CRCA KNOW HOW

CRCA.ASN.AU • MARCH 2016 • ISSUE 6

SCIENCEMEETSBUSINESS.COM.AU

TOP 25 SCIENCE MEETS BUSINESS

R&D SPIN-OFF COMPANIES

FROM THE BEST IN BIOTECH TO THE SMART MANUFACTURERS

The definitive ranking of Australia's science success stories

THE BUSINESS OF INNOVATION 2016 CONFERENCE PROGRAM

Bridging the innovation gap

Fiona M Wood, FRACS AM

The innovation pathway is driven by finding new solutions to the problems we encounter every day.

We encounter innovation at every turn in our daily lives. The capacity to live as we do today is through the evolution of yesterday's ideas. But is this as good as it gets? Clearly the answer is 'No!' – we continually learn from today to ensure tomorrow is better.

We innovate by identifying a problem and seeking answers. The chain of activities from question to answer is long and complex: discovering a problem, chasing down a solution (supported by a rigorous research framework), dealing with regulatory safety hurdles, scaling the solution from the lab to the marketplace, and delivering it in a practical and cost-effective way – a process that requires tenacity above all else.

Australia enjoys a level of excellence in a number of areas of research, and it is time to connect these areas and realise their potential on the world stage. This edition of *KnowHow* celebrates 25 companies who are clear examples of the ability to push through research excellence to true innovation. They provide us with great insight and encourage those treading their own path.

There are plenty of hurdles on the path to commercialisation; however, those who have succeeded in creating innovative, commercially successful outcomes provide us with the encouraging examples we need to keep going.

Linking problems with solutions is a skill we need to teach at every opportunity. Science, technology, engineering and mathematics (STEM) are pivotal to the success of our economy, but their potential lies in their utilisation: in problem solving, and in developing the skills to collaborate and progress along the innovation chain.

The stories presented here are a catalyst, proving that innovation can thrive in Australia.

Professor Fiona M Wood, FRACS AM, is the inventor of spray-on skin, and Director of the Burns Service of WA and Burn Injury Research Unit at the University of Western Australia.

FEATURES

COMMENTARY

NEWS

THE BUSINESS OF INNOVATION 2016
Brisbane, Australia, 7-9 March

CAREERS

SPOTLIGHT

Here's to a good idea

Tony Peacock

Firing up Australia's start-up sector by getting start-ups into high-growth mode earlier is a key national priority for innovation.

Stories of 'unicorn' Initial Public Offerings and billionaires in their 30s are great. But it's the creation of quality jobs that truly makes innovation a national priority.

A recent report from the Office of the Chief Economist showed Australia added about one million jobs from 2006–11. Start-up companies added 1.4 million jobs, whereas older companies shed 400,000 jobs over the same period. But it's not any start-up that matters; only 3.2% of start-ups take off in a dramatic fashion, providing nearly 80% of those new jobs. While Australia has a relatively high rate of companies starting up, the key seems to be getting more of them into high-growth mode.

When Israel faced a massive influx of immigrants after the collapse of the Soviet Union in 1990, it turned to innovation as a means of providing jobs. Given the country's lack of natural resources, they didn't have a choice. A population of four million people taking in one million more meant Israel had to become an innovative economy.

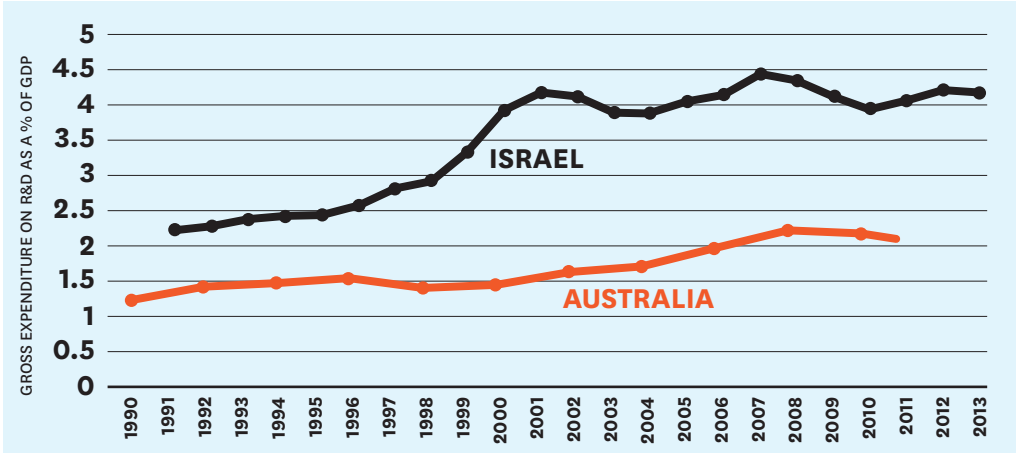
They grew their investment in research and development dramatically – to the point where Israel is now one of only two countries consistently spending more than 4% of GDP on R&D.

Israel has translated that spending into high-tech export success. Now, multinational technology company Intel employs over 10,000 Israelis. The Israeli Government is hands-on in its approach to de-risking early stage companies. But this is not achieved through government spending alone. In fact, the Israeli Government's share of total R&D spending is just one-third of that of Australia, and its higher education sector is just one half. Business carries the lion's share of R&D spending in Israel, making up 80% of the total, compared with 60% in Australia.

If we want jobs, we need innovation. We are in a unique period when there seems to be complete political agreement on this point. If we want innovation, we should take lessons from wherever we can learn them to develop the Australian system. A lesson from Israel is to use government spending more effectively at the early stages of company development to shift more start-ups into high-growth mode. If we could double the current 3.2% of today's start-ups that become high-growth companies, we could provide more rewarding jobs for Australia's future.

Israel concentrates almost 100% of its government innovation support for business on small and medium-sized enterprises. The comparable figure for Australia is 50% – a big hint for what we could do differently to fire up our start-up sector.

SPEND ON INNOVATION AS A PERCENTAGE OF GDP



Tony Peacock is CEO of the Cooperative Research Centres Association and founder of *KnowHow*.

DNA testing to protect grapevines

Improved management of a significant threat to grapevines through rapid DNA analysis is ensuring early detection and surveillance, **Laura Boness** reports.

Phylloxera is an aphid-like insect that is a pest of commercial grapevines worldwide. The Plant Biosecurity Cooperative Research Centre (PBCRC) is funding a project led by Vinehealth Australia to conduct field trials for a new, accurate, sensitive and cost-effective DNA-based test for detecting the pest.

CEO of Vinehealth Australia, Alan Nankivell, who is leading the project, says phylloxera had a significant economic impact on the wine industry, as "the quality of our wines is based on the quality of our vines". Eighty per cent of Australia's vineyards have vines that are own-rooted, rather than grafted onto resistant rootstock; some are very old and the wines produced from these are highly sought after.

Phylloxera (*Daktulosphaira vitifoliae*) feeds on grapevine roots and leaves them open to bacterial infection, which can result in rot and necrotic death due to cell injury. It destroyed substantial areas of vines in France in the mid-19th century and has affected several winegrowing areas of Australia; the only effective treatment is removing infested vines and replanting with resistant rootstock.

Financially, the cost of managing a vineyard with phylloxera is estimated to range from 10–20% in additional operating costs.

The current method of detection uses a shovel and magnifying glass to inspect sites in areas of low vigour; however, phylloxera may have been present for some time and the test is usually conducted in summer, one of the industry's busiest seasons.

The new DNA-based test requires 10-cm soil core samples to be taken 5cm from the vine's trunk. The samples are then sealed and sent to a lab where they are dried and tested for the presence of phylloxera DNA.

Nankivell says the incidence of finding phylloxera using the test was very high (around 98%), even when the amounts of phylloxera present were low.

"At the moment, we're able to find phylloxera at sites any time of the year."

The new DNA-based test could help prevent the spread of phylloxera in Australia, as those who have it on their property can determine where it is and whether it is spreading.

