctic Blue, Southern Right and Fin whales are expected to be at less than half their pre-exploitation numbers by 2100 because of slow growth rates and heavy historical whaling.

Southern Right whales, which were reported to have declined to just 300 before anti-whaling laws were established, raise one calf every two to three years, compared to humpback whales, which generally raise a calf each year.

NEXT NATIONAL OUTLOOK REPORT DUE IN 2018

More than 50 business, research and non-government leaders are working on the second Australian National Outlook to explore nationally significant issues, risks and opportunities – and how Australia might respond.

Brought together by CSIRO and NAB, project participants will explore issues affecting Australia's long-term future growth and prosperity across a range of scenarios and focus on three major themes: Natural Resources and Energy, Productivity and Services, and Cities and Infrastructure.

The final Project report is expected to be released in the last quarter of 2018. The research builds on CSIRO's 2015 Australian National Outlook, which explored the link between resource consumption and environmental pressures and pathways to economic growth.

Modelling results from CSIRO will be interrogated and distilled by project members seeking specific actions to help ensure Australia has prosperous and globally competitive industries, inclusive and enabling communities and sustainable underpinning foundations – including natural resources, environment, public institutions and social capital.

It will explore:

- how Australia attracts investment to continue to build globally competitive industries;
- the role a world-leading education system can play in creating opportunity for all Australians;
- how the jobs of the future will evolve; and
- how Australia's cities and regions might accommodate a growing population, while maintaining strong connectivity and liveability.

"Australian National Outlook brings together science, business, research and community leaders to collaborate and identify what will make the biggest difference to our country's future prospects," said Mr David Thodey AO FTSE, Chairman of CSIRO.

"The Australian business community has a key role to play in shaping Australia's future," said NAB Chairman Dr Ken Henry AC. "By discovering what some of Australia's future could look like, the Australian National Outlook has the capacity to guide all decision-makers – business, universities and other research institutions, community groups, and government – in developing actions today that will shape a strong and prosperous future for all Australians."

LINKING WITH BRAZIL

Australian and Brazilian scientists will collaborate more closely under a new Agreement signed by both country's governments. The Agreement for Cooperation on Science, Technology and Innovation will support Brazilian researchers in collaborating with Australian partners and support institution-to-institution and researcher-to-researcher links.

NEWS

Funding boost for new supercomputer

Australia's supercomputer, Raijin.

Named after the Shinto god of thunder, lightning and storms, Australia's highest performance supercomputer 'Raijin' will soon retire and be succeeded by a stronger processor.

The Australian Government has announced it will deliver $70 million to the National Computational Infrastructure (NCI) High Performance Computing (HPC) facility to replace the current, ageing supercomputer.

With the combined power of around 80,000 desktop computers, Raijin currently supports the work of more than 4000 researchers.

The announcement of funding will enable new research that is more ambitious and more innovative than ever before once the new supercomputer is commissioned in early 2019.

"The new NCI supercomputer will be a valuable tool for Australian researchers and industry, and will be central to scientific developments in medical research, climate and weather, engineering and all fields that require analysis of so-called 'big data', including, of course, astronomy," ANU Vice-Chancellor Professor Brian Schmidt AC FAA says.

NCI anticipates the resulting supercomputer will be ranked in the top 25 internationally.

It ensures researchers in 35 universities, five national science agencies, three medical research institutes, and industry will benefit from a boost in computational horsepower.

"The Government's announcement is incredibly important for the national research endeavour," Chair of the NCI Board Emeritus Professor Michael Barber FAA FTSE says.

"It means NCI can continue to provide Australian researchers with a world-class advanced computing environment that is a fusion of powerful computing, high-performance 'big data', and world-leading expertise that enables cutting-edge Australian research and innovation."

The funding boost is a response to an urgent and vital recommendation identified in the National Research Infrastructure Roadmap developed under Chief Scientist Alan Finkel AO FAA FTSE.

The funding, through the Department of Education and Training, will be provided as $69.2 million in 2017-18 and $800,000 in 2018-19.

HAWAIKI CABLE NEW AUSTRALIA–US LINK

Work has begun on installing the 14,000-kilometre Hawaiki trans-Pacific cable system linking Sydney and Pacific City, Oregon, on the US west coast – due for completion by mid-2018.

Placement of the more than 14,000km of cable and 170 repeaters, from two cable-laying ships, began in October.

Hawaiki will link Australia and New Zealand to the mainland US, as well as Hawaii and American Samoa, with options to expand to additional South Pacific islands. It will be the highest cross-sectional capacity link between the US, and Australia and New Zealand.

Hawaiki Submarine Cable LP, headquartered in Auckland, is the owner and developer of the Hawaiki submarine cable. 'Hawaiki' is a name revered as the original home of the Māori people; a legendary island from which the Polynesian people migrated to the islands of the Pacific Ocean in open canoes.

TE SubCon, a leader in undersea communications technology, manufactured the cable and repeaters at its facility in Newington, New Hampshire, before loading them onto its vessels *CS Global Sentinel* and *CS Responder.*

TE SubCom describes itself as a leading global supplier for today's undersea communications requirements – which designs, manufactures, deploys and maintains the industry's most reliable fibre optic cable systems. It has deployed more than 100 cable systems and enough subsea communication cable to circle the globe 15 times at the equator.

NEWS

Ten big ideas fast-tracked through ON Accelerate

Moving great science from the lab into real-world applications comes with a range of obstacles many researchers struggle to overcome. Powered by CSIRO, ON is Australia's national sci-tech accelerator, helping take big ideas from the drawing board and into execution.

Here are this round's participants, in no particular order.

- CareGivr – virtual reality technology that allows carers to learn by doing, safely (University of Newcastle);
- ECE Curtin – tool for preventing faults in power network assets before energy catastrophes hit (Curtin University);
- HORUS – a solar forecasting system (CSIRO, Energy);
- The Noisy Guts Project – an acoustic belt that uses the natural noises of the gut for health screening (University of Western Australia);
- eDNA field pump – an on-the-go field tool for reliable and transportable water monitoring (James Cook University);
- All in one prawn pathogen system – a new detection system that cuts costs and time delays for prawn farmers (CSIRO Agriculture and Food);
- GutHealthCo – an alternative to the expensive and cumbersome 'leaky gut' test for suspected sufferers (CSIRO Health and Biosecurity);
- Hyperdrive – a new way to beat the current costs and delays in new drug development (Macquarie University);
- Inflamark – on-the-spot testing for elite athletes and their sport scientists (University of Western Australia);
- Diffuse wind energy – a small wind turbine that can produce nearly twice the power of existing wind turbines of the same size (University of Newcastle).

USING 'SCIENTIFIC METHOD' TO SUPERCHARGE INNOVATION

A Deakin University team and its industry partner have developed 'an entirely new way' to optimise processes for manufacturing new materials – short fibres, alloys, cosmetics and food, for example.

They predict it will lead to a 'step change' in developing new materials, with huge potential to boost innovation.

This academic/industry collaboration uses machine learning and Bayesian mathematics (a sophisticated form of probability) to develop an abstract framework and software that is claimed to achieve a faster, cheaper and more effective approach to optimising products and manufacturing processes.

Commercial ventures within the Geelong Future Economy Precinct on Deakin's Waurn Ponds campus are pioneering the methodology.

A number of researchers from Deakin's Centre for Pattern Recognition and Data Analytics (PRaDA) and Institute for Frontier Materials (IFM) were involved. Dr Sunil Gupta and Dr Santu Rana led the PRaDA team, and Dr Alessandra Sutti headed the IFM team.

"This breakthrough offers a very powerful tool with huge potential for many industries," says project leader and world-leading IT expert ARC Laureate Fellow Professor Svetha Venkatesh FTSE, Director of PRaDA.

"We were able to develop this new method, which we call Adaptive Experimental Optimisation, through an alignment of world-class experts in machine learning, mathematics, physics, chemistry, materials, world-class facilities at Deakin and an innovative industry partner, HeiQ Australia."

"The collaboration was inspired by the challenges of industrial innovation," says Dr Murray Height, CEO, HeiQ Australia.

"We needed to efficiently generate knowledge about a novel technology with very tight timeframes, to bring a product to market. Adaptive Experimental Optimisation has given us a fast and powerful way to accelerate product development and implement advanced manufacturing processes.

"When businesses go about developing a new product or process, there is often enormous complexity in the range of variables they face, which can become expensive and unwieldy when running experiments, both in the lab or as large-scale trials on the factory floor.

(From left) Dr Sunil Gupta, Dr Alessandra Sutti, Professor Svetha Venkatesh and Dr Murray Height.

"This methodology has clear potential to benefit material and process-oriented industries seeking efficient and nimble innovation.'"

"Adaptive Experimental Optimisation allows us to be a hundred to a thousand times faster than conventional 'design of experiment' methods," Dr Sutti says.

The team assists HeiQ Australia to develop world-first short fibre materials that offer enormous potential in textile applications. Its first product, HeiQ Real Silk, reproduces the luxurious tactile properties of silk and the short-fibre material is manufactured in the Geelong Innovation Precinct at Waurn Ponds. This export product is used in the global textile market, including in apparel and home textiles, such as bedding.

"With new materials and new processes – unlike an established material like steel, for instance – the legacy knowledge base is often limited. The computational models don't exist and the cost of building new ones is very high," explains Professor Venkatesh.

"We don't have a complete data set for new materials, so we have to generate knowledge through experimentation. Machine learning allows us to be nimble, so we can optimise new materials using a handful of experimental data points – or lean data. The software acts as an experimental assistant to help navigate experimental complexity."


MIKE MILLER and GLENN WIGHTWICK
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IMAGE: DMITRII KOTIN VIA ISTOCK

Securing our digital future

OUR LIVES DIGITISED **Mike Miller** and **Glenn Wightwick** explain how our digital future depends on preparing industry and society for change.

Today's digital technologies are not only profoundly impacting Australia's society and economy but also underpin an emerging set of foundational technologies, such as the Internet of Things, big data, machine learning and autonomous systems.

These will disrupt every aspect of the economy.

To maximise opportunity in information, computing and technology (ICT) development and application and reduce societal impact, stakeholders across government, industry and the community must address three key areas:

- developing information and communication technologies in Australia;
- advancing digital transformation for industry and government in Australia; and
- evaluating the implications of digital transformation on society.

ATSE will provide guidance to various sectors on the required next steps as Australia's national capabilities in ICT and digital engineering strive to underpin growth in all Australian industry sectors – including health, agriculture, finance, mining and education.

The successful uptake of ICT services will continue to facilitate innovation, particularly in Australia's manufacturing, production and services sectors. They'll be enabled by more access to broadband – both fixed and mobile – as well as low power network technologies for the Internet of Things.

STORING AND SHARING PERSONAL DATA

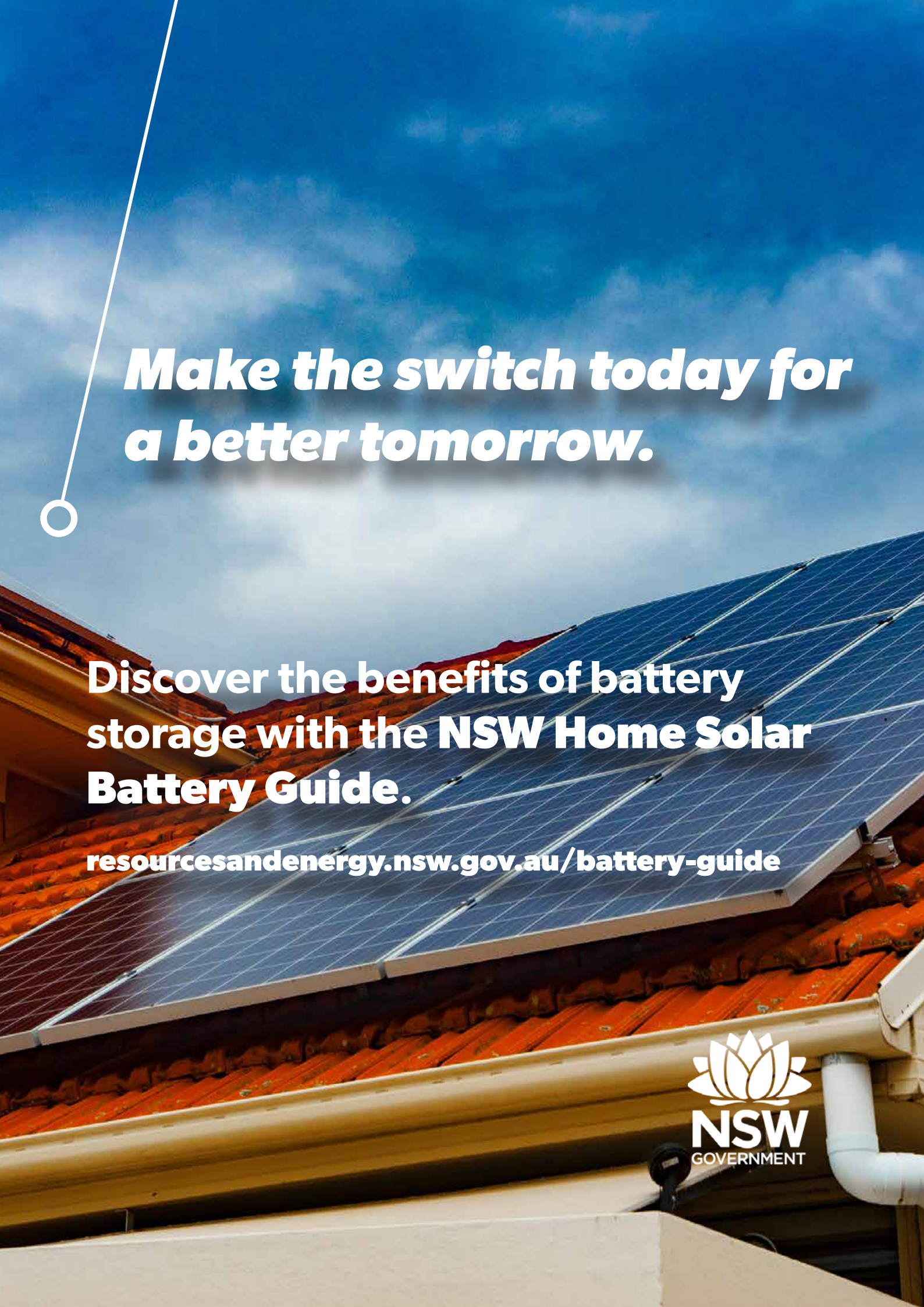
The pending boom in the number of sensors collecting huge quantities of data, which in turn must be stored, presents a range of technological opportunities.

ICT has already strongly impacted culture and behaviour. People are starting to live part of their lives in the digital world – socialising, learning, conducting financial transactions, and storing and sharing personal data.

Emerging technologies will see this evolution continue with a deepening of human–machine partnerships and relinquishing of tasks to autonomous systems.

This level of engagement will also create a societal response, as users of technology face issues around:

- Cybersecurity
  Secure and large storage systems to accommodate the proliferation of data being collected will continue to increase in demand, with failures around this impacting on advancements and user confidence.
- Ownership of data
  Clear ownership to facilitate adequate privacy and control will be central to some consumers and necessary for engagement in new and innovative programs as they emerge.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NSW
GOVERNMENT

- Ethics
  Around automation and artificial intelligence (social robotics) – as technology advances there may be a lag in response from the general community until broader awareness of potential issues grow. This can result in industries and innovation being stifled or dismantled.
- Privacy
  The community has varying expectations around privacy. Factors related to the Internet of Things and home safety may present issues for the development of IoT products.

Australia must address these matters at the forefront of technology development before they become issues, rather than responding after poor outcomes have become issues.