Sampling in vineyards across Australia over time will establish a baseline for the maintenance of area freedom. Nankivell says with this baseline in place, the quarantine management and farm-gate hygiene of vineyards will improve industry knowledge about where phylloxera is and isn't.

PBCRC researchers are currently working to establish the most suitable grid pattern for taking the soil core samples.

They will also compare the DNA sample method with two other methods: the 'shovel method' and another using emergence traps to catch insects inside an inverted container placed on the soil, to determine performance against selected criteria.

This research strongly supports the wine industry's focus on identifying and managing biosecurity threats to ensure the ongoing health of grapevines. Healthy vines are the foundation for a prosperous Australian wine industry.

WWW.PBCRC.COM.AU
WWW.VINEHEALTH.COM.AU

Alan Nankivell, CEO of Vinehealth Australia, is leading research to develop a new test for phylloxera of grapevines. Photo: PBCRC.

Genetic data speeds autism diagnosis

Australia's first ever Biobank will speed up and improve autism diagnosis in children, **Laura Boness** reports.

The Autism CRC is building Australia's first Autism Biobank, with the aim of diagnosing autism earlier and more accurately using genetic markers. Identifying children at high risk of developing autism at 12 months of age was "a bit of a holy grail", says Telethon Kids Institute's head of autism research Professor Andrew Whitehouse, who will be leading the Biobank. Researchers think the period between 12–24 months of age is "a key moment" in brain development, he adds.

As with other neurodevelopmental disorders, a diagnosis of autism is based on certain behaviours, but these only begin to manifest at a diagnosable level between the ages of two and five. Whitehouse says while there are great opportunities for therapy at these ages, researchers believe an earlier diagnosis will make the therapy programs more effective. Some 12-month-old children already exhibit behaviours associated with the risk of developing autism, for example not responding to their name, but currently doctors can't conclusively diagnose autism at this early age.

"If we can start our therapies at 12 months, we firmly believe they'll be more effective and we can help more kids reach their full potential," says Whitehouse.

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The biology of autism varies greatly between individuals, and it appears a combination of environmental factors and genes are involved – up to 100 genes may play a role in its development. Studying large groups of people is the only way to get a full understanding of autism and potentially identify genes of importance.

To do this, the Biobank collects DNA samples from 1200 families with a history of autism – children with autism aged 2–17 years old, who are recruited through therapy service providers, and their parents – as well as samples from control families who do not have a history of autism.

The samples are then shipped to the ABB Wesley Medical Research Tissue Bank in Brisbane for the Biobank's creation. Here, they are analysed for genetic biomarkers using genome wide sequencing – determining DNA sequences at various points along the genome that are known to be important in human development. Whitehouse says they are also planning to conduct metabolomic and microbiomic analyses on urine and faeces.

"It's the biggest research effort into autism ever conducted in Australia," he says.

The goal is to use the results to develop a genetic test that can be conducted with 12-month-old children who are showing signs of autism. The samples will also be stored at the Biobank for future research.

The aim is to expand internationally, so that researchers can exchange data with teams around the globe who are doing similar work, thus increasing the sample size.

WWW.AUTISMCRC.COM.AU

The new carbon industry

The Paris 2015 agreement presented cities with a global challenge. "Buildings and cities contribute upwards of 40% of global carbon emissions," says Professor Deo Prasad, CEO of the Low Carbon Living CRC (CRCLCL).

Leveraging the knowledge of researchers from the CSIRO and five of Australia's top universities, as well as experts in the field, the CRCLCL is heading up efforts to deliver a low carbon built environment in Australia. Its ambitious aim is to cut residential and commercial carbon emissions by 10 megatonnes by 2020.

"The CRCLCL is at the forefront of driving technological and social innovation in the built environment to reduce carbon emissions," says Prasad.

Recognised as a world-leading research organisation by the United Nations Environment Programme, the CRCLCL collaborates with industry partners like AECOM and BlueScope, and universities and governments.

The showcase Tyree Energy Technologies Building, UNSW, Sydney. Photo credit: Robert Largent

"We're looking to bring emissions down, and in the process we want to ensure global competitiveness for Australian industry by helping to develop the next generation of products, technologies, advanced manufacturing and consulting services," says Prasad.

CRCLCL activities range from urban sustainable design and solar energy to software and community engagement.

"By working effectively with government, researchers and industry, we employ an 'end-user' driven approach to research that maximises uptake and utilisation," says Prasad.

LOWCARBONLIVINGCRC.COM.AU

Real-time irrigation monitoring

The biggest challenge farmers face is often underfoot – maintaining healthy soil. But there is no direct method for farmers to measure how effectively they are feeding their plants.

Farmers can measure general soil parameters like pH with handheld probes, but detailed measurements require sending soil samples to a commercial lab, which is costly and time-consuming.

The lack of feedback can lead to under- or over-fertilisation, the latter of which can result in ground and surface water contamination.

CRC CARE (Contamination Assessment and Remediation of the Environment) is addressing the issue through probeCARE, a real-time irrigation monitoring system.

"We can identify the specific elements, like sodium and potassium, that are in fertilisers," explains Dr Liang Wang, head researcher on the project.

Wang says unlike a lab soil test, probeCARE will only read 'free' nutrients – these are not tied up in the soil and are more readily absorbed by plants.

Improvements on current systems are thus threefold: measurements are cheaper, immediate and give more relevant data to farmers than a lab test.

The small, portable and wireless probes will send data over the mobile phone network from the field to a farmer's computer. The technology is currently in prototype while CRC CARE secures international patent rights.

CRCCARE.COM

Driving social change in Indigenous health

There is a great disparity in the health and wellbeing of Aboriginal and Torres Strait Islander people and non-Indigenous Australians. The Lowitja Institute is an Aboriginal and Torres Strait Islander organisation working to eliminate that disparity through high-impact quality research, knowledge exchange, and by supporting the next generation of Indigenous health researchers. Through its new strategic plan, the Institute will focus its commitment to being, now more than ever, "a courageous organisation that delivers tangible and immediate outcomes", says CEO Romlie Mokak.

Aboriginal and Torres Strait Islander leadership is critical for driving research that is culturally ethical, says Mokak. The Institute has established program committees of senior Indigenous researchers for its three research streams. "Leadership by Aboriginal and Torres Strait Islander people will ensure that health research addresses the right questions and produces the evidence needed for effective policies and programs," says Mokak.

Another key focus is making the research accessible to policymakers through knowledge exchange activities. "We are absolutely committed to not just doing the research but translating it for action, impact and benefit," Mokak says.

The Lowitja Institute is striving to influence the national health research agenda and bring about policy change, shifting the focus of political and public debate about Indigenous Australians. In March 2015, Lowitja launched the 'Recognise Health' initiative, where 133 non-government organisations across the Australian health system signed a statement in support of constitutional change to recognise Aboriginal and Torres Strait Islander peoples in the Australian Constitution.

Mokak says through such initiatives they hope to "shift the narrative, which is typically around deficit or pejorative notions of Indigenous Australians, to one about empowerment and strength".

WWW.LOWITJA.ORG.AU

Connecting graduates with businesses

Opportunities for early career researchers are growing as Australian companies collaborate with researchers to find commercial solutions to real-life problems, **Marisa Wikramanayake** reports.

Gaining industry experience and seeing how their research can have practical applications is important to early career researchers. Universities and industry are now working together to help provide graduates with the opportunity to work on commercial solutions for real-life problems.

Sally Bradford won the 2015 Showcasing Early Career Researchers competition, and is a PhD candidate in clinical psychology at the University of Canberra. She developed an electronic mental health assessment app allowing physicians to diagnose and support their patients' previously undisclosed issues.

"We want access to innovative research to make practical use of what researchers are discovering."

Bradford's research is part of a larger collaborative project with the Young and Well CRC.

Perth-based cancer immunotherapy research group Selvax Pty Ltd has entered a commercial partnership with Curtin University. They signed a two-year contract to develop anti-cancer immunotherapy treatments in November 2015, after CEO Tony Fitzgerald saw value in Curtin Senior Research Fellow Dr Delia Nelson's ten years of research into immunological agents.

"We want access to innovative research to make practical use of what researchers are discovering," says Fitzgerald.

These industry partnerships aren't new. "It's a well-trodden path in the USA," says Fitzgerald. "But it's not as common in Australia – we're great at innovating, but not great at commercialising our work."

Perth-based energy company Bombora Wave Power needed to know what sensors would work underwater with its unique wave energy converter (WEC), so they partnered with Edith Cowan University (ECU) through the university's Industry and PhD Research Engagement Program, which matches Western Australian PhD candidates with industry. ECU graduate Gary Allwood researched ways of using optical fibre sensors to measure load and stress on the WEC system's membrane.

"The partnership allowed me to do things that haven't been done before, like use optical fibres as sensors instead of electrical sensors," says Allwood, who will work with Bombora Wave Power to test the sensors.

There are other, similar Australian programs. CRCs offer a number of scholarships across 14 different fields of research, giving PhD students a chance to gain industry experience.

Monash University started its Graduate Research Interdisciplinary Programs (GRIPs) in early 2015, allowing PhD students to solve real-world problems through collaborative research.

The Chemicals and Plastics GRIP has 20 industry partners offering training and funding, including Dulux and 3M. One student is treating coffee grounds to create a fertiliser to improve the soil quality of agricultural land.

"This is an exciting and innovative model for postgraduate education that encourages interdisciplinary and industry-engaged practice," says Monash University's Vice-Provost for Graduate Education, Professor Zlatko Skrbis.

ADVANCE QUEENSLAND

Jobs now, jobs for the future

Queensland needs a successful innovation system to prepare us for the jobs of the future. Globally, innovation is based on strong connections and collaboration between research and industry to address business challenges, translate research into outcomes, and innovate for the future.

The Queensland Government is investing $180 million over four years to create the knowledge-based jobs of the future – this is Advance Queensland.

To help universities and researchers capitalise on these opportunities, we are:

- offering a range of fellowships and scholarships focused on Queensland Science and Research priorities
- incentivising collaboration with business to help research lead to real world outcomes and commercial opportunities
- encouraging women to return to their research careers after starting a family
- increasing diversity through Aboriginal and Torres Strait Islander fellowships and scholarships
- providing opportunities for researchers to get 'business savvy' experience that leads to jobs.

Advance Queensland is a comprehensive suite of programs that will position the state as an attractive investment destination with a strong innovation and entrepreneurial culture.

It will help Queensland attract and retain the best and brightest research minds, build Queensland's reputation and capacity to conduct innovative research and development, deliver new products and services for Queenslanders, and establish new industries that will create jobs.

For more information about our funding programs, visit our website **qld.gov.au/advanceqld**.

'The top priority for the Queensland Government is employment opportunities for Queenslanders now, as well as jobs for the future. Advance Queensland is an important step in delivering this goal.'

Annastacia Palaszczuk
Premier of Queensland

Queensland Government

TOP 25 SCIENCE MEETS BUSINESS

R&D SPIN-OFF COMPANIES

Meet the best in the business – Australian companies that have successfully moved their R&D from lab to marketplace.

FOR A COUNTRY THAT MAKES UP JUST 0.3% of the world's population, Australia packs a heavyweight punch in science – generating 3.9% of the world's research publications. However taking that research to market has proved a broader challenge.

Fostering the commercialisation of research success and encouraging collaboration between industry and researchers is at the forefront of the government's renewed focus on scientific innovation, with over $1.1 billion earmarked to kickstart the "ideas boom" as part of the National Innovation and Science Agenda.

"Collaboration is key to turning Australian ideas into viable and lucrative commercial products and services," says Christopher Pyne, Minister for Industry, Innovation and Science, adding that high-tech knowhow plus innovative R&D will drive jobs and wealth in the future.

"We must capitalise on the opportunities that are presenting themselves in the economic transition taking place in Australia by being agile, innovative and creative," Pyne says.

He notes a range of measures, including the $155 million Industry Growth Fund and the R&D Tax Incentive program, are supporting firms to innovate and drive investment into new high-growth industry sectors.

From industry-funded ventures to university spin-offs and rising star start-ups, these are the *Science Meets Business* Top 25 Australian research and development spin-off companies.

1 FIBROTECH THERAPEUTICS PTY LTD

TYPE: NOT LISTED
CEO: Darren Kelly

SOLD FOR:
US$557.5 million

INNOVATION RATIO*:
0.15

Fibrotech develops novel drug candidates to treat fibrosis (tissue scarring) associated with chronic conditions such as heart failure, kidney and pulmonary disease, and arthritis. The company spun out of research by Professor Darren Kelly at the University of Melbourne in 2006, and its principal asset is a molecule, FT011, which helps prevent kidney fibrosis associated with diabetes. In May 2014, in one of Australia's biggest biotech deals at the time, Fibrotech was acquired by Shire, a Dublin-based pharmaceutical company, for an initial payment of US$75 million. Further payments, based on a series of milestones, will bring the total value of the sale to US$557.5 million, and the deal was awarded Australia's best early stage venture capital deal in 2014. At the time of the sale, FT011 was in Phase 1b trials for the treatment of renal impairment in diabetics – a market worth US$4 billion annually.

*Innovation ratio = patents published/cited

2 SPINIFEX PHARMACEUTICALS PTY LTD

TYPE: LISTED
MARKET VALUE: $264 million
CEO/President: Dr Tom McCarthy

INNOVATION RATIO: 0.13
SOLD FOR: acquired by Novartis for US$200 million up-front payment plus milestone payments

Spinifex Pharmaceuticals was launched in 2005 to commercialise chronic pain treatments developed by Professor Maree Smith of The University of Queensland. Pharmaceuticals giant Novartis acquired the company in 2015 for a total of US$725 million, based on the promising results in Phase 1b and Phase 2 clinical trials. Spinifex's treatment targets nerve receptors on peripheral nerves rather than pain receptors in the brain, making it possible to treat the pain from causes such as shingles, chemotherapy, diabetes and osteoarthritis without central nervous system side-effects such as tiredness and dizziness.

BIG 3 – RESMED LTD

TYPE: LISTED
MARKET VALUE: $7.85 billion
CEO: Michael J Farrell

INNOVATION RATIO: 0.02
REVENUE: $1.68 billion

For more than 25 years, ResMed has been a pioneer in the treatment of sleep-disordered breathing, obstructive pulmonary disease and other chronic diseases. The company was founded in 1989 after Professor Colin Sullivan and University of Sydney colleagues developed nasal continuous positive airway pressure – the first successful, non-invasive treatment for obstructive sleep apnoea. Today, the company employs more than 4000 people in over 100 countries, delivering treatment to millions of people worldwide.

3 ADMEDUS LTD

TYPE: LISTED
MARKET VALUE: $61.88 million
COO: Julian Chick
INNOVATION RATIO: 0.02
REVENUE: $10.2 million

Admedus is a diversified healthcare company with interests in vaccines, regenerative medicine, and the sale and distribution of medical devices and consumables. Currently, the company is developing vaccines for herpes simplex virus and human papillomavirus based on Professor Ian Frazer's groundbreaking vaccine technology. In the regenerative medicine field, Admedus is the vendor of CardioCel®, an innovative single-ply bio-scaffold that can be used in the treatment of congenital heart deformities and complex heart defects.

4 BIODIEM LTD

TYPE: NOT LISTED
CEO/Executive Director: Julie Phillips
INNOVATION RATIO: 0.22
REVENUE: $203,809

BioDiem specialises in the development and commercialisation of vaccines and therapies to treat infectious diseases. The Live Attenuated Influenza Virus vaccine technology provides a platform for developing vaccines, including one for both seasonal and pandemic influenza. BioDiem's subsidiary, Opal Biosciences, is developing BDM-I, a compound that offers a possible avenue for the treatment of infectious diseases that resist all known drugs.