EDUCATION REFORM

Education and regulatory frameworks need immediate and ongoing reform.

Australia's digital future will rely upon a science, technology, engineering and mathematics skills base. Critically, education systems must focus on STEM and they must evolve to meet the pace of digitalisation.

Digital literacy will be essential to the process of learning, from primary school through to tertiary education.

Students must have courses that teach computational thinking (for example, mathematics and coding) as part of the curriculum. And an exposure to entrepreneurship can harness each student's imagination, enlivening creative responses that align with the dynamic, real-world environment.

Tertiary institutions must focus on providing the skills to meet the technical and analytical needs created by increasing volumes of data.

This should include courses for data scientists and analysts, already in demand, to facilitate effective information management services that ensure the availability, confidentiality and integrity of data.

Courses must also produce graduates with cybersecurity skills that enable them to hit the ground running. Vocational educational systems, with strong alignment with industry and flexible and responsive course design, will be essential in accommodating emerging skills trends.

"Australia must address these matters at the forefront of technology development before they become issues, rather than responding after poor outcomes have become issues."

This article originally appeared in Australasian Science (austscience.com).

Professor Mike Miller AO FTSE and Professor Glenn Wightwick FTSE co-chair ATSE's Digital Futures Working Group.

Professor Glenn Wightwick FTSE joined the University of Technology Sydney (UTS) as Deputy Vice-Chancellor (Research) in August 2014 and he recently became Deputy Vice-Chancellor (Innovation and Enterprise). He joined UTS from IBM, where he was Director, IBM Research Australia and IBM Australia Chief Technologist.

Professor Mike Miller AO FTSE spent nine years with Telecom Australia and 35 years at the University of South Australia, where he was Professor of Telecommunications and Foundation Director of the Institute for Telecommunications Research. He was Australian Professional Engineer of the Year in 1995, and in 2015 he was inducted into the SA Engineering Hall of Fame.

PREPARING FOR OUR DIGITAL ECONOMY

Understanding the role technology plays – and will continue to play – in our economy is imperative for determining how we can prepare for sweeping changes across industry, government, education systems and the community.

In November last year, ATSE made a submission to the Australian Government's Department of Industry, Innovation and Science Digital Economy Strategy Consultation, drawing on the expertise and input of the Academy's eminent Fellows.

THE KEY POINTS INCLUDE:

- strategies should be devised to boost digital transformation expertise in all industry sectors;
- national leadership is required to ensure high-quality digital network infrastructure and access across Australia;
- cybersecurity must be viewed as an enabler for our digital future by maintaining the highest of cyber security standards; and
- education sectors at all levels must accept that the knowledge to understand information and communications technology are critical in our 21st century society

BY MARY-ANNE WILLIAMS
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Data analytics and the robot uprising

OUR LIVES DIGITISED As more of the world logs online, robots, in turn, become more sophisticated. **Mary-Anne Williams** explains how data influences robot systems and what still must be done for robots to prosper.

Mary-Anne Williams works on Softbank's robot, Pepper. IMAGE: SUPPLIED

Fuelled by sci-fi movies, developments in artificial intelligence, and real-life feats like passing Medical Licencing Exams for the first time, robots have captured our imaginations. But how easy is it to predict the future of robots?

Some imagined futures are concerning. Elon Musk worries that intelligent robot technologies will take jobs, including those of CEOs, causing major disruptions to business, society and the global economy. Stephen Hawking sees robots as one of the most dangerous inventions ever created. He predicts that "the development of full artificial intelligence could spell the end of the human race".

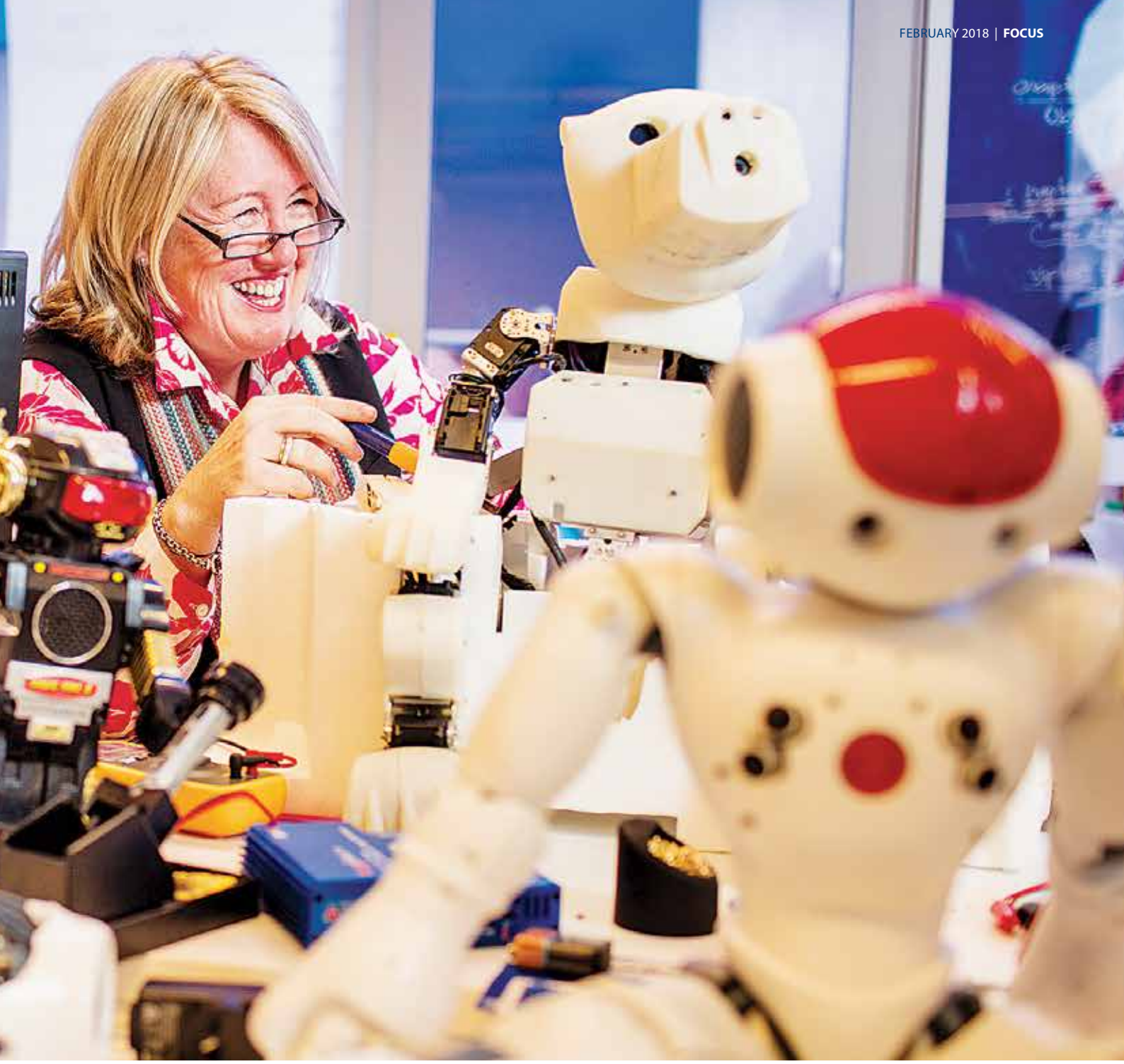
But not all predictions imagine dystopian or doomsday futures. Robots are, after all, able to solve many problems better than humans, and they can augment human capabilities to help solve problems that humans simply cannot solve alone.

Consider the 2010 oil leak 1.5 kilometres below the ocean surface in the Gulf of Mexico, on the seabed, more than 60 km offshore. Several multi-million-dollar, thruster-powered robots played a critical role in stopping hundreds of thousands of gallons of oil per day spewing into the sea.

Recent advances in robotics and increasing adoption of this technology suggest it is time to take a closer look at state-of-the-art of robotics, and the scientific and engineering challenges that must be overcome for robots to achieve their destiny.

Today, big data analytics is at the heart of robot systems.

Progress in the field has been accelerated by inexpensive sensing technology and transformed by scalable artificial intelligence (AI). Over the past few years, robust machine learning algorithms, tools and techniques have become more available. Recent advances in AI have been applied to an



impressive array of new robot hardware with new software architectures. They use new methods that integrate new data analytics tools with robot sensory data within a framework of new industry standards.

These are the building blocks that have contributed to rapid development and industry adoption of specialised robot systems.

WHAT DOES A ROBOT LOOK LIKE?

The range of robotics applications has become so broad that we should reconsider what it means to be a robot.

Today, specialised robots with varying autonomy are used in industry for specific tasks.

These robots range from stationary industrial manufacturing robots with limited sensing and no autonomy to partially autonomous driverless cars and autonomous drones. We are also witnessing the deployment of robots with social awareness enabling them to safely interact with humans by predicting our emotions, behaviours, requirements and intentions.

Much-loved robots from sci-fi movies often looked like humans, with human-like skills and capabilities. But today, robots that make decisions and undertake physical tasks in real time are networked distributed

"In lab conditions, robots can perform breathtaking feats most humans can't do ... however, they have often failed when deployed in real-world settings."

computer systems. They have sensors and actuators that collect and process large volumes of complex unstructured data.

Robots work by executing software designed around the classical sense–think–act cycle multiple times a second.

- Sense – collect real-time data about their surroundings.
- Think – use AI and data analytics to integrate real-time data with background knowledge such as goals and plans to, generate insights and select next actions.
- Act – perform the selected actions

HOW ROBOTS USE DATA

Robots use data to build perceptions, derive insights, make decisions and enact behaviours that solve problems, complete tasks and deliver services. They collect data directly through environment-facing sensors (cameras, lasers, microphones, cameras) and internal-facing sensors (motors) for self-perception. Robots can also access networked data sources such as corporate databases, mobile devices, health technologies, wearables, Wikipedia, social media, cryptocurrency exchanges and the Internet of Things (IoT).

For example, smart mobile phones are a kind of not-so-smart robot. Mobile apps execute the sense¬–think–act cycle. They interpret sensor data (camera, microphone, accelerometer) and connect to information services to form perceptions, make decisions and take actions.

Robot bodies are increasingly mass produced and standardised, enabling mass adoption. At the same time, data structures and software are more interoperable, sharable and available as open source.

Specialised software repositories are available for processing and integrating sensor data. This allows robots to identify objects and navigate from place to place avoiding obstacles in complex spaces.

Roboticists can use the many general open source data analytics algorithms implemented in a wide range of programming languages, such as C, C++ and Python. The Robot Operating System (ROS), for instance, has become the de facto industry standard and is open source.

FROM 'DUMB AND DANGEROUS' TO HUMAN HELPERS

The robotics industry has been growing and diversifying from traditional 'dumb and dangerous' industrial robots to more agile, helpful, collaborative robots (co-bots), able to team with people and boost productivity.

Co-bots can be placed alongside humans in small-spaced electronics assembly lines to perform repetitive, dirty, dangerous, boring and ergonomically challenging tasks. They are affordable to purchase and easy to train without the need for direct software programming.

According to predictions from The Robot Report (www.therobotreport.com), the market will be US$87 billion by 2025, with significant growth in agricultural, service, healthcare and consumer applications.

Start-ups, established companies and some governments are taking advantage of the cost reductions in robot technology to address large-scale societal problems and unmet customer needs.

For example, Zipline – with its autonomous fixed-wing drones – is saving lives in mountainous Rwanda by transporting blood products from a central distribution centre to hospitals across the highly mountainous country. Zipline provides life-saving supplies in minutes, rather than days.

These kinds of cost-effective systems can transform disaster response when earthquakes, floods and fires take out roads, bridges and airports.

One of the fastest growing areas in robotics is social robots – they're designed for the home, workplace, hospitals, hotels, airports and other public places.

For instance, CBA and the University of Technology Sydney (UTS) are working with airlines to improve customer experiences in airports. Some recent experiments saw the Sydney International Airport take on a social humanoid robot to help Air New Zealand customers at check in and at the gate.

IMAGE COURTESY OF CBA

CHIP assists customers at Sydney Airport.

WHY ROBOTS CAN'T SURVIVE IN THE WILD YET

Robots, according to the McKinsey Institute Report, are a disruptive technology. But before robots can wreak the expected havoc on business, society and the global economy, a wide range of pressing scientific and engineering challenges must be addressed.

In lab conditions, robots can perform breathtaking feats most humans can't do. Out in the wild, however, they have often failed when deployed in real-world settings.

Some of the complex and wickedly interdependent challenges for robotics are:

Autonomy

Robots today are closely monitored and supervised by humans. When robot behaviour can be designed to be safe, future robots will be more independent

and purposeful, able to roam and act autonomously. But for now, robots are not well equipped to handle unexpected situations that unfortunately arise all too often in the real world.

Intelligence, adaptability and learning

Robots tend to be pre-programmed with a fixed set of formulaic behaviours to undertake simple tasks in structured, predictable environments. To learn on-the-fly and adapt to unexpected events, robots need to develop smarter, more flexible and adaptable behaviours.

Proactive behaviours

Robotic behaviour is severely limited because robots are mostly reactive, guided by fixed plans that fail in complex situations. They tend to only react to sensory input, rather than use sensory information to take proactive steps, allowing them to gather information and avoid disaster before it happens.

Human–robot interaction and sociability

Today, robots are mostly antisocial and physically dangerous. In fact, robots are irrational – repeating the same unsuccessful behaviour over and over again – and psychopathic – they have no concern about the safety of others and no compassion. Robots of the future should interact with people safely, fluently, effectively and legally with sophisticated skills.

Cybersecurity

Security is often an afterthought in robot design. Robots gather vast volumes of sensitive information that can be compromised. As imported robots are more widely adopted and use black-box AI algorithms, they present significant cybersecurity threats to the nation. Other security threats include theft or modification of sensor and symbolic data and algorithms; control of robot actions to open doors and/or steal physical possessions; modifications to a robot's decision-making and feedback mechanisms to alter robot behaviour.

Ethics and law

Robots present ethical and legal risks, particularly robots that interact with people or property. They have the opportunity to not only help but cause harm. They can help the disabled accomplish life-transforming tasks, but also lie, bully, threaten, harass, physical hurt people, damage property, and steal.

PHOTO: SRINIVAS MADHISETTY, PHD STUDENT, UTS MAGIC LAB

Steve Wozniak, co-founder of Apple and Distinguished Adjunct Professor, hugs Social Robot GUTSY.

WHY WE NEED MORE ROBOTICISTS

Since robotics is largely a real-time data analytics challenge, roboticists are in high demand globally. A key differentiator for roboticists among data scientists is their ability to design and develop systems that can use data to make smart decisions in real-time.

Roboticists are trained to use sophisticated real-time data filters, real-time control mechanisms and real-time feedback. Data-intensive companies look for these skills, particularly in the new 'Internet of Everything'-world where organisations are flooded with data and desperate for insights that can drive innovation and competitive advantage in a global economy.

Despite its strength in AI and robotics, Australia lags behind its competitor nations in leadership, scale and investment. To ride current and future AI and robotics waves of innovation Australia urgently needs more AI and robot builders, explainers and trainers to create much needed opportunity, to reduce the risk of importing black-box robot technology, and to secure our future prosperity.