5 VAXXAS PTY LTD

TYPE: NOT LISTED
CEO/Director: David Hoey

Vaxxas is pioneering a needle-free vaccine delivery system, the Nanopatch, which delivers vaccines to the abundant immunological cells just under the skin's surface. Preclinical studies have shown that vaccines are effective with as little as one-hundredth of a conventional dose when delivered via a Nanopatch. In 2014, Vaxxas was selected by the World Economic Forum as a Technology Pioneer, based on the potential of Nanopatch to transform global health.

6 ACRUX DDS PTY LTD

TYPE: LISTED
MARKET VALUE: $122.39 million
CEO: Michael Kotsanis
INNOVATION RATIO: 0.01
REVENUE: $25.4 million

Biotech company Acrux was incorporated in 1998 after researchers at Monash University developed an effective new spray-on drug delivery technology that improved absorption through the skin and nails. In 2010, Acrux struck a US$335 million deal with global pharmaceutical company Eli Lilly for AxironTM, a treatment for testosterone deficiency in men. It was the largest single product licensing agreement in the history of Australian biotechnology.

7 PHARMAXIS LTD

TYPE: LISTED
MARKET VALUE: $72.9 million
CEO: Gary J Phillips
INNOVATION RATIO: 0.76
REVENUE: $59.25 million

Listed on the ASX in 2003, Pharmaxis has two products on the market: Bronchitol, a treatment for cystic fibrosis; and Aridol, a lung function test to diagnose and assess asthma.

In 2015, Pharmaxis sold the rights to a treatment for the liver condition nonalcoholic steatohepatitis, to Boehringer Ingelheim in a deal that could be worth US$750 million.

8 OPTHEA PTY LTD

TYPE: LISTED
MARKET VALUE: $42.80 million
CEO/MD: Dr Megan Baldwin
INNOVATION RATIO: 0.01
REVENUE: $939,008

With a focus on ophthalmology, Opthea's main product is OPT-302 – a treatment for wet age-related macular degeneration – which is currently in a Phase 1/2a clinical trial. Wet macular degeneration is the leading cause of blindness in the Western world. Opthea was formerly known as Circadian Technologies, acting as a biotechnology investment fund before transitioning to developing drugs in 2008.

9 BENITEC BIOPHARMA LTD

TYPE: LISTED
MARKET VALUE: $63.01 million
CEO: Greg West
INNOVATION RATIO: 0.14
REVENUE: $1.37 million

Benitec Biopharma's leading product is DNA-directed RNA interference (ddRNAi) – a platform for silencing unwanted genes as a treatment for a wide range of genetic conditions. ddRNAi has broad applications, and can assist with conditions as diverse as neurological, infectious and autoimmune diseases, as well as cancers. The company's current focus inludes hepatitis B and C, wet age-related macular degeneration and lung cancer.

10 CATAPULT GROUP INTERNATIONAL LTD

TYPE: LISTED
MARKET VALUE: ~$256 million
CEO: Shaun Holthouse
REVENUE: $11.8 million

Catapult makes athletic performance monitoring systems using global and local positioning technologies for more than 750 elite teams, universities and institutions worldwide. The technology was commercialised in 2006 and its IPO in December 2014 raised more than $12 million from investors – including from US billionaire Mark Cuban.

11 SMARTCAP TECHNOLOGIES PTY LTD

Using a wearable electroencephalograph (EEG), SmartCap monitors driver fatigue by measuring changes in brain activity without significant discomfort or inconvenience. It notifies users when they are fatigued and what time of day they're most at risk. SmartCap was formally EdanSafe, a CRCMining spin-off company.

TYPE: NOT LISTED **CEO:** Dush Wimal **INNOVATION RATIO:** 0.03

12 ECOULT PTY LTD

TYPE: NOT LISTED
CEO: John Wood

Founded by the CSIRO in 2007 to commercialise the UltraBattery, Ecoult was acquired by the East Penn Manufacturing Company in 2010. The UltraBattery makes it possible to smooth out the peaks and troughs in renewable power, functioning efficiently in a state of partial charge for extended periods.

13 QUICKSTEP HOLDINGS LTD

MARKET VALUE: $87.09 million
CEO/MD: David Marino
INNOVATION RATIO: 0.04
REVENUE: $39.51 million

Composite materials company Quickstep was founded in 2001 to commercialise their patented manufacturing process. Working with the aerospace, automotive and defence industries, Quickstep supplies advanced carbon fibre composite panels for high technology vehicles. In 2015, the company increased its manufacturing capacity, establishing an automotive production site in Victoria in addition to their aerospace production site in NSW.

14 ENGENEIC LTD

TYPE: NOT LISTED
JOINT CEOs/ DIRECTORS: Dr Jennifer MacDiarmid and Dr Himanshu Brahmbhatt
MARKET VALUE: $178 million
INNOVATION RATIO: 0.03

EnGeneIC's cancer treatment platform, the EnGeneIC Dream Vector (EDVTM), is a first-in-class cytoimmunotherapy. The EDV is a nanocell mechanism for delivering drugs and functional nucleic acids and can target tumours without coming into contact with normal cells, greatly reducing toxicity. Above all, the EDV therapeutic stimulates the adaptive immune response, thereby enhancing anti-tumour efficacy. More than 260 patents support the technology, developed entirely by EnGeneIC, giving the company control over its application.

BIG 3 – COCHLEAR LTD

TYPE: LISTED
MARKET VALUE: $4.8 billion
INNOVATION RATIO: 0.05
CEO/ PRESIDENT: Chris Smith
REVENUE: $925.6 million

Cochlear delivers hearing to over 400,000 people worldwide through products like the cochlear implant. Pioneered by the University of Melbourne's Professor Graeme Clark and developed with assistance from The HEARing CRC, the bionic devices were first successfully implanted by the Royal Victorian Eye and Ear Hospital for people with moderate to profound hearing loss. The global company now employs 2800 staff and assists people in 100 countries.

15 SNAP NETWORK SURVEILLANCE PTY LTD

TYPE: NOT LISTED
CEO: Simon Langsford
CTO/FOUNDER: Dr Henry Detmold

Snap's FMx is a unique approach to video surveillance that forms cameras into a network based on AI that learns relationships between what the cameras can see. It enables advanced real-time tracking and easier compilation of video evidence. Developed at the University of Adelaide's Australian Centre for Visual Technologies, the system is operational at customer sites in Australia, Europe and North America.

16 ORTHOCELL LTD

TYPE: LISTED
MARKET VALUE: $32.89 million
MD: Paul Anderson
INNOVATION RATIO: 0.81
REVENUE: $1.69 million

Orthocell develops innovative technologies for treating tendon, cartilage and soft tissue injuries. Its Ortho-ATI™ and Ortho-ACI™ therapies, for damaged tendons and cartilage, use the patient's cells to assist treatments. Its latest product, CelGro™, is a collagen scaffold for soft tissue and bone regeneration.

17 REDFLOW

TYPE: LISTED
MARKET VALUE: $111.3 million
CEO: Stuart Smith
INNOVATION RATIO: 0.16
REVENUE: $265,436

As the demand for effective energy storage grows, RedFlow's zinc-bromide flow batteries are gaining attention. RedFlow has outsourced its manufacturing to North America to keep up with demand, while the company's research and development continues in Brisbane.

18 MINIFAB PTY LTD

TYPE: NOT LISTED
CEO: Dr Erol Harvey
INNOVATION RATIO: 2

Since 2002, precision engineering company MiniFAB has completed more than 900 projects for customers across the globe. MiniFAB provides a complete design and manufacturing service, and has developed polymer microfluidic and microengineered devices for medical and diagnostic products, environmental monitoring, food packaging and aerospace.

BIG 3 – CSL LTD

TYPE: LISTED
MARKET VALUE: $44.93 billion
CEO/MD: Paul Perreault
INNOVATION RATIO: 0.05
REVENUE: US$5.6 million

CSL is Australia's largest biotechnology company, employing over 14,000 people across 30 countries. The company began in 1916, when the Commonwealth Serum Laboratories was founded in Melbourne. It was incorporated in 1991, and listed on the ASX in 1994. Since that time, CSL has acquired established plasma protein maker CSL Behring, and Novartis' influenza vaccine business, and has become a global leader in the research, manufacture and marketing of biotherapies.