Robots of the future will not be like R2D2 or C3P0 of *Star Wars* fame. Instead, they will be the Jedi Knights able to use The Force to control digital assets and physical objects connected via the IoT. Just like any technology, robots will be developed to benefit humans or not, depending on the legal and ethical frameworks we enforce, the economic incentives and drivers we put in place, and the way we embed our society's values into the design of this game-changing technology. ⊙

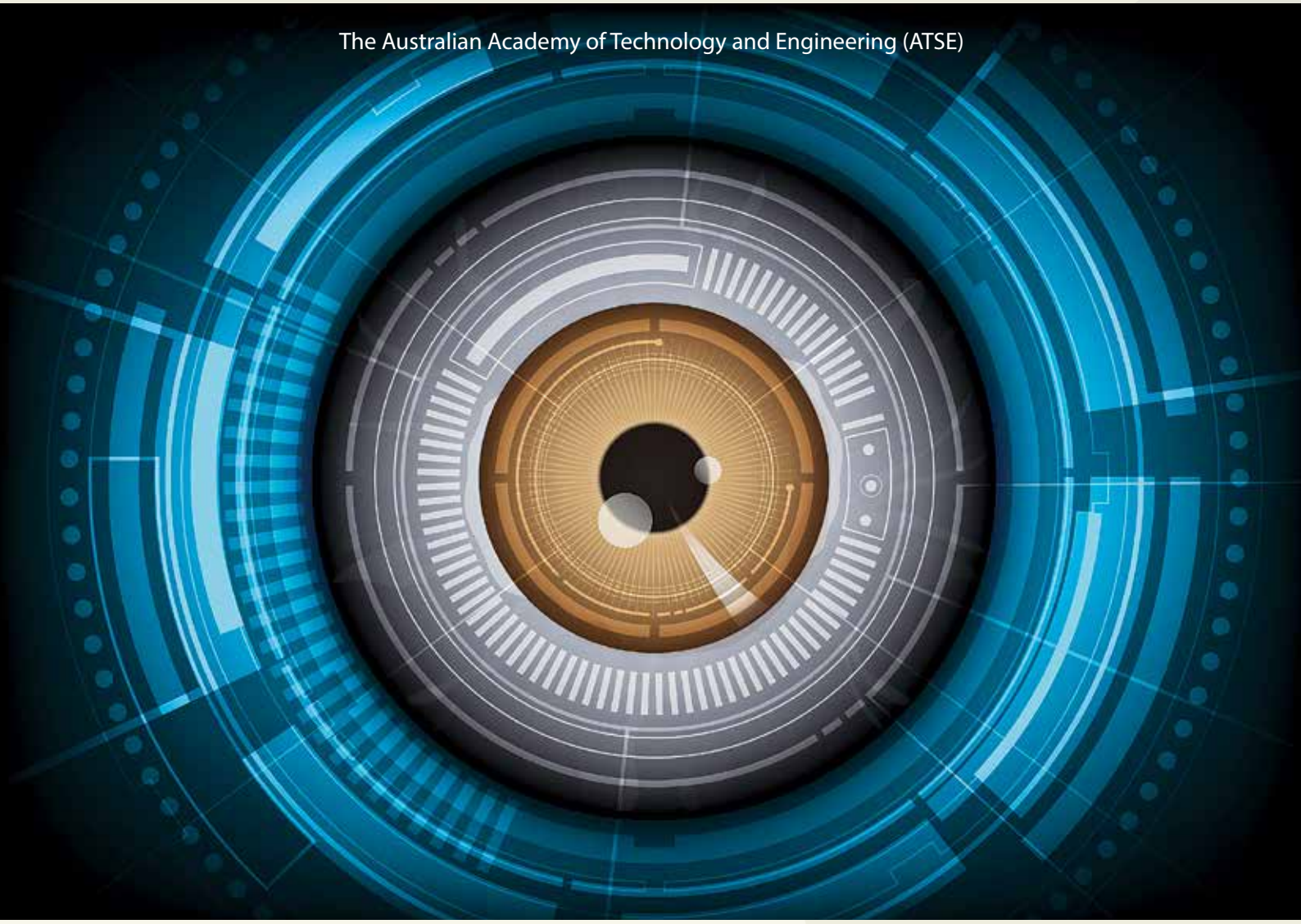
Professor Mary-Anne Williams FTSE is a Distinguished Research Professor at the University of Technology Sydney (UTS) and Director of Disruptive Innovation. She is Founder and Director of the UTS Magic Lab. Her team includes Steve Wozniak, co-founder of Apple, and Peter Gärdenfors, a member of the Nobel Prize Committee for Economics, bringing science fiction to reality. She heads Australia leading group in social robotics research. Mary-Anne has a fellowship at Stanford University. She will appear on a panel with the Dalai Lama in mid-2018 to discuss how to design a compassionate future with artificial intelligence and robots.

"The range of robotics applications has become so broad that we should reconsider what it means to be a robot."

ATSE

PROMOTING AUSTRALIA'S ADVANCEMENT THROUGH TECHNOLOGY

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 agriculture, education, energy, health, infrastructure, innovation, mineral resources and water – and increasingly on climate change mitigation and ICT issues. ATSE is keenly aware of 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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Six common threats to our privacy

OUR LIVES DIGITISED

Protecting our data.

Privacy seems likely to come under further fire, with legal – and illegal – initiatives keen to observe or subvert our data becoming more intense. NordVPN, an international virtual private network provider, says 2017 has shown us that we are all vulnerable to cyber threats, having dealt with such major scandals as election hacking, two major global ransomware attacks, and a general rise in hacking.

"With the new level of the Internet surveillance rising, privacy becomes a luxury that is not so easy to obtain," it says.

Here are six threats our privacy faces, according to NordVPN.

PHISHING

Phishing campaigns will become even more sophisticated.

"Criminals are now able to create emails that look like typical invoices or letters from banks about account updates or missed payments. While 94 per cent of internet users say they are able to recognise a phishing email, statistics show that almost half of them will click on a dangerous link. It will get even harder when cyber criminals get even more advanced in creating sophisticated fake emails."

RANSOMWARE

There will be more ransomware attacks.

"Hackers behind the two recent global ransomware attacks proved that major world companies have serious security issues – meaning these types of attacks will keep increasing, and their scale is frightening. As long as big companies don't start taking security seriously, there will be criminals taking advantage of it. For example, 94 per cent of companies in the UK said they believed IT security was important, but only 56 per cent have a strategy in place in case of cyber attacks."

BIG BROTHER

Government involvement in data collection will keep increasing.

"Governments across the world are strengthening their surveillance laws. For example, the UK's Investigatory Powers Act, nicknames 'the Snooper's Charter', allows the British Government to force companies to hack their own customers, even by inserting malware into their devices. The Australian Government wants to be capable of spying on encrypted means of communications, including services built into devices like the iPhone, as well as apps like Telegram, WhatsApp and so on."

ISP ACCESS

ISP data collection rules change.

"The US has recently passed a law allowing internet service providers (ISPs) to collect customer data without their consent and share it with third parties. ISPs are now free to collect and share their subscribers' private data, including precise geolocation, financial information, health information and web browsing history."

HACKERS

Hackers will access more platforms.

"While currently cyber criminals mostly attack Windows platforms, they will be getting sophisticated enough to attack iOS and Android, as well as Linux and MacOS."

DDoS ATTACKS

There will be more DDoS attacks on IoT devices.

"With the advancement of the IoT (Internet of Things), the number of properly unsecured devices has greatly increased over the past few years – and it's only the beginning. The number of smart home gadgets will be growing exponentially in the next few years, allowing hackers to launch DDoS (distributed denial of service) attacks on a scale never seen before, involving botnets or extortion attempts."

BY JACKIE CRAIG
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Safeguarding Australia in the Digital Age

OUR LIVES DIGITISED Digital technology is rapidly resulting in a wide range of threats that are difficult to detect, recognise and counter. **Jackie Craig** discusses this evolving threat landscape, the cyber and electronic warfare systems that will defeat attacks, and the developing 'mind craft' needed by those researching, planning and operating against such a backdrop.

Digital technology will profoundly impact our future and the pace of progress is fast – 'the future is now'. Opportunities abound for more efficient industries, economic wealth and societal well-being. We are already experiencing the disruptive effect of digital technology in many aspects of our lives and there is every sign of this accelerating, with future advancements being oft-quoted, eagerly awaited and actively pursued across the globe.

Digital technology is also signficantly shaping the evolution of military capability. As with all technology advancement there will be both opportunities and threats. The opportunity to design and develop highly capable systems is counterbalanced by an increasingly testing threat landscape. For those involved in safeguarding Australia, the most important challenge will be to ensure that the opportunity outweighs the threat.

OUR UNCERTAIN FUTURE

We are entering an era of great uncertainty characterised by a highly variable, diverse and rapidly evolving threat landscape. Many threats are 'unknown' – and may be very difficult to detect, recognise or counter.

Digital technologies have been democratised globally. This widespread accessibility means individuals, organised groups and state actors can adopt and adapt commercial-off-the-shelf technology and services – including for malicious purposes.

Digital technology, combined with other technology advances, is fuelling the emergence of improvised threats, and there are almost limitless possibilities for surprise. New threats can emerge very quickly and have significant impact on national security and military operations.

As a result of this uncertainty, there will be fundamental changes in the approach to understanding threats, and in the systems designed to counter them.

For individuals researching, planning and operating within such a setting, how they think will be as important as what they know. They will develop a 'mind craft' that is proactively future-looking, able to reason under uncertainty, willing to partner with artificial intelligence (AI) entities and will evolve as the technology evolves.

THE EMERGING THREAT LANDSCAPE

Digital technology is responsible for an increasingly large spectrum of threats that include network-enabled threats, cyber-physical (embedded processor) systems and cyber threats that can be software-, hardware- or data-based.

Networked enabled threats can range from precision-guided munitions, networked to sophisticated targeting systems, through to use of the internet by organised groups to plan and share information.

Cyber-physical systems – where the charactersitics of the system are defined in software, rather than hardware – are rapidly and easily upgraded, and are already present in the landscape. A clear leader in this area is the commercially available Software Defined Radio communication system, where traditional hardware components have been replaced by software, resulting in significant flexibility in its performance.

We are all familiar with cyber threats that are software-based. An emerging threat that is less well known and is of particular concern are Hardware Trojans. These are intentional, malicious modifications of electronic circuits.

They enter systems through the supply chain and can be inserted at any point during design, manufacturing, distribution or maintinence. They can reside within any of the myriad of electronic chips within a system and remain dormant until activated externally or by an internal signature such as time.

Hardware Trojans are designed to compromise the performance of the systems containing the circuits and bring with them a new concern – uncertainty in the trustworthiness of our own systems.

In the future we can expect to be faced with real-time adaptive threats. For instance, smart munitions with embedded processors will be able to recognise countermeasures and adapt to overcome them. There will be highly agile threats, such as surveillance and targeting radars that can very rapidly vary their signals (from pulse to pulse) to deny detection or knowledge of their intent.

Finally, there will be multifunctional systems, where within a single hardware platform it will be possible to encompass functions such as radar, threat warning, electronic intelligence and communications.

FORESHADOWING EMERGING THREATS

Traditionally, development of countermeasures has relied on developing a deep understanding of threats after they have entered the landscape.

In the digital era, however, this is

becoming a less credible option. Instead, there will be greater emphasis on reducing the element of surprise by proactively estimating the nature of future threats and planning and training around these.

Predictive threat estimation is a multidisciplinary endeavour that includes technology foresighting studies, sophisticated computer-based modelling, simulation and analysis, prototype development of possible threat exemplars, and input from the operational community.

It informs how specific technologies may introduce new threats, impact the evolution of extant threats, and how advanced other relevant technologies must be for a threat to be realised.

Importantly, threat estimation also gives context of technical difficulty and cost, helping indicate the likelihood and potential source – whether state-based, organized groups or an individual – of any particular threat type. For example prototyping of Hardware Trojan threats develops an understanding of how these may enter the supply chain and the extent of the potential threat they pose.

NEW SYSTEMS TO COUNTER NEW THREATS

Systems designed to defeat emerging threats will also change. Systems that can sense, interpret and successfully respond to the threat environment are evolving fundamentally different capabilities that will have, at their core, artificial intelligence and autonomous tools.

They will have real-time reconfigurable, geographically distributed, networked, sensing and response platfroms, all sharing data and collaborating on common goals.

Sensors will collect very large quantities of data from the physical, electromagnetic and cyber domains, and this 'big data' will be used along with other collateral data to provide real-time, comprehensive situational awareness and support to decision-making.

The role of AI and autonomy will grow significantly and will emerge throughout system architectures to help interpret and respond to threats.

Analyst support tools will increasingly include: automated processes to ingest, store and fuse data; AI techniques to detect very small signals in very large quantities of data; and visualisation tools to aid the human operator.

At high operational tempos there will be a growing reliance on automated processes to provide warnings and indicators, advice on the possible intent of 'unknown threats' and to generate course-of-action suggestions.

Autonomous processes will succeed in situations where humans are unlikely to act in a timely and effective manner, for example, in the cyber domain where the required response times can be extremely short.

Autonomous agents will take on more complex tasks without human intervention,

including cooperating with each other to self-organise to achieve defined goals. The are already a number of research prototypes in this area, including autonomous cyber agents to locate and remediate cyber security incidents, and networked small unmanned aerial vehicles (UAVs) that autonomously reconfigure to provide a resilient communications function.

Next-generation systems designed to respond to the complex threat environment will have a large increase in their AI capabilities and will be cognitive. This means they will interact with their environment to reason about alternative courses of action to defeat an unknown threat.

Such systems have not yet been realised but are being actively researched in a number of laboratories across several nations.

Last but not least is the human element. Clearly, safeguarding against emerging threats will be highly complex and will involve deepening partnerships between humans and AI entities. We are entering an era where trust in technology will take on a new meaning as humans learn to share some of their most critical decision-making with AI. This will not be a step easily taken. As we move into the future we must grow and evolve humans who will work effectively with AI and be able to appropriately balance trust in the technology with caution regarding its limitations.

Technology is not waiting for us to catch up. We cannot delay the progress of the human element. The future is now. ⊙

"We are entering an era of great uncertainty characterised by a highly variable, diverse and rapidly evolving threat landscape. Many threats are 'unknown' – and may be very difficult to detect, recognise or counter."

Dr Jackie Craig FTSE was a Defence scientist for 35 years, working for the UK Ministry of Defence and the Australian Department of Defence. She spent 26 years at Defence Science and Technology Group and for the last 10 years of her career was a Chief of Division, leading research in the areas of electronic warfare and cyber. She has held senior positions in the international intelligence and defence S&T communities and has a number of awards for outstanding scientific leadership. She is currently an honorary fellow at DST Group.

BY GÖRAN ROOS
goran@roos.org.uk

What will a digital future mean for society?

OUR LIVES DIGITISED The way value is created is experiencing a profound shift, fundamentally restructuring the economy. **Göran Roos** explains.

Every 50 to 70 years there's a major shift in how value is created in society, thanks to emerging technology. Historically, the onset of new technology spurred five major shifts that restructured the scaffold of society:

1 1770 – the Industrial Revolution transformed textile production through mechanisation, and a canal infrastructure led to the UK emerging as a key industrial state.

2 1830 – the steam engine revolution – including the development of machine tools and railway infrastructure. Towards the end of this revolution, the UK was challenged by the US.

3 1870 – the steel-, chemistry- and electricity-based heavy engineering paradigm and its focus on mega-structures, such as bridges and ships. The US was the dominant nation, but Germany and Europe soon became challengers.

4 1910 – the combustion engine. The infrastructure focus was on roads and pipelines, and the period saw mass production and dependence of oil and minerals. China emerged towards the latter years to challenge Germany and the US for leadership.

5 1970 – the world began to go digital, with an emphasis on information (such as edgeware, software and hardware). China will become the likely leader by overtaking the US and Europe.

Each of these periods was characterised by same pattern: emergence followed by one or more bubbles; a recession (which is also the turning point where the new ways of creating value are accepted as the future); a long era of prosperity; and finally a reduction in productivity improvement, laying the foundation for the next paradigm to emerge.

So where are we placed now? Presently, we're at the end of a recession period.

BUBBLES, THE ECONOMY AND THE DESTRUCTION OF THE OLD

It takes between 20 and 40 years from its first visibility to when new technology starts changing the structure of the economy. Three-dimensional (3D) printing, for instance, had already taken shape in the early 1980s, but only now has begun to have a major impact.

In the early phases of this shift, we tend to overestimate the short-term impact of new technologies while underestimating their long-term impact – an effect well known in technology forecasting and sometimes labelled macro-myopia.

This is one of the reasons the bubbles appear in the early phases of a new value-creating model.

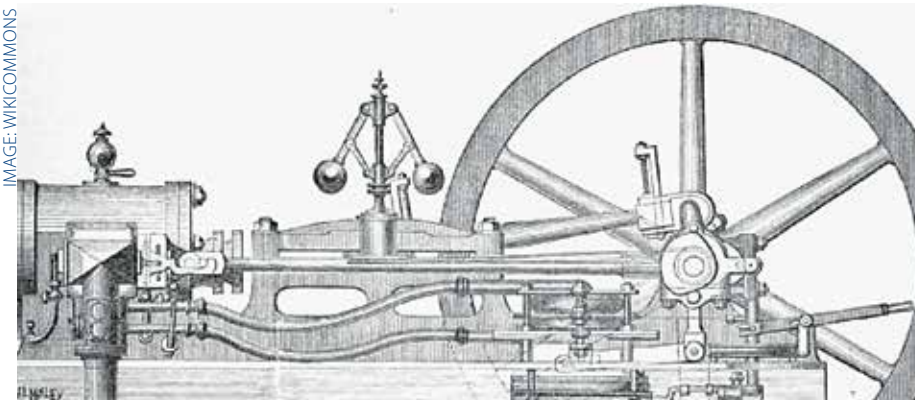
During each of these major shifts there will be a gale of creative destruction. This means that individual firms and other types of organisations must choose to adopt these new technologies and change the way they create value, or be expelled from the market they operate in.

Essentially, they must update or perish.

As it ebbs and flows, innovation both responds to and drives change to individual behaviour, societal norms, organisational structures and the legal underpinnings of nation states.

Consider the Cold War – the perpetual state of fear and the race of might drove innovation. Today, it's a clean, low-resource footprint, economic growth and the ageing population.

IMAGE: WIKICOMMONS



The Hugon stationary gas engine, taken from an advert in the Newspaper Press of 1871. This was the 2nd commercial internal combustion engine to be made, only the Lenoir engine being earlier.

UPDATING SKILLS MEANS HIGHER EARNINGS

New skills in labour will be in demand and can command high earnings. There will also be a slow, 10-year shift in the structure of organisations, as well as the regulatory environment, providing continuous growth.

In this stage, it's normal to see rapid boosts to productivity and strong income polarisation benefiting those updating their way of creating value.

It's not uncommon to experience technological hypes and financial bubbles, such as the dot-com bubble around 2000 and the casino economy bubble leading to the global financial crisis in 2008.

As the technology matures, we see it disseminated across the economy, facilitated by more competence and by reducing risk from standardisation.

The market allocates resources to the most productive firms that embrace changes to value creation. For these firms, the focus moves towards efficiency in their activities, leading to more competition. And it's further facilitated by a stabilising regulatory environment as regulations catch up with the new way of creating value

Firms clinging to the old way of operating will either die or adjust to modernity.

If firms don't adjust to modernity, they will vanish. The result? A fundamental transformation of the economy.

WHAT WILL HAPPEN TO JOBS?

The present transition to the digital value creating model will impact the composition of jobs. The number of jobs will decrease in some domains and increase in others.

High routine content jobs and high algorithmic content jobs will suffer losses, while jobs requiring creative and interactive skills will abound. And jobs will boom in sectors where the productivity improvement is lower than the underlying demand growth, for instance, in health and aged care.

Excitingly, new jobs will be created that previously didn't exist. Already the 21st century has given us bloggers, drone operators and machine learning trainers, for instance. Careers like these never needed to exist before.

There will be an increase in the number of jobs pairing technology with human skill. This means the costs of automation is not only the price of the technology itself, but also the cost of its human complement.

'Drone operator' is one of the many jobs that didn't exist before the 21st century.

"As it ebbs and flows, innovation both responds to and drives change to individual behaviour, societal norms, organisational structures, and the legal underpinnings of nation states."

PRODUCTIVITY PATTERNS EMERGE

The interplay of diffusion and adoption of technology has a major impact on productivity. Some interesting patterns emerge:

Distribution

Distribution of new technology causes major resource reallocation between sectors in the economy. Growth will primarily take place in areas relating to the provision of new technology enabled offers and the major beneficiaries will be the 'first mover' sectors and firms.

Growth

Growth areas providing input to the first movers, as well as in sectors and firms that provide products and services complementing the products and services from the first mover sectors and firms.

More divergence between sectors of the economy linked to the new ways of creating value will accelerate their growth. For those linked to the old way of creating value, growth will slow down and eventually turn into a decline. This means resource allocation by the market from low-growth sectors to the high-growth sectors will change at a lightening pace.

FUTURE WORK CHANGES

The risk of a net reduction in number of jobs is low and the probability of a global boost in job numbers is high. Most jobs, however, will see a large change in the task composition of the job.

While many specific jobs will be eliminated, those disappearing in one location will be compensated for by jobs appearing in another, creating challenges for some economies but benefiting others.

Careers will be more flexible, agile, networked and connected. This will involve a major transformation in not only the tasks that make up a job, but also in their scaffolding.

Everyone in the future will likely be interacting with robots during most of their waking hours – inside and outside the work environment.

It's obvious that the capabilities to succeed in tomorrow's world will be different from those that will lead to success today.

Governments have a major role to play ensuring policies, institutions, infrastructure and finances enable people and organisations to succeed and capturing those that will not make it in this new environment. ⊙

Professor Göran Roos FTSE is a member of the Economic Development Board of South Australia, the advisory board for Investment Attraction SA, METS Ignited Australia Ltd's Innovation Advisory Council (MIAC), an Invited Chair of CSIRO Manufacturing Business Unit Advisory Committee and a strategic Advisor to Defence SA and the Defence SA Advisory Board. He is a Stretton Fellow appointed by the City of Playford at the University of Adelaide; Adjunct Professor at the University of Technology Sydney Business School; and Visiting Professor at Tongji University, Shanghai.

ATSE IN ACTION

Energy Symposium: the NEM after the Finkel Review

The future of Australia's electricity market was the subject of lively debate at ATSE's Symposium, 'The National Electricity Market after the Finkel Review'.

Held at the CBA Colonial Theatre in Sydney in November last year, the Symposium heard presentations from Australia's Chief Scientist Dr Alan Finkel together with international contributions from Professor John Loughhead, Chief Scientific Advisor to the UK Government, and Mr James Gallagher, Executive Director of the New York State Smart Grid Consortium.

The Symposium was organised by ATSE's NSW Division and attended by 150 industry experts.

Authoritative addresses from respected industry leaders, including power system investors, electricity system operators and legal experts. Papers covered energy policy, investment opportunities and the associated political, economic and technological challenges associated with the Finkel Review recommendations being implemented by the Energy Security Board (ESB) for the NEM.

Alan Finkel

Key Symposium findings can be found on the ATSE website, www.atse.org.au

REVIEW OF FRACKING SCIENCE FOR WA INQUIRY

In December 2017, ATSE delivered a commissioned report reviewing relevant scientific and governmental reviews on hydraulic fracturing and shale gas development to support the Independent Scientific Panel Inquiry investigations into Hydraulic Fracture Stimulation in Western Australia.

The report considered a selection of relevant scientific and governmental reviews from Australia and four reference countries: Canada, South Africa, the UK and the US.

ATSE summarised each review's findings and highlighted areas of both consensus and ongoing debate relating to the effects of shale gas development on water, air, land, biodiversity, health and society.

The Independent Scientific Panel, which is chaired by ATSE Fellow and WA EPA Chair Tom Hatton, is accepting submissions until 19 March 2018. Further details can be found at frackinginquiry.wa.gov.au.

ATSE IN ACTION

Taking STEM education to far-flung regions of Indonesia

STELR – ATSE's initiative to bring hands-on, inquiry-based STEM education into schools – continues to gain traction on a global scale, particularly in Indonesia.

In November 2017, STELR presented a five-day training workshop in Bandung, Indonesia, on behalf of the South East Asia Ministers of Education Organisation (SEAMEO) for the third consecutive year. And after the success of the workshop, STELR's Executive Manager Peter Pentland was invited to represent Australia a month later as one of four keynote speakers at a seminar on the future of STEM education in Indonesia.

TRAINING WORKSHOP

The workshop was attended by more than 40 teachers from nine different countries, including Indonesia, Laos, Cambodia, Malaysia, Singapore, the Philippines and Thailand, as well as two countries outside the region, the Maldives and Pakistan.

Through representations, inquiry-based learning and hands-on activities, the sessions focused on developing conceptual understanding, promoting collaborative learning and working scientifically. STELR staff Peter Pentland and Pennie Stoyles presented sessions with Dr Greg Smith from Charles Darwin University, Connie Cirkony from Deakin University and Simone Blom from Southern Cross University. Greg, Connie and Simone are education professionals who have been involved in writing for STELR over the past few years. The workshop was made possible by a grant provided by the Australia–Indonesia Institute.

INTERNATIONAL SEMINAR

STERL's Peter Pentland was a keynote speaker on the topic 'STEM Education Journey in Australia – Lessons Learned and Best Practices'. Other keynote speakers were from Japan, Korea and Thailand, and there were more than 400 participants.

The Seminar had four objectives:

- form a national policy on STEM education that addresses global issues while taking local conditions in to account;
- establish a common approach to STEM though avoiding a one-size-fits-all attitude;
- find the best system for implementing STEM education, based on the successes and failures of developing countries; and
- develop a national scheme and promotion of STEM at every learning level.

After the Seminar, Peter travelled to Bontang in East Kalimantan, where four new schools joined the STELR community. They were each presented with class sets of STELR Renewable Energy equipment, provided through Orica sponsorship. This brings the number of STELR schools in Bontang to nine.

The idea of creating a hub for STEM in Bontang was also discussed. Called the STEM House, the hub would be a resource for local, remote schools to dip into.

Peter also visited two schools already running the STELR program, meeting with teachers and students.

He was joined by Dr Indarjani, Deputy Director of the SEAMEO Regional Centre for Quality Improvement of Teachers and Education Personnel (QITEP) in Science, based in Bandung, Indonesia.

The STELR Workshop in November 2017.

ANOTHER SUCCESSFUL YEAR FOR THE AUSTRALIA-CHINA SYMPOSIUM

In its 13th year, the 2017 Australia–China Symposium once again tackled a topic of great importance to both countries. ATSE joined the Australian Academy of Science and the Chinese Academy of Sciences to take on synthetic biology – one of the fastest-growing areas of modern science.

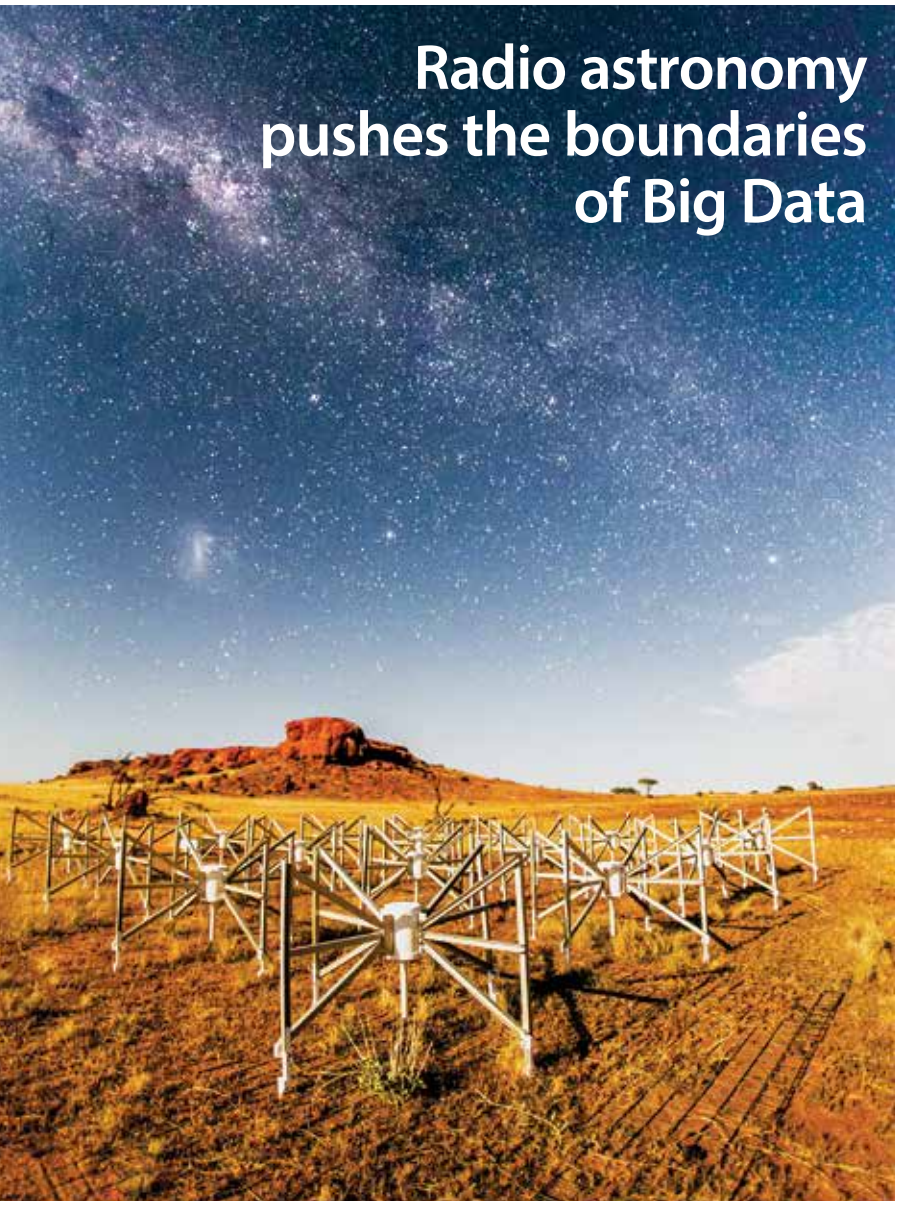
The cohort of eminent speakers discussed a range of synthetic biology challenges and ideas, from synthetic DNA templates to photosynthetic metabolism. The Symposium was also attended by a group of early-to-middle-career researchers from both countries.

The symposium comprised four sessions, each focused on a different aspect of the growth of synthetic biology: macromolecular design, pathways, genome scale and ethics.

Two of ATSE's Fellows – the University of Queensland's Professor Peter Gray and ANU's Professor Simon Foote – were part of the Steering Committee. The annual event is funded through the Australia–China Science and Research Fund (ACSRF), administered by the Australian Government Department of Industry, Innovation and Science, and the Chinese Academy of Sciences.

ATSE IN ACTION

Radio astronomy pushes the boundaries of Big Data



Tile 107, or 'the Outlier' as it is known, is one of 128 original tiles of the Murchison Widefield Array radio telescope located in the remote outback of Western Australia. The MWA telescope is a designated precursor of the SKA. PHOTO: PETE WHEELER

The Square Kilometre Array (SKA) will be the world's largest radio telescope and one of the largest scientific endeavours in history. Professor Peter Quinn FTSE, Executive Director of the International Centre for Radio Astronomy Research, described Australia's pivotal role in designing and building the SKA to ATSE's NSW Division in its 'Big Data' luncheon series in November.