19 RAYGEN RESOURCES PTY LTD

TYPE: NOT LISTED
CEO: Robert Cart
INNOVATION RATIO: 0.74

RayGen's power generation method involves an ultra high efficiency array of photovoltaic cells, which receive focused solar energy from heliostats (mirrors) that track the sun, resulting in high performance at low cost. In December 2014, RayGen and the University of New South Wales (UNSW) collaborated to produce the highest ever efficiency for the conversion of sunlight into electricity. The independently verified result of 40.4% efficiency for the advanced system is a game changer, now rivalling the performance of conventional fossil power generation.

20 CARNEGIE WAVE ENERGY LTD

TYPE: LISTED
MARKET VALUE: $88.38 million
MD: Dr Michael Ottaviano
INNOVATION RATIO: 0.21
REVENUE: $1.72 million

Carnegie Wave Energy's CETO technology converts ocean swell into zero-emission renewable power and desalinated freshwater. Ten years of research at test sites off the coast of Western Australia, along with over $100 million in local and foreign investment, has helped grow the company's global profile. A recent £2 million grant from the Scottish government boosted stock prices.

21 DYESOL LTD

TYPE: LISTED
MD: Richard Caldwell
MARKET VALUE: $110.13 million
INNOVATION RATIO: 0.12
REVENUE: $1.44 million

Dyesol Limited (ASX: DYE) is a renewable energy supplier and leader in Perovskite Solar Cell (PSC) technology – 3rd Generation photovoltaic technology. The company's vision is to create a viable low-cost source of electricity with the potential to disrupt the global energy supply chain and energy balance.

22 EVOGENIX LTD

TYPE: NOT LISTED
SOLD FOR: $207 million
INNOVATION RATIO: 0.11

EvoGenix began as a startup in 2001 to commercialise EvoGene™, a powerful method of improving proteins, developed by the CSIRO and the CRC for Diagnostics. It acquired US company Absalus Inc in 2005, then merged with Australian biotechnology company Peptech in 2007, to form Arana Therapeutics. In 2009, Cephalon Inc bought the company for $207 million.

23 MURADEL PTY LTD

TYPE: NOT LISTED
CEO/MD: David Lewis
REVENUE: $4.18 million

With a vision to create sustainable energy through renewable biofuels, Muradel is a joint venture between the University of Adelaide, Murdoch University and SQC Pty Ltd. Their $10.7 million Demonstration Plant converts algae and biosolids into green crude oil. Muradel has plans for upgrades to enable the sustainable production of up to 125,000 L of crude oil, and to construct a commercial plant capable of supplying over 50 megalitres of biocrude from renewable feedstocks.

24 iCETANA

TYPE: NOT LISTED
CEO: Gary Pennefather
INNOVATION RATIO: 0.05

iCetana's 'iMotionFocus' technology employs machine learning to determine what is the 'normal' activity viewed by each camera in a surveillance system and alerts operators when 'abnormal' events occur. This enables fewer operators to monitor more cameras with greater efficiency.

25 PHYLOGICA LTD

TYPE: LISTED
MARKET VALUE: $33.82 million
CEO: Dr Richard Hopkins
INNOVATION RATIO: 0.09

Phylogica is a drug discovery service, and the owner of Phylomer® Libraries, the largest and most structurally diverse suite of natural peptides. It has worked with some of the world's largest drug companies, including Pfizer and Roche, to uncover drug candidates.

The ***Top 25 Science Meets Business R&D spin-off companies*** was written by Refraction Media in consultation with universities, industry and funding bodies, and supported by data from Thomson Reuters. The research compiled by Refraction was judged by a panel comprising of: Dr Peter Riddles, biotechnology expert and director on many start-up enterprises; Dr Anna Lavelle, CEO and Executive Director of AusBiotech; and Tony Peacock, Chief Executive of the Cooperative Research Centres Association. The panel considered the following: total market value, annual turnover, patents awarded and cited, funding and investment, growth year-on-year, social value, overseas expansion and major partnerships.

Professor Darren Kelly

FOUNDER, CEO & DIRECTOR OF FIBROTECH THERAPEUTICS; OCCURX

R&D company Fibrotech Therapeutics has the goal of treating fibrosis, which results from persistent tissue damage and leads to organ failure in more than 45% of diseases. Fibrotech develops orally active anti-fibrotic inhibitors designed to treat underlying pathological fibrosis in kidney and heart failure.

Kelly co-founded Fibrotech with Associate Professor Spencer Williams from the Bio21 Institute, and Dr Henry Krum and Professor Richard Gilbert from the University of Melbourne.

Their goal was to take compounds through early safety studies in animals and humans, before selling on to a pharmaceutical company. They designed compounds off the structure of tranilast, an anti-fibrotic compound, reducing its toxicity and increasing its potential.

Fibrotech was sold to global specialty biopharmaceutical company Shire in 2014 for an upfront US$75 million and further milestone payments of US$482.5 million.

In May 2015, Kelly launched OccuRx to develop drugs to treat ophthalmic disorders associated with retinal fibrosis and inflammation, and aims to take them to Phase 2 clinical trials. "We licensed the technology to administer anti-fibrotics to people with eye disease and fibrosis."

Fibrotech Therapeutics tops the Top 25 *Science Meets Business* list of Australia's most successful R&D companies.

"Key drivers to any biotechnology startup are passion and tenacity, and the desire to make a difference," says Kelly.

Read more: sciencemeetsbusiness.com.au

THE BUSINESS OF INNOVATION 2016

Brisbane, Australia, 7-9 March

CONFERENCE PROGRAM

This year's Cooperative Research Centres Association conference explores the importance of business and industry working with science to create innovation, and how to foster these relationships. A highlight of the event will be the first ever Science-Business Match-up, offering a platform for forging new and cooperative relationships to drive innovation and create future success.

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PROGRAM

MONDAY 7 MARCH 2016

1400–2000	Registration, outside Boulevard Room
	BOULEVARD ROOM
1500–1600	Welcome to Country, **Songwoman Maroochy** of the Turrbal People **Dr Alan Finkel AO,** Chief Scientist of Australia **Mr Philip Marcus Clark AM,** Chair, Cooperative Research Centres Advisory Committee *Chaired by the Hon Tony Staley AO, Chair, CRC Association*
1600–1630	Tea and coffee break
1630–1800	**Showcasing Early Career Researchers,** sponsored by CSIRO, introduced by Ms Christine Emmanuel, CSIRO **Professor Ian Frazer AC,** University of Queensland, The Ralph Slatyer Address on Science and Society *Chaired by Dr Tony Peacock, CEO, CRC Association*
1800–2000	Welcome function – drinks and canapés

TUESDAY 8 MARCH 2016

	BREAKFAST SESSIONS (pre-registered only)	
	PLAZA LEVEL MERIVALE STREET, ROOM P3	**ARBOUR LEVEL, ROOM A1**
0700–0830	**Commercialising IP from a CRC: what works and what doesn't** *Rachel Sciascia and Rob McInnes, DibbsBarker*	**Amplifying impact: developing indicators of public value in public communication** *Professor Axel Bruns, QUT*
0800–0900	Registration, outside Boulevard Room	
	BOULEVARD B1/B2/B3	**BOULEVARD ROOM**
0900–1030	**Professor Anne Kelso AO,** CEO, National Health and Medical Research Council **Dr Len Sciacca,** Chief, Partnerships and Engagement, DSTG **Mr Peter Schutz,** Chair, Food Innovation Australia Ltd **Mr Daniel Sullivan,** CEO, METS Ignited Australia Ltd **Mr Ken Fitzpatrick,** Chair, Oil, Gas and Energy Resources Growth Centre	**Science-Business Match-up** 20-minute meeting timeslots from 0900–1600 *Researchers – meet the businesses that want you and your ideas* *Businesses – find out what R&D is out there and explore new possibilities* *Investors – meet researchers and entrepreneurs looking to do the amazing*
1030–1100	Morning tea	
	BOULEVARD B1	**BOULEVARD B2**	**BOULEVARD B3**
1100–1230	***Workshop*** **Australian Government assistance and how to get it** Mr Tim Williamson, AusIndustry	***Workshop*** **ANDS services: connecting research data for business and CRCs** Dr Ross Wilkinson, Australian National Data Service	***Workshop*** **CRC collaboration with business and industry: an open conversation** Dr Jeff Coutts and Mr Gordon Stone, QualDATA
1230–1330	Lunch		

	BOULEVARD B1	BOULEVARD B2	BOULEVARD B3	BOULEVARD ROOM
1330–1515	***Presentations*** **Start-ups**	***Presentations*** **Business research needs**	***Presentations*** **Innovation investors**	**Science-Business Match-up** *continued*
1515–1600	Afternoon tea			
			BOULEVARD B3	
1545–1630			CRCA Annual General Meeting	
	BOULEVARD ROOM			
1830–1930	Pre-dinner drinks and canapés			
1930–2230	**Excellence in Innovation Awards dinner**			

WEDNESDAY 9 MARCH 2016

	BREAKFAST SESSION (pre-registered only)		
	ARBOUR LEVEL, ROOM A2		
0700–0830	**Get it together: online tools for collaborative innovation development** *Brian Ruddle, Impact Innovation Group*		
0800–0900	Registration, outside Boulevard Auditorium		
	BOULEVARD AUDITORIUM		
0900–1030	***Keynote speakers*** **Dr Alison Mitchell,** Research Director, Vitae, UK **Dr Charles Wessner,** Global Innovation Policy, Georgetown University, USA **Ms Alison Page,** Designer, Director Ninti One and CRC for Remote Economic Participation Great Grange Challenge Draw, Capital Hill Consulting		
1030–1100	Morning tea		
	BOULEVARD B1	**BOULEVARD B2**	**BOULEVARD B3**
1100–1230	***Workshop*** **Measuring, monitoring and improving your partnership arrangements** Dr Nick Fisher, ValueMetrics Australia	***Workshop*** **Global innovation policies** Dr Charles Wessner, Georgetown University	***Workshop*** **Developing the next generation of researchers** Dr Alison Mitchell, Vitae
1230–1330	Lunch		
	BOULEVARD B1	**BOULEVARD B2**	**BOULEVARD B3**
1330–1500	***Workshop*** **Breaking down silos: how to use crowd-sourcing technology to accelerate your R&D objectives** Dr Ben McNeil, Thinkable	***Workshop*** **World's best practice research translation** Dr John Bell, Australian Council of Learned Academies (ACOLA) and Professor Dr Reinhart Poprawe, Fraunhofer Institute for Laser Technology, Germany *Chaired by Dr Geoff Garrett, Queensland Chief Scientist*	***Workshop*** **Thinking outside the square in the outback: innovation in remote Australia** Ms Alison Page, Ninti One and CRC REP, *Chaired by Mr Rod Reeve, Managing Director, Ninti One and CRC REP*
1530–1630	**Resilient Cities – ABC Big Ideas broadcast event; presented by Paul Barclay**		
1630	Conference close		

Showcasing Early Career Researchers

PROUDLY SPONSORED BY

CSIRO

Finalists 2016

The Showcasing Early Career Researchers competition celebrates good research that is well communicated. Entrants were asked to submit a 30-second video clearly and effectively conveying the aim of their research. Five finalists were then selected from 23 entrants to attend the 2016 CRC Association Annual Conference in Brisbane, The Business of Innovation 2016, 7–9 March, to give a five-minute presentation on their research. An audience vote at the conference will determine the winner.

Mary Abdelsayed
Dairy Futures CRC

Healthy data, healthy cows

With no national dairy cow health dataset, dairy farmers have been unable to reliably select for genetically healthier cows. I have quantified the data already being collected on farms to estimate disease incidence. This new national dataset is available to industry, and will allow geneticists at the Australian Dairy Herd Improvement Scheme to develop new breeding values for health issues.

Antony Crowther
Dairy Futures CRC

Endophyte viability test

Fungal endophytes confer benefits to their host, perennial ryegrass – the Australian dairy industry's most important feedbase. Farmers planting seed with low viability endophyte experience one year less persistence in their pasture. I have developed a metabolomics-based test that gives commercial ryegrass breeders a much quicker result at a much lower cost.

Amanda Mizzoni
Autism CRC

Autism brain development

Although behavioural therapies are proven to be highly effective for young children with autism, research has only examined how therapy changes behaviours. However, the success of therapy is largely attributed to the fact that children's brains are highly plastic. My research is the first to explore what new connections children with autism are making in the brain during therapy, and how this compares to brain activity of typically developing children.

Tenielle Porter
CRC for Mental Health

Preclinical Alzheimer's

There are currently no treatments approved for Alzheimer's disease, possibly due to clinical trials being targeted too late in the disease process. My project aims to develop a genetic test to identify people in the early stages of Alzheimer's disease. This test could decrease the cost of clinical trials, but more importantly, increase the chance of identifying a treatment that can be used by patients.

Roya Rudd
AutoCRC

Clever Optical Particles

Engineered nanoparticles (NPs) have become a significant class of new materials, with interesting optical properties that make them very attractive for commercial development. Tailoring the size of NPs opened up the amazing possibility of tuning the optical properties such as absorption and emission. The goal of this study is to engineer the size of the NPs to achieve new optical properties for automotive applications.

Science, business and fun meet in Brisbane

All eyes are on Brisbane this month as world-leading scientists and celebrities headline top-tier events, **Brett Szmajda** reports.

Taking place outside New York for the first time since its inception in 2008, the World Science Festival Brisbane will feature street demonstrations, multimedia programs, opportunities to meet with leading scientists, and performances that explore the nexus between science and the arts.

At the same time, some of Australia's top scientists will be meeting at the Cooperative Research Centres Association's (CRCA's) annual conference, The Business of Innovation 2016, to discuss the importance of a tight-knit integration between science and industry. Organisers of both events will share their knowledge and expertise as the global spotlight shines on Brisbane and emphasises Australia's potential as a global innovation hub. The program includes celebrities such as string physicist and author Professor Brian Greene, astrophysicist and Nobel Laureate Professor Brian Schmidt, and Radio National's Science Show host Robyn Williams.

"We envision the future for Brisbane as a centre for knowledge transfer and innovation."

"The Festival is not just for people with a PhD in science. We want everyone to be as enthusiastic about science as they are about the AFL Grand Final or MasterChef," says Professor Suzanne Miller, CEO and Director of Queensland Museum Network.

By promoting a general science curiosity and literacy, the conference organisers hope to provide an avenue for public engagement with science, technology, engineering and mathematics (STEM).

"A large proportion of the population would love to be engaged with science, but don't feel equipped," says Miller. "We want people to feel really comfortable participating in serious political and economic debate that, at its heart, is based in science."

"Brisbane is a a fantastic place to do serious business, but with a very personal and welcoming approach," says Rob Nelson, general manager, Brisbane Convention Bureau, at Brisbane Marketing.

"We envision the future for Brisbane as a centre for knowledge transfer and innovation."

The World Science Festival Brisbane will be staged in the city annually for at least the next six years, and gives science-orientated organisations the opportunity to align their conference with the festival in Brisbane and the chance to interact with the festival's program and presenters as well as the city's research and innovation institutions.

Brisbane's 2022 New World City Action Plan notes that in order to become a new world city – "a globally connected, prosperous city with an enviable, irresistible lifestyle quality" – Brisbane should aim to be among the world's top 100 cities for commercial investment, and rates the knowledge sector as one of Brisbane's sources of greatest growth.

With this in mind, about 500 of Australia's best scientists will be meeting alongside the Festival to discuss the intersection between science and business at The Business of Innovation conference.

"Innovation happens in hotspots around the world. In March 2016, Brisbane is going to be the focus of world interest in science and innovation. Business, governments and scientific institutions are building momentum to make Brisbane a world innovation hotspot," says CRCA chief executive Dr Tony Peacock.