The SKA is arguably one of the most exciting developments in radio astronomy since 'The Dish' was built at Parkes, NSW, half a century ago.

The SKA is an international, multi-decade project that will require computer-processing power far beyond the performance of the largest computer systems on Earth today.

It will produce a stream of science data products that are exascale in terms of their storage and processing requirements. Exascale computing refers to computing systems capable of at least one exaFLOPS, or a billion billion calculations per second. Such capacity represents a thousand-fold increase over the first petascale computer that came into operation in 2008.

This Google-scale enterprise is attracting immense international interest and excitement from within industrial and academic communities.

The SKA will revolutionise our view of the universe. It will push the boundaries of our knowledge back in time to the formation of the first stars and galaxies. It will also push the boundaries of our technology and will provide new industrial, educational, scientific and technological opportunities in the 21st century.

Exploring the entire universe through space and time, from now to the very first stars and galaxies that existed more than 10 billion years ago, is an unparalleled feat of human scientific endeavour. There are tremendous opportunities for Australian astronomers, computer and data scientists to play a key role in the global collaboration for decades into the future.

CAETS CONVOCATION: UNDERSTANDING THE BIOECONOMY

Engineering must be embraced on a global scale, with international collaboration, if we are to secure a sustainable future. This is the renewed focus of the International Council of Academies of Engineering and Technological Sciences (CAETS).

In November last year CAETS held a Convocation that helped tackle some of the major global issues innovative engineering can solve, hosted in Madrid by the Royal Academy of Engineering of Spain.

The Convocation theme was 'Challenges of the Bioeconomy'. Sessions on food security, genetic engineering, the blue bioeconomy and energy were held, with presentations from experts from around the world.

'The bioeconomy' refers to the use of renewable biological resources and the ability to convert them into products, such as food and feed. The production, processing, storage, consumption, recycling and disposal of natural resources demands innovative techniques.

Essentially, the bioeconomy brings together the various sectors of the economy that are related to biological resources (agriculture, forestry, fisheries, food, bio-based chemicals and materials and bioenergy).

ATSE's President Professor Hugh Bradlow FTSE and Executive Director of Policy Dr Matt Wenham attended and contributed to the wider discussion, as well as holding side discussions with sister academies from China, Japan, Korea, India, the US and the UK.

The CAETS Council also considered diversity and the ethical considerations that arise in engineering futures.

ATSE IN ACTION

Nick Birbilis wins Batterham Medal

One of Australia's outstanding young engineering innovators has been awarded the prestigious Batterham Medal, recognising his contributions to engineering over the past five years.

The winner of this year's medal, which is administered by ATSE, is Monash University engineer Professor Nick Birbilis, for his work on corrosion.

Professor Birbilis has had an impressive career to date. At 39 years old, he is a professor, the Head of Materials Science and Engineering, and is the Woodside Innovation Chair at Monash University.

"The engineered environment is one that is constructed by people. To this end, we are responsible for the materials we use, the technologies we develop, and in turn, their durability," he says.

As an internationally recognised expert in corrosion, durability management and the behaviour of metallic elements, Professor Birbilis solves problems both locally and globally across this broad range of engineering fields.

He began his engineering career working in materials consulting with Maunsell (now AECOM). Before he transitioned into academia, he was already renowned across Australia for expertly tackling corrosion.

"Corrosion of metals is the result of nature wanting to return the metal atoms back to their preferred raw form and the suppression of this involves innovation in corrosion control," he says.

His signature contribution in the past five years was his breakthrough in developing lightweight 'stainless' magnesium and aluminium alloys.

In contrast, stainless steels are heavy and rely on large amounts of chromium alloying. It's Professor Birbilis' goal, however, to create corrosion-resistant ultra-lightweight versions of aluminium and magnesium alloys – for everything from portable electronics to structural materials.

Lightweight vehicles, for example, would reduce energy, fuel and carbon emissions.

Regarding the award, Professor Birbilis says any celebration of achievements in STEM are extremely important.

"Such awards not only elevate the profession, but also serve as platforms to notify and inspire young students or those looking towards a career in engineering. This award also highlights the role of ATSE as a voice for Australia's technology and innovation capability."

ATSE acknowledges the Group of Eight Deans of Engineering and Associates for funding the Batterham Medal.

HOW IS THE WINNER CHOSEN?

The winner is an engineering graduate of an Australian university, under 40 years of age on 1 January in the year of the award, who has:

- demonstrated excellence, innovation and impact in a field of engineering;
- clearly demonstrated a signature contribution to engineering in the five years prior to their nomination; and
- advanced the standing of the engineering profession.

"The engineered environment is one that is constructed by people. To this end, we are responsible for the materials we use, the technologies we develop, and – in turn – their durability."

ATSE IN ACTION

Getting Australia tech ready

Is Australia ready to take on new technologies? ATSE has started assessing the 'technological readiness' of key industry sectors to determine if Australia can keep up with the pace of change of 'Industry 4.0'.

IMAGE: BIRGIT KORBER VIA ISTOCK

Technological readiness is defined as the readiness to develop, adapt to or adopt new technology. Over the next three years, ATSE will develop a roadmap of what Australian industry must do to maintain currency for new and emerging technologies, and to fully integrate them to boost our economic advantage.

The project will also develop a 10-year plan for technology research in Australia, linking industry and researchers to address industry problems that arise when new technology is embraced.

The project's Steering Committee, co-chaired by Mr Drew Clarke AO PSM FTSE and Ms Kathryn Fagg FTSE, had its first meeting in December 2017.

"Australians have a new opportunity in the face of rapid technological change. We need new approaches to ensure Australian policy-makers, industry leaders and researchers work together to deliver the greatest benefit to Australians," Ms Fagg says.

"The project will use the breadth of ATSE's expertise to bring together otherwise siloed aspects of industry, and this will be a contribution that existing projects don't have," Mr Clarke says.

The decadal plan will help guide decisions by researchers to ensure investment and effort in the workforce are focused to promote industry competitiveness. Industry sectors will be selected according to how important they are to the Australian economy – for instance, transport, agriculture and defence.

Drawing on ATSE Fellows' diverse experiences in research and industry, the project will take a collaborative approach to identify the likely scenarios of 2030.

For instance, the technologies predicted to drive the digital evolution include the Internet of Things, automation (such as autonomous vehicles), artificial intelligence, cybersecurity and material manipulation (such as gene editing and nanotechnology).

FOOD SAFETY IS AN INTERNATIONAL ISSUE: ATSE WORKSHOP WITH CAE

ATSE hosted the Chinese Academy of Engineering for a Food Safety Workshop, focused on improving trade in food and agricultural products between Australia and China, in November 2017.

The workshop looked closely at technology and innovation in food safety, and built upon an earlier workshop between the two academies in Beijing in 2016.

From the risk of norovirus contamination to consumer perception of food safety, the workshop covered a wide range of topics.

The workshop included four sessions, where participants discussed food safety in agri-food supply chains, digital transformation methods of provenance and traceability, food safety in industry and real-time food-safety issues.

Workshop members from the Chinese Academy of Engineering in Werribee.

"Food safety is an international issue, it can't be just looked at independently within a nation," Food Standards Australia New Zealand CEO Mark Booth said in a speech at the workshop.

The workshop helped strengthen ties between Australian and Chinese researchers and agriculture industry representatives, ultimately forging a stronger bond between the two countries.

The workshop was accompanied by two days of site visits to Australian food technology hubs, including the CSIRO Food Innovation Centre, horticulture producer Fresh Select's operations in Werribee, and the Agriculture Victoria National Centre for Dairy Research and Development in Ellinbank.

ATSE IN ACTION

Inaugural ICM Agrifood Award winners announced

Two inspiring young agrifood innovators fortifying Australia's food security were recognised for their contributions last year, winning the inaugural ICM Agrifood Awards, administered by ATSE.

James Hunt IMAGE VIA LAUREN CELENZA FROM WANTFA

La Trobe University agronomist and crop physiologist Dr James Hunt and NSW Department of Primary Industries (DPI) agricultural climatologist Dr Rebecca Darbyshire each received the $5000 ICM Agrifood Award at ATSE's Oration Dinner held in Sydney on 24 November.

The ICM Agrifood Award is a prestigious early career award open to all agrifood innovators, such as entrepreneurs, researchers and technologists. The Award is supported by major Australian agribusiness group ICM Agribusiness, which is chaired by ATSE Fellow Mr Doug Shears FTSE.

Dr Darbyshire, 35, says the award puts a spotlight on the value of and innovation in Australia's agricultural research.

"It shows that research in agriculture is challenging and rewarding for young people and that women are valued in the sector," she says.

Dr Hunt, 39, says the agriculture and food sectors have both enormous challenges and opportunities ahead of them in the coming years.

"I feel excited to win an award that recognises the contribution of young professionals in the agriculture and food sector," he says.

Rebecca Darbyshire

VITAL FOOD RESEARCH

Dr Rebecca Darbyshire, whose research focuses on fruit and nut trees, is leading Australia on climate change readiness.

"Through the knowledge gained in my research, farmers are ultimately able to make better decisions and investments to improve productivity and profitability," Dr Darbyshire says.

One of her major contributions to Australia's agriculture sector has been to introduce innovative ways to make complex scientific results more readable and accessible for on-the-ground application. Often, adaptation techniques aren't applied because of poor understanding.

She has also boosted the knowledge on how fruit trees respond to a range of weather conditions, focusing on winter chill and extreme heat damage, as well as flowering cycles.

Dr James Hunt has dedicated his research to supporting grain growers across the Australian wheatbelt to improve the productivity and profit of grain-based farms.

Since 2012, he has improved summer fallow management across the southern and western grain regions of Australia; helped properly define optimal flowering and sowing dates in different Australian environments; and developed the 'fast winter' wheat cultivar.

"It is extremely rewarding to work in a field of science where you can see your research having impact in farmers' fields straight away," Dr Hunt says.

"I'd strongly encourage anyone with an interest in biological sciences and natural systems to consider a career in the agriculture sector, there are some really great opportunities for young people."

HOW ARE THE WINNERS CHOSEN?

The winners must have achieved substantial recognition for their work in a field critical to continued improvement of the overall Australian food sector in the past five years, and be under 40 years of age. They must have:

- demonstrated excellence, innovation and impact in a field related to food and agriculture in Australia;
- been acknowledged by peers for outstanding contributions to the food and agriculture sector in the past five years; and
- advanced the standing of the broad profession of agriculture and food.

ATSE IN ACTION

Australia's mining sector must step up

Whether we like it or not, Australians rely on mining to keep up our current lifestyle – our phones, cars and even medical equipment use materials pulled from the Earth.

But with more than 50,000 abandoned historic mining sites scattered across Australia potentially posing major environmental, safety and financial risks, the mining sector needs to step up and take care of its legacy, ATSE says.

In a recent Action Statement, ATSE calls on Australian governments and mining industries to make our minerals sector a world leader in managing its environmental and socio-economic impacts.

ATSE launched the Statement, 'Addressing the Environmental Impacts of Australian Mining's Past and Future', at a panellist discussion at the University of Technology Sydney last year.

"When you talk about any industry, there is always a range of performance," Chair of ATSE's Mineral Resources Forum Ms Denise Goldsworthy FTSE said.

"One of the facts of life with the mining of commodities is that the profitability of mines swings significantly from year to year, and addressing environmental impacts is often left to the good years or close to the end of life of a mine operation.

"Better mining practices can be achieved with some of the latest technologies and innovations, but it requires a change in the way mining companies, METS companies (mining equipment, technology and services), researchers and regulators work together to fund these solutions."

Ms Goldsworthy chaired the panel discussion at the ATSE Statement launch, which included representatives from government, industry and academia.

WHAT IS THE ISSUE?

Failure to properly regulate the mining industry in the past means thousands of abandoned mine sites have never been rehabilitated and some continue to damage the environment.

One of the major environmental risks is acid mine drainage. Legacy mine sites can spill acid into the local environment, potentially infiltrating and poisoning ground and surface water.

Denise Goldsworthy

Mining today still poses a variety of environmental risks to water quantity and quality, air quality, biodiversity, landscape stability and climate change.

And a 2014 study by CSIRO suggested the Australian public's confidence in the mining industry is low, despite understanding the sector's importance to society.

WHAT NEEDS TO BE DONE?

ATSE outlines the way forward for the government and mining industries to follow. Broadly, there are three key focus areas:

- proactively address Australia's legacy mine challenge and ensure that current and future mine operators are held accountable for mine site remediation and closure;
- improve environmental risk assessment and management for mining operations; and
- earn the public's trust through transparency in management.

AUSTRALIA COULD LEAD ENERGY STORAGE: ACOLA

On 20 November 2017, The Australian Council of Learned Academies (ACOLA) released a report that says Australia could be a world leader in developing large- and home-scale energy storage systems – if public uncertainty can be overcome.

According to the report, *The Role of Energy Storage in Australia's Future Energy Supply Mix*, Australia has a wealth of natural advantages that could help develop new industries, exports and create jobs.

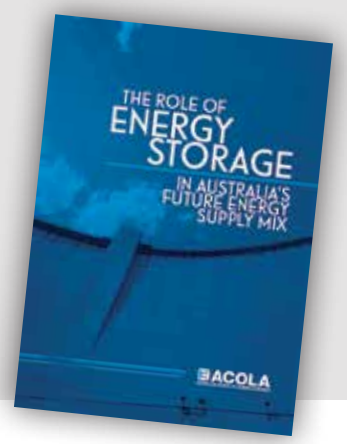
Without proper planning and investment in energy storage, however, electricity prices would keep rising and the electricity supply would be less reliable.

The report also found public awareness was limited. Generally, the public had some awareness of energy storage systems, such as batteries and pumped hydro, but not of emerging technologies such as renewable hydrogen.

The Chair of ATSE's Energy Forum, Bruce Godfrey, chaired the Expert Working Group for the study.

"This report clearly shows the two sides of the coin – that energy storage is an enormous opportunity for Australia but there is work to be done to build consumer confidence," he said.

The report was co-funded by ACOLA and the Office of the Chief Scientist. ATSE contributed both the initial scoping report and a contributing report on industry and research opportunities and challenges.



WOMEN IN TECHNOLOGY

Emma Johnston

Science and Technology Australia has a new president

Leading authority on marine ecology and broadcaster Professor Emma Johnston was recently appointed as the new President of Science and Technology Australia – the peak Australian body for the STEM sector.

Professor Johnston, who is also Dean of Science at the University of NSW, has taken over the position from Emeritus Professor Jim Piper AO. Her goal is to turn support for science into action so Australia can pioneer emerging technological fields, with more government spending to power research.

Professor Johnston wrote an article for the Science and Technology Australia website, and stated:

"You've heard it all before: science and technology contribute billions of dollars to the economy; Australia punches well above our weight in research outputs; our universities are first-class and internationally renowned. All of these things are true, however we have achieved this in spite of the conditions we are subject to …

"We have had five Ministers for Science in four years, which has meant little consistency from leadership despite the pronounced passion of individuals in that role …

"We have all of the right ingredients to cook up success – energy, diversity, talent and resources – all we need is someone to mix it together and finish the dish."

KERRY SCHOTT HEADS ENERGY SECURITY BOARD

Dr Kerry Schott AO has been appointed to chair the Energy Security Board (ESB), established by the COAG Energy Council to coordinate the implementation of the energy reform blueprint produced by Australia's Chief Scientist, Dr Alan Finkel AO FAA FTSE.

Dr Schott has extensive public and private sector experience. She is chair of Transgrid and a director of Infrastructure Australia, CEDA, NBNCo and Moorebank Intermodal Co and has expertise in economic, energy and infrastructure matters.

Ms Clare Savage has been appointed Deputy Chair. She is Executive Director Policy, Energy and Climate Change of the Business Council of Australia.

Her work on electricity and gas market design, network pricing and retail market regulation, alongside governance, climate change and renewables policy development, has been informed by senior positions in EnergyAustralia, the Energy Supply Association of Australia and the Australian Government Department of the Treasury.

The establishment of the ESB was agreed at the Energy Council meeting on 14 July and comprises an Independent Chair, Independent Deputy Chair and the heads of the Australian Energy Market Commission, Australian Energy Regulator and Australian Energy Market Operator.

TWO $5000 AWARDS OPEN FOR FEMALE STEM EXPERTS FROM QUEENSLAND

Applications for the 2018 Queensland Women in STEM prize opened early this year and will award two female experts cash prizes of $5000 to support professional development opportunities.

The goal of the competition is to showcase early–mid career female experts in science, technology, maths and engineering who are both making important contributions to their fields and engaging with the broader community.

Two free science communication training sessions were held on 6 February 2018 to help applicants with their entries. Submissions close on 26 February 2018 and winners will be announced on 24 March 2018 at the World Science Festival Brisbane 2018. The competition offers two prizes: a Jury Award and a People's Choice Award.

For more information visit
2018-queensland-women-in-stem-prize.thinkable.org

JURY AWARD

An expert judging panel will evaluate applications on how well communicated the research is, the positive impact and relevance of the work to advancing Queensland, and the evidence for communication and promoting awareness of the STEM field.

PEOPLE'S CHOICE AWARD

The applicant with the highest number of registered votes on the Thinkable website will win the People's Choice Award. Applicants must be made online and include a summary of the work, how it benefits Queensland, any STEM promotion/engagement activities undertaken in the past five years, a short CV and a video suitable for a general audience.

WOMEN IN TECHNOLOGY

The STEMMinist Book Club: join the discussion

Men dominate history books, leaving the important roles women played relatively unknown, and this is indeed the case for science. Women are under-represented in science history, as well as in STEMM fields (science, technology, engineering, maths and medicine).

But Dr Caroline Ford, a cancer researcher from the University of NSW and an advocate for more women in STEMM, has come up with a way to broaden the conversation.

She launched the STEMMinist Book Club on Twitter on 2 January 2018, and soon after, a Good Reads community. In only 24 hours, 200 people from around the world became part of the STEMMinist Book Club. After a week, 750 people in total joined in, and the numbers continue to grow rapidly.

So how does the book club work? Based in Sydney, the club recommends a new book to read each month, and then at the end of the month members meet up. For the inaugural month, the book was Angela Saini's *Inferior: How Science Got Women Wrong – and the New Research That's Rewriting the Story*.

You can join the discussion online using the hashtag: #STEMMinistBC

Here, Dr Ford answers a few questions about the STEMMinist Book Club.

One book club member reads her copy at the beach.

What does it mean to be a 'STEMMinist'?

A STEMMinist is anyone working in, or with an interest in STEMM that considers themselves a feminist.

Did you expect so many members to join when you started?

Absolutely not, I've been totally blown away by the response! I knew there was an incredible community of women in STEMM on Twitter but the size of the response has been a wonderful surprise.

How did you get the idea to create a book club? What inspired you?

I was reading all these great books on women in science and gender equity, and I wanted to discuss them with more people. When I saw via Twitter that University of Sydney Associate Professor Renae Ryan was also reading Inferior on her summer holiday, it fired me up!

At first I thought it might just be a great opportunity to get a small bunch of likeminded women together over a beer in Sydney, but then I realised that through Twitter the conversation could be much larger and more diverse.

Why did you decide to launch it on Twitter?

Twitter is full of so many interesting STEMM folk. I set up a personal Twitter account a few years ago at the urging of two incredible scientists (Nikola Bowden and Deborah Marsh) and was immediately impressed by the positive supportive online community of Australian scientists, engineers, educators, technologists, doctors and allied health professionals.

Why did you choose *Inferior* as the first book to discuss?

Because it's great! A well-written analysis of how science is also subject to gender bias, and the impact it has had on establishing myths about differences between men and women. It's a fascinating read, and I thought it would generate lots of discussion.

"At first I thought it might just be a great opportunity to get a small bunch of likeminded women together over a beer in Sydney, but then I realised that through Twitter the conversation could be much larger and more diverse."

WOMEN IN TECHNOLOGY

Invisible farmers start to emerge

Amy Paul with chickens, Walkerville, South Gippsland, 2017.

SOURCE: MUSEUMS VICTORIA, PHOTOGRAPHER: CATHERINE FORGE

Women are the backbone of the agriculture industry, but rarely the face of it.

This lack of recognition is what inspired 'The Invisible Farmer Project' – the largest ever study of Australian women on the land. The project was recently included in AgriEducate's list of the Top 10 Advancements and Achievements in Agriculture for 2017.

In Australia, women produce around half of farm income, yet the image associated with 'Australian farmer' is predominantly that of a white man. And in positions of rural leadership and decision-making, women are significantly under-represented.

Launched last year, the three-year project aims to create new histories of rural Australia, recognising the postcolonial contributions and varied roles of women, including Indigenous women, in agriculture.

The Invisible Farmer Project, funded by the Australian Research Council, involves a nationwide partnership of rural communities, academics, government and cultural organisations.

To get in touch or share a story with the Invisible Farmer Project, visit the project's website www.invisiblefarmer.net.au, or follow Invisible Farmer on Facebook, Twitter and Instagram (@invisfarmer).

$25,000 FELLOWSHIPS FOR WOMEN IN SCIENCE

Applications for the L'Oréal–UNESCO for Women in Science Australia and New Zealand Fellowships will open on 19 February 2018.

The 2018 program will recognise four Australian scientists and one from New Zealand, and each will be awarded $25,000.

The Fellowship is intended to give practical help for the winners to undertake scientific research, whether the money is spent buying scientific equipment or paying for childcare or travel costs, for instance.

Beginning in 1998, this program has recognised more than 2250 women in 110 countries, honoured 94 International Laureates for excellence in science (including two women who went on to be awarded a Nobel Prize) and awarded over 2200 talented young female scientists to pursue their promising research projects.

ATSE Fellow Professor Michelle Simmons was recognised as a 2017 International Laureate (see *Focus* 201).

AWARDS CHAMPION VICTORIAN BUSINESS WOMEN

For more than 20 years, the Telstra Victorian Business Women's Awards have championed women from diverse industries, celebrating their achievements. Last year, the winners were as inspiring as ever.

2017 Victorian Woman of the Year was awarded to Michelle Gallaher. She founded Women in STEMM Australia and The Social Science – two businesses powered by the belief that Australia won't reach its innovation potential if women are under-represented.

Monash University clinical neuropsychologist Associate Professor Kate Hoy won the Public Sector and Academia category. She is the Deputy Director of the Therapeutic Brain Stimulation division and heads the Cognitive Therapeutics Research Program at Monash.

Nominations for the 2018 awards are now open.

BY MARLENE KANGA
marlene@iomniscient.com

Australia's innovation lacks grit

OPINION And what can – and must – be done about it. **Marlene Kanga** explains.

By global measures, Australia has recently had some great successes. But the nation is falling behind in the innovation race. The World Economic Forum 2017 Global Innovation Index places Australia at 23, one rank below China. We've slipped from ranking at 17 in 2014, while other nations forge ahead.

In the South-East Asian region, Singapore maintained its spot at 1st position while Australia fell to 7th (from 4th in 2014), behind New Zealand at 5th and China at 6th position.

While the pundits pontificate on what needs to be done, there are some obvious solutions that can achieve significant results.

Australia's low rate of commercialisation is in stark contrast to the lead Australia has in the quality of our universities, teaching and research. It's clear there are barriers to be overcome in commercialising research.

Innovation and Science Australia will address this issue in its forthcoming Strategic Plan. And it must be urgently addressed if Australia is to stay ahead of the pack in the innovation race.

Ranking 23, we came in at 12 in terms of innovation inputs – including the quality of education and universities – and 30 in terms out innovation outputs. We ranked 76 on innovation efficiency, measuring how well we produce valuable outcomes for the nation.

And curiously, Australia ranked 32 in terms of university–industry collaboration, far behind Singapore (7), Malaysia (11) and New Zealand (18).

Collaboration with universities is an important measure of the health of our innovation system and the ability for students and researchers to generate great ideas and take them to market.

Systemic changes are needed. Specifically, a cultural shift enabling students to consider entrepreneurship as a possible early career path and for industry to absorb the technical output from universities.

DEMOLISH OUTDATED BARRIERS FOR GREATER RETURNS

One of the most impenetrable barriers to pairing industry and universities is how it's not recognised that universities are large institutions with an unequal power base when dealing with individual students, researchers or small innovative companies.

University legal departments can be quite heavy handed with complex contracts when allocating risk and returns, and in particular, the ownership of intellectual property.

And in a recent study by the Royal Academy of Engineering (UK), businesses identified the ownership of intellectual property as the top barrier for collaboration with universities.

My first-hand experience is that legal complexities – not technical ones – put a stop to prospective projects.

These deliberations are critical because intellectual property is a significant, strategic asset for innovating companies. Intellectual property must be addressed early in a project so there can be focus on the technology advancements at the core of a collaborative research activity.

Importantly, addressing these process issues can yield huge benefits to the university, the start-up and the economy, without any additional cost. Over the years, many universities in Australia have updated their policies on the ownership of intellectual property, developing a range of strategies from 'open innovation' to innovation that can be commercialised by researchers over a limited period.

This is a complex area with no standardised solutions. But the situation is changing quickly overseas.

For example, universities in the US and Canada must make their research publicly available within a year of its release. This is a boon to young students who are the main source of new ideas and who have the energy and passion to engage in commercial projects.

THE UNIVERSITIES OVERSEAS DOING IT RIGHT

One of the best models for commercialising research is at the Massachusetts Institute of Technology (MIT) where students at all levels, even undergraduates, are encouraged to be entrepreneurs. The results have been phenomenal.

MIT alumni have launched more than 30,000 companies that employ nearly five million people and generate nearly US$2 trillion in annual revenues.

Stanford University, which famously incubated Google and Cisco, has fostered nearly 40,000 companies with more than US$3 trillion in revenues.

Other countries, including Singapore, have adopted this model in their leading universities, achieving astonishing results in less than five years, with a thriving innovation ecosystem around the well-known Block 71 in Singapore.

> **"Collaboration with universities is an important measure of the health of our innovation system."**

'China's MIT', Tsinghua University, has had similar success. Alumni have established more than 10,000 companies, generating more than US$50 billion in annual revenues and establishing an ecosystem to mentor and support emerging entrepreneurs from the university.

India is also entering the race through the 'Start-Up India Stand-Up India' initiative, with incubators quickly being established on university campuses and new companies emerging at an increasing rate.

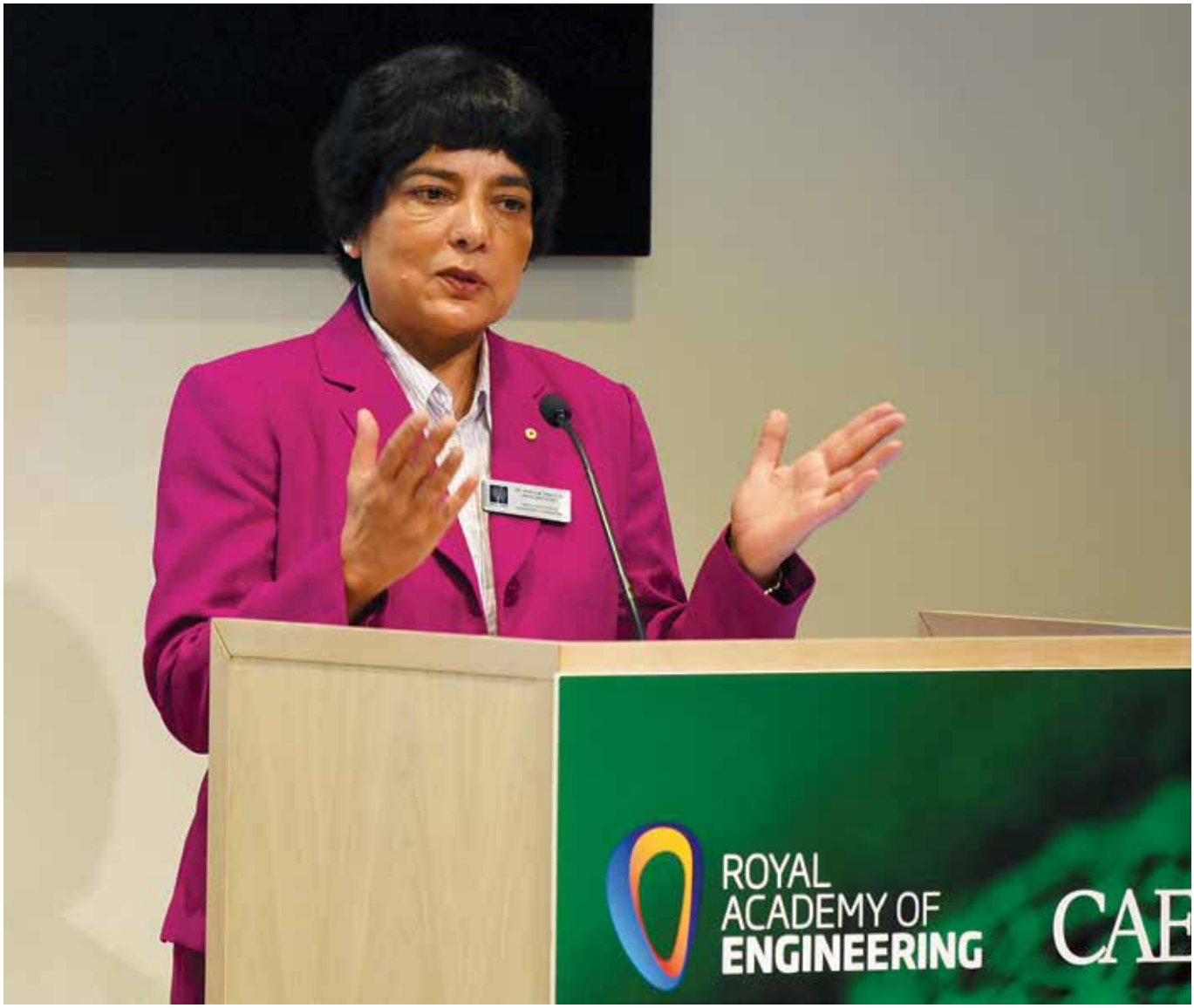
These programs create the skills and mindset for entrepreneurship – students might seek to start their own business ahead of finding their first job in established companies.

Entrepreneurship will become more important as the impact of new technology innovations causes many conventional jobs to disappear.

Malaysia has recognised the need to boost the entrepreneurial mindset and culture. In its latest national education strategy, for instance, innovation and entrepreneurship are put alongside world-class education in its strategic shift in developing the skills for the future workforce.

Australia can learn from these examples of progressive policies. Our universities can not only create a wealth of ideas, but also generate wealth by translating ideas into commercial outcomes, securing Australia's future.

Dr Marlene Kanga AM FTSE is President of the World Federation of Engineering Organizations, the peak body for engineering institutions worldwide. In 2013 she was National President of Engineers Australia. She is a Board Member of Sydney Water Corporation, Air Services Australia and various boards involving innovation, and a director of iOmniscient Pty Ltd. She has been listed among the Top 100 Women of Influence in Australia and the Top 100 Engineers in Australia and was the 2014 FEIAP (Federation of Engineers in Asia and the Pacific) Professional Engineer of the Year, the first woman to be so awarded.