Discover the wonder of science in Brisbane this March, and consider bringing your next event to Brisbane to coincide with future festivals.

WORLDSCIENCEFESTIVAL.COM.AU
CHOOSEBRISBANE.COM.AU/CONVENTIONS

Collaborate or crumble

Finding collaborators and creating an interdisciplinary culture in your organisation is key to successful research commercialisation, **Carrie Bengston** reports.

BOOKSHELVES IN OFFICES around Australia groan under the weight of unimplemented reports of research findings. Likewise, the world of technology is littered with software and gadgetry that has failed to gain adoption, for example 3D television and the Apple Newton. But it doesn't have to be this way.

Adoption of research is a critical success measure for CRCs. One CRC in particular, the CRC for Water Sensitive Cities, has succeeded in having its research adopted by governments, companies and even the UN. Its secret is fruitful collaborations spanning diverse academic disciplines to deliver usable results. These are the kind of collaborations CRCs are well placed to deliver, argues Professor Rebekah Brown, project leader and former Chief Research Officer of the CRC for Water Sensitive Cities and director of the Monash Sustainability Institute.

The best are not always adopted. To change that, says Brown, developers need to know how their research solutions will be received and how to adapt them so people actually want them.

"Physical scientists, for example, benefit from understanding the political, social and economic frameworks they're operating in, to position the science for real-world application," she says.

The big-picture questions around knowledge and power, disadvantage and information access, political decision-making, community needs and aspirations, policy contexts and how values are economised – these are the domains of the social sciences. When social science expertise is combined with that of the physical sciences, for example, the research solutions they produce can have a huge impact. In the case of the CRC for Water Sensitive Cities, such solutions have influenced policy, strategy and regulations for the management of urban stormwater run-off, for example. Brown and her colleagues have found it takes a special set of conditions to cultivate this kind of powerful collaborative research partnership.

The CRC for Water Sensitive Cities has seen considerable growth. It started in 2005 as a $4.5 million interdisciplinary research facility with 20 Monash University researchers and PhD students from civil engineering, ecology and sociology. The facility grew over seven years to become a $120 million CRC with more than 85 organisations, including 13 research institutes and other organisations such as state governments, water utilities, local councils, education companies and sustainability consultancies. It has more than 230 researchers and PhD students,

"Businesses don't think of science in terms of disciplines as scientists do."

Rebekah Brown

8 tips to successful collaboration

Cultivating interdisciplinary dialogue and forming productive partnerships takes time and effort, skill, support and patience. Brown and her colleagues suggest the following:

1 Forge a shared mission to provide a compelling account of the collaboration's overall goal and to maintain a sense of purpose for all the time and effort needed to make it work;

2 Ensure senior researchers are role models, contributing depth in their discipline and demonstrating the skills needed for constructive dialogue;

3 Create a leadership team composed of people from multiple disciplines;

4 Put incentives in place for interdisciplinary research such as special funding, promotion and recognition;

5 Encourage researchers to put their best ideas forward, even if unfinished, while being open to alternative perspectives;

6 Develop constructive dialogue skills by providing training and platforms for experts from diverse disciplines and industry partners to workshop an industry challenge and find solutions together;

7 Support colleagues as they move from being I-shaped to T-shaped researchers, prioritising depth early on and embracing breadth by building relationships with those from other fields;

8 Run special issues of single-discipline journals that focus on interdisciplinary research and create new interdisciplinary journals with T-shaped editors, peer-reviewers or boards.

Source: Brown, R.R, Deletic, A. and Wong, T.H.F (2015), *How to catalyse collaboration*, Nature, 525, pp. 315-317.

"Our innovation dilemma is a critical national challenge and we must do better."

and its work has been the basis for strategy, policy, planning and technology in Australia, Singapore, China and Israel.

In a 2015 *Nature* special issue (see p25), Brown and Monash University colleagues Ana Deletic and Tony Wong, project leader and CEO respectively of the CRC for Water Sensitive Cities, shared their 'secret sauce' on bridging the gap between the social and biophysical sciences, which allowed them to develop a partnership blueprint for implementing urban water research.

A recent Stanford University study found almost 75% of cross-functional teams within a single business fail. Magnify that with PhD research and careers deeply invested in niche areas and ask people to work with other niche areas across other organisations, and it all sounds impossible. Working against resistance to collaborate requires time and effort.

Yet as research partnerships blossom, so do business partnerships. "Businesses don't think of science in terms of disciplines as scientists do," says Brown. "Researchers need to be able to tackle complex problems from a range of perspectives."

Part of the solution lies in the 'shape' of the researchers: more collaborative interdisciplinary researchers are known as 'T-shaped' because they have the necessary depth of knowledge within their field (the vertical bar of the T), as well as the breadth (the horizontal bar) to look beyond it as useful collaborators – engaging with different ways of working.

Some scholars, says Brown, tend to view their own discipline as having the answer to every problem and see other disciplines as being less valuable. In some ways that's not surprising given the lack of exposure they may have had to other disciplines and the depth of expertise they have gained in their own.

"At the first meeting of an interdisciplinary team, they might try to take charge, for example talk but not listen to others or understand their contribution. But in subsequent meetings, they begin to see the value the other disciplines bring – which sometimes leaves them spellbound.

"It's very productive once people reach the next stage in a partnership where they develop the skills for interdisciplinary work and there's constructive dialogue and respect," says Brown.

In a recent article in The Australian, CSIRO chief executive and laser physicist Dr Larry Marshall describes Australians as great inventors but he emphasises that innovation is a team sport and we need to do better at collaboration. He points out that Australia has the lowest research collaboration rates in the OECD, and attributes this fact to two things – insufficient collaboration with business and scientists competing against each other.

"Overall, our innovation dilemma – fed by our lack of collaboration – is a critical national challenge, and we must do better," he says.

Brown agrees, saying sustainability challenges like those addressed by the CRC for Water Sensitive Cities are "grand and global challenges".

"They're the kind of 'wicked problem' that no single agency or discipline, on its own, could possibly hope to resolve."

The answer, it seems, is interdisciplinary.

WATERSENSITIVECITIES.ORG.AU
WWW.ACECRC.ORG.AU

Moving forward

Alison Mitchell

There's a wealth of great advice that CRCs can tap into. For example the Antarctic Climate & Ecosystems CRC approached statistical consultant Dr Nick Fisher at ValueMetrics Australia, an R&D consultancy specialising in performance management, to find the main drivers of the CRC's value as perceived by its research partners, so the CRC could learn what was working well and what needed to change.

Fisher says this kind of analysis can benefit CRCs at their formation, and can be used for monitoring and in the wind-up phase for final evaluation.

When it comes to creating world-class researchers who are T-shaped and prepped for research partnerships, Alison Mitchell, a director of Vitae, a UK-based international program dedicated to professional and career development for researchers, is an expert. She describes the Vitae Researcher Development Framework (RDF), which is a structured model with four domains covering the knowledge, behaviour and attributes of researchers, as a significant approach that's making a difference to research careers worldwide.

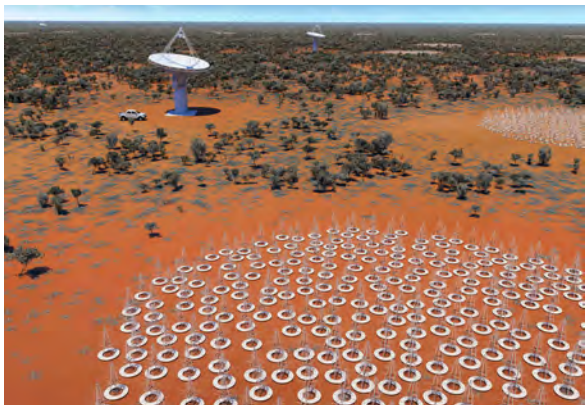
The RDF framework uses four 'lenses' – knowledge exchange, innovation, intrapreneurship [the act of behaving like an entrepreneur while working with a large organisation] and entrepreneurship – to focus on developing competencies that are part and parcel of a next generation research career. These include skills for working with academic research partners and industry.