Marlene Kanga speaks at the global engineering academies convention, the CAETS Convocation 'Engineering a better world', in September 2016.

BY JOHN HARVEY
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Agriculture is not the same as farming: RIRDC boss

OPINION John Harvey, Managing Director of the Rural Industries Research and Development Corporation (RIRDC), explains.

The Australian agriculture sector faces a near critical skills shortage. While agriculture is the biggest employer in rural and regional Australia – employing about 300,000 people directly and more than 1.6 million people across the supply chain – workforce capacity looms as the sector's most significant issue.

As the sector faces the challenge of feeding a rapidly growing global population and increasing technical complexity, the composition of jobs and available career paths have changed considerably in recent times and now the opportunities are abundant.

For the past 10 years, there have consistently been many more jobs available in agriculture than there are qualified candidates. University graduates finishing agriculture-related degrees can expect to have full-time employment secured before they've completed their degree.

According to the latest research from Charles Sturt University's Professor Jim Pratley there are upwards of five jobs for each graduate in the current market.

Most of these graduates (and indeed many of the people employed in the agriculture sector) are not farmers. The Australian agriculture industry is about the whole value chain, from on-farm production through to transport, manufacturing, marketing, finance, innovation, services and more.

We have to bust the myth that agriculture equals farming. You don't have to be a farmer to work in agriculture, you don't have to have an agricultural background or qualification to work in agriculture, and you don't necessarily have to live in a rural area to be part of the sector.

"You don't have to be a farmer to work in agriculture, you don't have to have an agricultural background or qualification to work in agriculture, and you don't necessarily have to live in a rural area to be part of the sector."

Really, it's any job that is involved in the production of food, feed or fibre, or which supports that production and helps get those products to market. It's everything from a graphic designer working on packaging concepts for supermarket rice cakes, to engineers building robots to monitor fruit, to the train driver delivering wheat to port and much more.

The future of our sector depends not only on more farmers but on more people coming to work in the sector in an off-farm capacity. We used to think that to secure agriculture's future we had to keep young people on the land and working on farms. Now we know we must not only retain our young farmers but attract people from other industries and other backgrounds. It's also not a male-dominated sector anymore. Enrolment data from university agriculture courses shows women have outnumbered men (albeit marginally) since 2003.

RIRDC's own Horizon Scholarship program, which supports young people passionate about agriculture and helps them become part of the sector's next generation of leaders, has been awarded to more women than men again this year. And even more significantly it's no longer a scholarship for rural university students but is attracting young people from metropolitan areas who are passionate about agriculture despite not being from a farming background.

To guarantee the future workforce of our sector we have to do a better job of promoting the strength and diversity of Australian agriculture and its abundant career opportunities.

If the sector is to grow as expected, make the productivity gains required to feed the world and keep abreast of new technology we need more people to come across to agriculture.

As Professor Pratley says, we must 'maintain the rage' about attracting talent to agriculture if we are going to be able to meet the needs of an expanding industry.

Given we are competing against a myriad other sectors for the new skills our industry needs, like IT and engineering, more work has to be done to make agriculture stand out and attract talented people.

The future workforce of our industries is not guaranteed without more action to improve the image of the sector, moving it away from the traditional farmer icon, and promoting agriculture as a truly fulfilling career choice. ⊙

ATSE PEOPLE

IN MEMORIAM

Tony Linnane: a lifetime devoted to science

Professor Anthony Linnane AM DSc FAA FRS FTSE was a giant in biochemistry and molecular biology.

Born in 1930, in Sydney, the Monash University emeritus professor helped make Australia's contribution to science internationally recognised. And in the process, he became globally renowned among biology researchers.

He pioneered studies into the biogenesis of mitochondria (components of a cell that help with respiration), interferon research (a protein released by animal cells), gastrointestinal cancer and ageing.

Tony Linnane

Admiring the model of state universities in the US, Professor Linnane moved to the University of Wisconsin for two years as a postdoctoral fellow, more deeply exploring mitochondria. He said he considered these two years the most formative of his career.

Biochemistry had been the love of his life since he first enrolled in a biochemistry course in his second year of an undergraduate degree, he said in a 2010 Invited Recollections article, published in *IUBM Life*.

Professor Linnane founded *IUBM Life* – then called *Biochemistry and Molecular Biology International* (BAMBI) – and was Editor in Chief for the first 46 volumes.

After his first degree, he continued studying at the University of Sydney, graduating with a PhD in 1956, his thesis on functional yeast mitochondria and the properties of petite yeast.

Admiring the model of state universities in the US, Professor Linnane moved to the University of Wisconsin for two years as a postdoctoral fellow, more deeply exploring mitochondria. He said he considered these two years the most formative of his career.

He returned to the University of Sydney as a young lecturer and embraced protein synthesis and molecular genetics, then in their infancy.

In 1962 he moved to Monash University and became a Professor of Biochemistry soon after, at only 35 years old, staying in this role for 30 years.

In this time he also served as Associate Dean (1973–76), was founding director of the Centre for Molecular Biology from 1996, and served on all major Faculty of Medicine Committees at Monash University.

In recognition of his accomplished career, he became a Fellow of the Australian Academy of Science (1972), received the Lemberg Medal from the Australian Biochemical Society in 1973 and was elected a Fellow of the Royal Society in 1980. He was elected to the ATSE Fellowship in 1999.

Among his many far-reaching scientific breakthroughs, the discovery of a diagnostic tool for gastrointestinal cancers led him to transition from scientist to entrepreneur, creating the public company Mabtech Ltd in 1994 to commercialise this work.

In 1996, Professor Linnane became an Honorary Professor at the University of Melbourne, and in 2000 he and his team were awarded the Distinguished Service Award by the International Union of Biochemistry and Molecular Biology.

In his later years he worked as a part-time professor at the University of Queensland Medical School, debunking the general conclusion that antioxidants ameliorate the ageing process.

Professor Tony Linnane passed away in November 2017, aged 87.

MIKE MILLER WINS LIFETIME ACHIEVEMENT MEDAL FOR ICT

In his long and successful career, the University of South Australia's Emeritus Professor Mike Miller AO FTSE has helped pioneer telecommunications in Australia. Last year the scholar and researcher was awarded the Pearcey Medal, which recognises an individual's distinguished lifetime achievement and contribution to the development and growth of the ICT industry in Australia.

"It's been a privilege to have had a really interesting career – highlighted by interacting with dozens of outstanding doctoral students in ITR (the Institute for Telecommunications Research) at UniSA – and supported by so many telecom business organisations in Australia and overseas," he says.

His influence on Australia's telecommunications industry has taken three notable forms: in start-up board-of-director positions, where his technical knowledge and enthusiasm has helped a fledgling company; encouraging students to form start-up companies; and in advisory board positions, facilitating technology transfer from the university to industry.

"Telecommunications and associated information technology is arguably the key driver of productivity growth and innovation in the 21st century," Professor Miller says.

"It is an exciting field in which to practice, given its significant impact on the welfare of our society and because the telecommunications environment is so dynamic and complex."

Professor Miller, a former Vice President of ATSE and SA Division Chair, is currently co-chair of ATSE's new Digital Futures Working Group.

ATSE PEOPLE

GRAEME YOUNG WINS AUSTRALIAN MUSEUM EUREKA PRIZE

Professor Graeme Young AM FTSE FAHMS, a Flinders University Professor of Global Gastrointestinal Health, can add two new notches to his belt.

He was recently elected as a Fellow of the Australian Academy of Health and Medical Sciences (AAHMS) and was awarded the 2017 Australian Museum Eureka Prize for Innovation in Medical Research.

The Eureka Prize was awarded in recognition of his work with CSIRO and Clinical Genomics colleagues on a novel circulating tumour DNA blood test for colorectal cancer patients.

Professor Young says the award is important because it recognises the team from three different groups, each bringing the crucial skills needed to overcome the challenge of creating a blood test for colorectal cancer.

"It recognises the step that is the hardest to take successfully, namely translation of a good idea into practice," he says.

The Australian Museum Eureka Prize for Medical Research is a $10,000 award for an individual or team contributing to a healthcare solution.

Applicants are judged based on four different criteria: scientific rigour, the potential for commercialisation, potential impacts and benefits, and how innovative the research is.

Professor Young laughs and says the award means he can't retire yet. "I now have time to think through things properly and we seem to make even better progress than at any time in the more than four decades since I graduated."

IN MEMORIAM

Stuart Wenham remembered as a pioneer of energy research

Professor Stuart Wenham's ability to harness the sun's energy was unrivalled, and his pioneering work in solar engineering led him to play an important role in transitioning Australia and the world to renewable energy.

Stuart Wenham

Inventing or co-inventing a suite of solar cell technologies, Professor Wenham's career was highly influential in both research and industry. His last role was as the director of the Centre of Excellence for Advanced Photovoltaics and Photonics at the University of NSW.

"I am fortunate enough to have seen Stuart in all aspects of his life – work, family, church, sport and friends. He had the same positivity, enthusiasm, passion and care for everyone and everything in his life," said his daughter, Dr Alison Ciesla, a postdoctoral fellow at UNSW's School of Photovoltaic and Renewable Energy Engineering.

"It is some consolation knowing that he will live on through his many solar projects and the engineers he taught around the world, as well as the values and kindness he inspired in those around him," she added.

Professor Wenham invented advanced hydrogenation hydrogen passivation – a technology that uses lasers to control the charge of hydrogen atoms in the silicon wafers of solar panels. It boosted solar cell efficiency 100-fold and has been taken on by eight industry partners.

The UK Institution of Engineering and Technology heralded it as a "breakthrough for silicon voltaics" and the invention garnered him the 2013 A.F Harvey Engineering Prize.

Professor Wenham became an ATSE Fellow in 1999. That year he had also won the Australia Prize with Professor Martin Green, his former mentor, also from UNSW.

It was the second time the prize was awarded to an all-Australian team, indicating the pair's global dominance of photovoltaic research. And in 1992 the two won the CSIRO External Medal.

Born in Sydney in 1957, Professor Wenham had an early drive for excellence. He was dux of Kingsgrove High School, won the 1980 Chamber of Manufacturers' Award for first place in the final year of electrical engineering, and the 1980 Thesis Prize for the best undergraduate thesis in his Electrical Engineering degree.

Professor Wenham invented advanced hydrogenation hydrogen passivation – a technology that uses lasers to control the charge of hydrogen atoms in the silicon wafers of solar panels.

He began his engineering career by establishing Australia's first commercial solar cell production in 1981.

In December 2017, Professor Wenham's team at UNSW won a $7.83 million grant from the Australian Renewable Energy Agency to further advance solar cell technology.

Professor Wenham passed away peacefully, aged 60, on 23 December 2017 with family and close friends by his side.

ATSE PEOPLE

Peter Corke IMAGE: SUPPLIED

Why Peter Corke is one of Australia's best teachers

Queensland University of Technology's Professor Peter Corke FTSE brings "infectious enthusiasm" for robotics to his classrooms, uplifting potentially dry, theoretical material.

In December, the robotics visionary won an Australian Government Award for University Teaching in the Physical Sciences and Related Studies category. Here he gives a snapshot of his classroom environment.

How do you feel about winning this award?
Stoked! I think I've always seen myself as a researcher and technologist who enjoys teaching. This changes my mental model to thinking of myself as a teacher.

How do you try to make your classes engaging?
I teach in traditional university classrooms but the bulk of my students are in online courses.

DIMITY DORNAN BRINGS SOUND TO DEAF CHILDREN

Dr Dimity Dornan AO FTSE has won the Queensland Senior Australian of the Year 2018 – an award that recognises her life-changing work in more than 50 years of speech pathology.

Dr Dornan has devoted her career to changing the lives of thousands of hearing impaired children and young adults through Hear and Say, an organisation she established 25 years ago.

With implantable bionic technologies, such as the cochlear implant, Dr Dornan helps hearing impaired children train their brains to listen and speak. Currently, more than 900 children use the services provided by Hear and Say. But the reach of her influence extends further than Australia. Dr Dornan has also established several national and global research collaborations, including Hear and Say WorldWide – an initiative that tackles deafness in children from developing countries.

Now, Dr Dornan is creating the Human Bionics Interface to combat as yet untreatable medical conditions. The Interface is a network of leaders, researchers, clinicians, businesses, start-ups and investors who are collaborating to boost the delivery of bionic solutions.

ATSE PEOPLE

"Classroom teaching is more a performance art, which gives you a real buzz when it goes well and the class is engaged."

There are a lot of mathematical concepts underpinning robotics and a lot of books and courses are quite dry and theoretical.

I try to bring the theory in only as required and illustrate it with examples, demonstrations, physical props and so on. These mathematical concepts need to be embedded in software to make a robot do a thing, so I emphasise the software embodiment, which for many students makes the abstract concepts tangible and patently useful.

I also ask students to be introspective about the way they do things. For example, how did you get to this room? What were your thought processes? What were you looking at? This gives powerful insight and helps us think about the sensors and algorithms we might need for a robot to replicate this skill.

At an unconscious level, I apparently have an infectious enthusiasm for robotics – it gets commented on a lot by the students. I can't control this but it seems to help.

Why do you like teaching?

Robotics is a pretty easy thing to teach because there's a huge fascination with the topic at all age levels. I've always enjoyed explaining things and seeing ideas and concepts transferred to another person.

My preferred way of explaining is through writing, because of its richness (not just words but also pictures, graphs and, of course, equations) and you have the time to think and refine the argument to help the idea get across.

Classroom teaching is more a performance art, which gives you a real buzz when it goes well and the class is engaged. You lose that with online teaching where the interaction is via chat forums.

Is there anything else you'd like to bring to your classrooms?

I'd really like to take e-books to the next level, to create a truly interactive e-book with rich media resources that comes with its own robot that you can control and program from inside the e-book!

To what extent do you think this award will impact your career?

I'm hoping it will give me the opportunity to spend more time and resources for creating online course material. Robotics is a big field and I've started in just one corner. However, to do it well requires a big team of learning designers, graphic designers, animators, videographers, web developers and so on and this is expensive.

MIN GU JOINS CHINESE ACADEMY

RMIT's Distinguished Professor Min Gu FTSE has recently been elected a Foreign Fellow of the Chinese Academy of Engineering (CAE).

Professor Gu is RMIT's Associate Deputy Vice-Chancellor for Research Innovation and Entrepreneurship.

He is a world-leading authority in the fields of nanophotonics, nanofabrication and biophotonics, with internationally renowned expertise in three-dimensional optical imaging theory. His research has led to significant impacts on societal challenges in renewable energy, information technology and big data storage.

He says the emerging discipline of biophotonics, combined with nanofabrication, allows scientists to develop new devices with accuracy at the nanoscale.

"These devices can be a platform to develop the new medical and health strategy for the community," he says.

As one of CAE's Foreign Fellows, Professor Gu joins an exclusive group of innovators around the world, and he says he has been excited since he got the news.

Foreign Fellows are elected from scholars and specialists with foreign citizenship who have made significant contributions to engineering and technology in China, and enjoy high academic standing.

For Professor Gu, who studied in China, the award not only recognises his contribution to science and engineering, but also recognises the quality of education and training he had in China, he says.

"The award gives me a new platform for promoting the collaboration between Australia and China including ATSE and CAE," he says.

Min Gu

CHERRELL HIRST RECEIVES HONORARY DOCTORATE

The University of the Sunshine Coast has awarded Dr Cherrell Hirst AO FTSE an honorary doctorate for her outstanding achievements as a health pioneer, business trailblazer, doctor and researcher. Dr Hirst is known for her distinguished clinical career in breast cancer diagnosis. She is also CEO and deputy chair of life sciences venture capital fund QIC BioVentures.

ATSE PEOPLE

Mary O'Kane wins engineering medal

NSW Chief Scientist and Engineer Professor Mary O'Kane AC FTSE has been awarded the most distinguished engineering prize in Australia – the Peter Nicol Russell (PNR) Medal Career Achievement Memorial Medal by Engineers Australia.

The award is given to an Honorary Fellow of Engineers Australia who has made a notable contribution to science or engineering in Australia. Awarded annually, Professor O'Kane is the second woman to win the PNR Medal since its inception in 1923.

She says the medal celebrates the importance of engineering leadership with national impact and feels incredibly honoured to have been awarded.

"To join this list of major contributors to Australia's wellbeing is very humbling," Professor O'Kane says.

A leading figure in Australian artificial intelligence, ICT and engineering more generally, her academic career spans more than three decades.

One of the biggest highlights of her career, she says, is "inventing the term 'early career researcher' – admittedly somewhat accidentally!

"Putting into practice the concept that we need to take particular measures to ensure researchers at the early phases of their careers flourish has really improved research productivity in Australia and in the many other countries that have adopted the concept," she says.

Mary O'Kane

GRAHAM CURRIE WINS TRANSPORT RESEARCH AWARD

New ATSE Fellow (2017) Professor Graham Currie FTSE, a world-renowned public transport research leader and policy adviser, recently won the John H Taplin Award for Best Paper at the 39th Australian Transport Research Forum.

Written with Dr Chris De Gruyter, their paper, 'Exploring the Sustainability of Public Transport in Australasia', delved into transport sustainability and built on previous research.

Professor Currie says he's delighted to have been awarded the John H Taplin Prize as the award builds both his team's local and international profile.

"We have won many international awards, which I think our clients in Australasia don't know much about," he says.

"All good research is a team effort and my team deserves the recognition for their outstanding work."

A pioneer in transport research, Professor Currie has published more papers in leading international research journals in this field than any other researcher in the world.

He is also the founder of World Transit Research – an online resource accessed by users in more than 170 countries that consolidates all research in this discipline.

His passion for public transport stems from the scale of challenges cities face in the future.

"Transport is a confounding problem at the interface between technology, engineering and people. We are focused on bringing all the disciplines together to find solutions for cities into the future," he says.

Graham Currie

ATSE PEOPLE

Data analytics tackling biggest problems

Data analytics let society tackle some of its biggest problems – in the environment, food security and dealing with a growing and ageing population – according to Dr Ian Oppermann FTSE, Chief Data Scientist for the NSW Government.

"The irresistible digitisation of our lives coupled with innovative application of analytics have led to astonishing changes in the way we understand the world, the services we create and how we connect," he told an ATSE meeting.

Talking to an audience of more than 100 at the ATSE NSW Division's third lunch in the series 'Big Data – Big Impacts', Dr Oppermann said a major surprise was the extent to which personal information was being collected in almost all aspects of our lives in the private and public sectors, and the enormous value of such data.

He noted that existing privacy provisions were ill-equipped to face the challenges posed by personal data collection and analysis.

The inability of human judgement to determine 'reasonable' likelihood of re-identification when faced with sets of large complex data limited the ability to appropriately apply existing privacy regulations, and demonstrated the need for a robust legal framework under privacy provisions to be built into law, he said.

Technology could potentially play a role in addressing this challenge, but agreeing and then communicating the acceptable degree of anonymisation, and how to achieve it in quantitative terms, would also greatly improve data sharing.

The clarification of existing legal frameworks needed to include quantified descriptions of acceptable levels of risk compatible with modern data analytics.

He noted that rapid advances were being made to address complex problems of out-of-home health care, where predictive analytics was helping organisations manage cases, allocate family support and forecast short and long-term needs – in particular identifying children most at risk, their re-entry into out-of-home care and ways to assist high-risk families.

The NSW Data Analytics Centre is a central point for coordinating data-sharing initiatives within the NSW Government and also coordinates activities to support a whole-of-government view of overcoming the challenges faced by individual cross-agency data-sharing projects.

"The irresistible digitisation of our lives coupled with innovative application of analytics have led to astonishing changes in the way we understand the world, the services we create and how we connect."

KAREN REYNOLDS BECOMES EA HONORARY FELLOW

Flinders University biomedical engineer Professor Karen Reynolds FTSE FAHMS has recently become an Honorary Fellow of Engineers Australia for her innovative contributions to research and to the Australian medical device industry.

Engineers Australia's Honorary Fellowships are prestigious awards given to eminent engineers who excel in their specific disciplines.

Professor Reynolds was celebrated for her passion, research, industry engagement and teaching, and for her work in creating life-changing solutions for people with poor health.

Regarded as one of South Australia's brightest scientific minds, Oxford-educated Professor Reynolds regularly features in the Top 100 Most Influential Engineers in Australia and was named South Australian Scientist of the Year in 2012.

She is Dean (Research) of the College of Science and Engineering, Director of Flinders' Medical Device Research Institute, Founder and Director of the Medical Device Partnering Program (MDPP) and an ATSE Director.

Karen Reynolds IMAGE VIA FLINDERS UNIVERSITY

ATSE PEOPLE

Kanga heads World Federation of Engineering Organizations

Chemical engineer Dr Marlene Kanga AM FTSE began her role as the new President of the World Federation of Engineering Organizations (WFEO) this month. She is the second woman and second Australian to do so in its 49-year history.

Previously Dr Kanga was the President of Engineers Australia. Now as the new President of WFEO, she represents approximately 75 million engineers from 90 nations.

"I decided to stand for election as President because I felt I could make a contribution that would make a difference to the organisation and the engineering profession," Dr Kanga says.

She has been listed among the Top 100 Women of Influence in Australia and the Top 100 Engineers in Australia, and was the 2014 Federation of Engineers in Asia and the Pacific Professional Engineer of the Year – the first woman to be so awarded.

Dr Kanga's passion for engineering stems from the discipline's broad, world-changing applications.

"I am passionate about engineering and communicating the huge contributions that engineers make to the economy and to society," she says.

"Engineers have made the modern world – from clean running water and sanitation, to all forms of transport, to the manufacture of medicines and the processing of foods."

As President of WFEO, Dr Kanga aims to progress the UN's Sustainable Development Goals through engineering, bringing together national and regional members of WFEO over the next two years.

"By coming together to progress the UN Sustainable Development Goals, we have the opportunity to create a better, sustainable world," she says.

"Engineers have made the modern world."

STEPHEN POWLES BECOMES A HIGHLY CITED SCIENTIST

The University of Western Australia's Professor Stephen Powles FAA FTSE has become a Web of Science Highly Cited Researchers (HiCi), meaning he is in the top one per cent most cited scientists globally across 21 category disciplines.

In Professor Powles' discipline, agricultural science, there are 156 Highly Cited Researchers in the world. Six of these are from Australia, and of these, Professor Powles is the only crop and weed scientist. He says it's very satisfying to have such quantifiable recognition by his peers.

"As I am in the twilight of my research career this award of HiCi is meaningful for our research team and co-authors and for my university more than it is for me personally," he says of the effect this achievement will have on his career.

Professor Powles is Director of the Australian Herbicide Resistance Initiative and an international authority on herbicide resistance in plants, from biochemistry to the farm. But the biggest achievement of his career to date, he says, is having a 'sixth sense' in being able to identify where to invest research efforts on important, real-world issues.

"And then marshalling resources and people to do good, relevant research aimed at solutions."

TWO ATSE FELLOWS WIN LIFELONG ACHIEVEMENT AWARDS

Two ATSE Fellows are among the 18 winners of the Australian Academy of Science's 2018 honorific awards, recognising outstanding contributions to science. Career honorifics for lifelong achievement were awarded to Professor Douglas MacFarlane and Professor Calum Drummond.

PROFESSOR DOUGLAS MACFARLANE FAA FTSE

Monash University Professor MacFarlane was awarded the 2018 David Craig Medal and Lecture. Throughout his academic career his research has focused on the discovery and development of novel liquid salt compounds – ionic liquids. Research into ionic liquids has boomed over the past 25 years, thanks to Professor MacFarlane and his team's discoveries, which helped establish the area as a major field in chemistry.

The purpose of the annual David Craig Medal and Lecture is to recognise contributions of a high order to any branch of chemistry by active researchers. The winner is then expected to give public lectures across Australia.

PROFESSOR CALUM DRUMMOND FTSE

The 2018 Ian Wark Medal and Lecture was awarded to RMIT University Professor Drummond for outstanding contributions to understanding molecular assembly, and particle–surface interactions in liquids.

Professor Drummond is renowned for his use of sophisticated high-throughput preparation and characterisation techniques at the nanoscale. This fast-tracks materials' creation to determine their structure and properties.

This $3000 biennial award recognises research contributing to Australia's prosperity by advancing scientific knowledge, its application, or both.

ATSE PEOPLE

Eric Reynolds awarded 2017 PM's Prize for Innovation

World oral health expert Professor Eric Reynolds FTSE has won the 2017 Prime Minister's Prize for Innovation.

As a young dental researcher, Eric discovered a protein in dairy milk that repairs and strengthens teeth.

Today, that protein, sold as Recaldent, is used by millions of people every day when they chew gum or visit the dentist.

Products using Recaldent have generated sales of more than $2 billion to date and it has been estimated they have saved more than $12 billion in dental treatment costs worldwide.

The Prime Minister's Prizes for Science are Australia's most prestigious and highly regarded awards for outstanding achievements in scientific research, research-based innovation and excellence in science teaching.

The $250,000 award was presented at a ceremony in the Great Hall at Parliament House in Canberra in October.

Since starting in the University of Melbourne's Department of Preventive and Community Dentistry in 1978, Professor Reynolds has conducted and supervised research published in more than 270 publications, won countless awards, given hundreds of lectures globally, secured 22 patents and attracted more than $100 million in research funding.

How do you feel about winning this award?
The award of the PM's Prize for Innovation was a wonderful honour and recognition of my work.

I have worked long and hard on the science behind the technologies that have now been commercialised in products used in over 50 countries worldwide. Clinical trials have shown that these products help reduce the substantial social and economic impact of oral diseases.

What might it mean for your career?
The media interest in this award has been considerable.

The International Association for Dental Research placed notification of the award of the PM's Prize in their global newsletter, which was emailed to all members. This has resulted in the receipt of many invitations to give presentations at international scientific meetings.

I hope this award will increase awareness of the substantial impact of oral diseases and how they can be prevented to improve the quality of life.

What is it about oral health that drives you?
The impact of oral diseases tends not to receive appropriate recognition. The global economic impact has been estimated at around $500 billion per year and oral diseases have been linked with an increased risk of cardiovascular diseases, certain cancers and chronic inflammatory diseases.

Furthermore, with an ageing population, the prevalence and severity of oral diseases is increasing, so they represent a substantial public health challenge.

With education and the proper use of modern consumer and professional oral care products, oral diseases are preventable. Australia is a world leader in the development of new and improved technologies to prevent oral diseases and the award of the PM's Prize is recognition of that leadership position.

"With an ageing population, the prevalence and severity of oral diseases is increasing, so they represent a substantial public health challenge."

Eric Reynolds IMAGE VIA UNIVERSITY OF MELBOURNE

ATSE PEOPLE

IN MEMORIAM

Pharmacist, rugby player, educator: Geoffrey Vaughan covered all bases

Spanning more than 50 years, Dr Geoffrey Vaughan's academic career was instrumental in ensuring pharmacy research and drug development in Australia was world class.

His visionary leadership and outstanding communications skills made him a driving force in Australian education, research, industry and government, as well as bridging these often insular sectors.

As Dean of the Victorian College of Pharmacy (VCP) from 1979 to 1986, Dr Vaughan led its conversion from a small teaching college into an internationally competitive drug research centre.

"Geoff was a leader – he had great foresight and vision. He was generous to those he worked with, and always saw opportunities that made tomorrow better," said Bill Charman, Dean of the Faculty of Pharmacy and Pharmaceutical Sciences.

"He had a big personality, and it was always enjoyable to be with him. The Faculty would not be what it is today without Geoff's contributions and leadership."

Following his tenure as Dean of VCP, Dr Vaughan became the Director of the Chisholm Institute of Technology, leading the institution when it merged with Monash University.

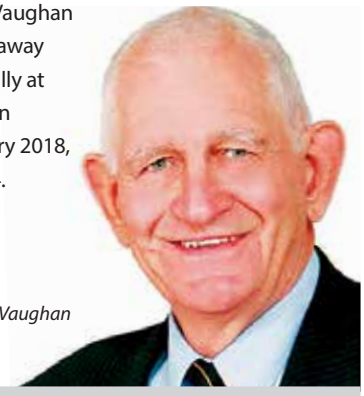
At Monash, he served as Deputy Vice-Chancellor (Research) until 1992, and then he was appointed to National Manager and CEO of the Australian Government's Therapeutic Goods Administration.

In 2006, Dr Vaughan became an Officer in the Order of Australia (AO), in the Queen's Birthday Honours List. The citation for his award reads: "For service to scientific research and development, particularly through contributions to the development of government policy initiatives, to the growth of innovative technology-based Australian companies, and to education as a mentor and supporter of young scientists."

But Dr Vaughan's passions stretched further than pharmacy and academia. Before his long career in pharmacy, Dr Vaughan was a rugby union prop forward, representing Australia. He was selected for the 1957-58 Australia Wallabies tour of Britain, Ireland, France, the US and Canada. He was also vice-captain for the three Wallaby Tests against the New Zealand Maori.

While his professional rugby career came to an end when Dr Vaughan decided to pursue his PhD, he remained involved with the sport for many years. He has served as a Board Member of the Victorian Rugby Union, played for The University of Melbourne at the London 'Golden Oldies' in 1985, and in 1997–2003 he was Director of the Victorian Rugby Union.

Dr Vaughan passed away peacefully at home on 4 January 2018, aged 84.



Geoffrey Vaughan

IN MEMORIAM

Geoffrey Taylor was a geologist and a children's author

The field of coal petrology in research and industry has Dr Geoffrey H Taylor to thank for his pioneering work, spanning more than 50 years.

Born in 1924, Professor Taylor's academic career began in 1950 after a four-year stint as a Sub Lieutenant in the Royal Australian Naval Reserve (1942–46). He was an assistant geologist for the Geological Survey of South Australia for three years before he began his long and accomplished tenure with CSIRO.

From 1955 to 1986 Dr Taylor worked in a variety of roles at CSIRO, from research scientist then up the ranks to a member of the CSIRO Executive (1982–86). Between 1980 and 1982 he was the Director of the Centre for Resource and Environmental Studies at the Australian National University.

Dr Taylor became a Fellow of ATSE in 1979, when he was the Officer in Charge of the CSIRO Fuel Geosciences Unit. By then Dr Taylor was already respected internationally for his work in coal petrology and its industrial applications. His discovery and study of mesophase formation during coal carbonisation, for instance, had a profound and lasting impact on developing techniques in manufacturing coals and in the conversion of coals to liquid fuels. But his enthusiasm for geology reached further than research and industry. Dr Taylor was the author of an illustrated children's book, *Ores and Minerals*, published in 1964.

Geoffrey Taylor

His many accolades include receiving the Geroge Skakel Memorial Award from the The American Carbon Society in 1995. In 1997 he was awarded the ICCP Reinhardt Thiessen Medal and then in 2001 he won The Society for Organic Petrology's John Castano Honorary Membership Award.

The Society for Organic Petrology said Dr Taylor "was a passionate advocate for our science, and among his many fine personal attributes he will be remembered by his contemporaries for his low-key style of verbal presentation and the clear and effective promotion of his viewpoints".

Dr Taylor passed away on 30 July 2018, he was 86 years old.