Cloud collaboration

Cloud services – internet resources available on demand – have created a powerful computing environment, with big customers like the US Government and NASA driving developments in data and processing.

When building the infrastructure to support the Square Kilometre Array (SKA), soon to be the world's biggest radiotelescope, the International Centre for Radio Astronomy Research (ICRAR) benefitted from some heavyweight cloud computing experience.

ICRAR's executive director, Professor Peter Quinn, says the centre approached cloud computing services company Amazon Web Services (AWS) to assess



An artist's impression of the Square Kilometre Array's antennas in Australia. © SKA Organisation

whether it could process the data from the SKA.

When operational in 2024, the SKA will generate data rates in excess of the entire world's internet traffic.

ICRAR used an international consortium of astronomers to conduct a survey with the Janksy-VLA telescope, employing AWS to process the data, and they are now trying to determine how the services will work with a larger system.

Head of ICRAR's Data Intensive Astronomy team, Professor Andreas Wicenec, says there are many options from AWS. "Things are changing quickly – if you do something today, it might be different next week."

Quinn says cloud systems assist international collaboration by providing all researchers with access to the same data and software. They're also cost-effective, offering on-demand computing resources where researchers pay for what they use.

WWW.ICRAR.ORG

Fighting corrosion in the desert

Natural gas pipelines are a vital part of our infrastructure, bringing energy from distant fields to households and industry. Maintaining the integrity of pipelines is a crucial factor to keeping the gas flowing – a major concern of the Energy Pipelines CRC (EPCRC), which is tasked with enabling safer, more efficient and reliable pipelines to meet Australia's growing energy needs.

Deakin University PhD student Ying Huo had first-hand experience of the impact of the work of the EPCRC during a three-week industry placement last year, working with a team detecting corrosion in pipelines on just a small section of Australia's 35,000 km long gas pipeline network.

Corrosion can be caused by a number of factors related to the environment around the pipeline. The damage caused by corrosion can potentially affect the pipeline's integrity. Inspection technology uses ultrasound and magnetic measurements to find corrosion and determine its area and depth. Pipeline operators can then decide how best to deal with the corrosion.

"Every student should get the chance to get out in the field to see how industry works," says Huo.

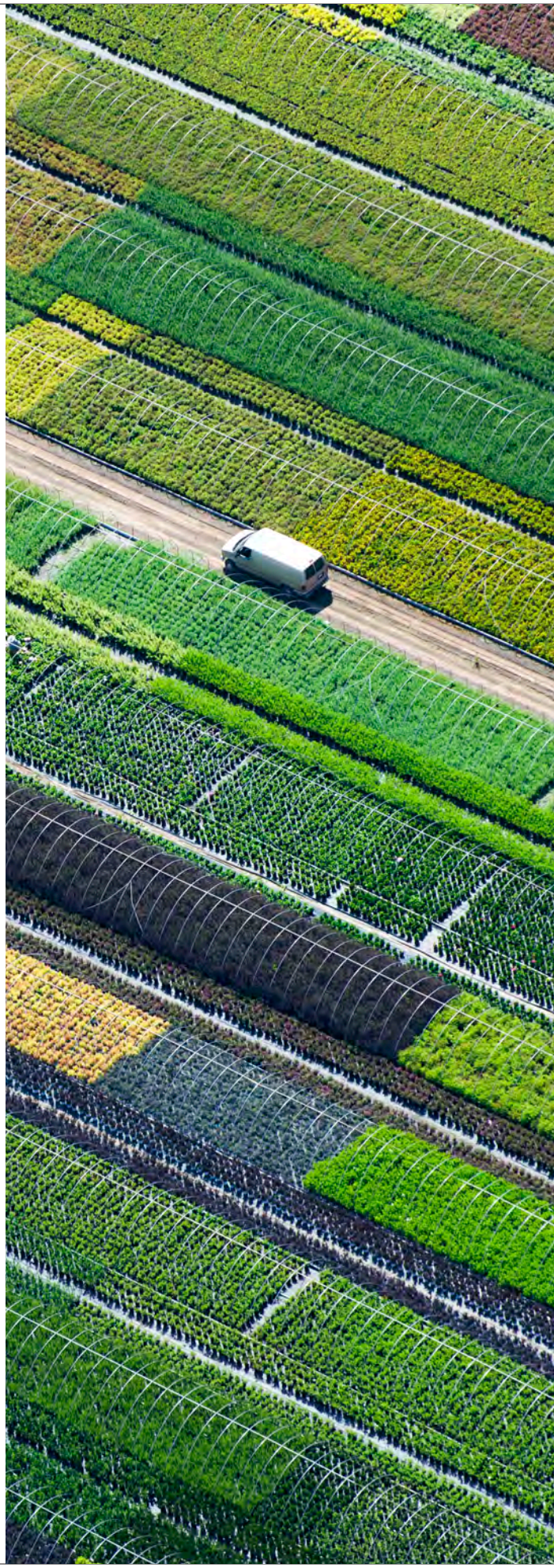
"I was able to observe firsthand how technology and asset management decisions are used to ensure the safe and continued operation of pipelines in Australia."

This opportunity would not have been possible without the strong collaboration between the Australian pipeline industry and the EPCRC.

WWW.EPCRC.COM.AU

Our daily bread

Climate change will have an impact on plant growth and the nutritional value of the food we produce, **Carl Williams** reports.



CLIMATE CHANGE IS AFFECTING THE EARTH, through more frequent and intense weather events, such as heatwaves and rising sea levels, and is predicted to do so for generations to come. Changes brought on by anthropogenic climate change, from activities such as the burning of fossil fuels and deforestation, are impacting natural ecosystems on land and at sea, and across all human settlements.

Increased atmospheric carbon dioxide (CO_2) levels – which have jumped by a third since the Industrial Revolution – will also have an effect on agriculture and the staple plant foods we consume and export, such as wheat.

Stressors on agribusiness, such as prolonged droughts and the spread of new pests and diseases, are exacerbated by climate change and need to be managed to ensure the long-term sustainability of Australia's food production.

Researchers at the Primary Industries Climate Challenges Centre (PICCC), a collaboration between the University of Melbourne and the Department of Economic Development, Jobs, Transport and Resources in Victoria, are investigating the effects of increased concentrations of CO_2 on grain yield and quality to reveal how a more carbon-enriched atmosphere will affect Australia's future food security.

Increasing concentrations of CO_2 in the atmosphere significantly increase water efficiency in plants and stimulate plant growth, a process known as the "fertilisation effect". This leads to more biomass and a higher crop yield; however, elevated carbon dioxide (eCO_2) could decrease the nutritional content of food.

"Understanding the mechanisms and responses of crops to eCO_2 allows us to focus crop breeding research on the best traits to take advantage of the eCO_2 effect," says Dr Glenn Fitzgerald, a senior research scientist at the Department of Economic Development, Jobs, Transport and Resources.

"We see an increase in crop growth on one hand, but a reduction in crop quality on the other."

According to Fitzgerald, the research being carried out by PICCC, referred to as Australian Grains Free Air CO_2 Enrichment (AGFACE), is also being done in a drier environment than anywhere previously studied.

"The experiments are what we refer to as 'fully replicated' – repeated four times and statistically verified for accuracy and precision," says Fitzgerald. "This allows us to compare our current growing conditions of 400 parts per million (ppm) CO_2 with eCO_2 conditions of 550 ppm – the atmospheric CO_2 concentration level anticipated for 2050."

The experiments involve injecting CO_2 into the atmosphere around plants via a series of horizontal rings that are raised as the crops grow, and the process is computer-controlled to maintain a CO_2 concentration level of 550 ppm.

"We're observing around a 25–30% increase in yields under eCO_2 conditions for wheat, field peas, canola and lentils in Australia," says Fitzgerald.

This increased yield is due to more efficient photosynthesis and because eCO_2 improves the plant's water-use efficiency.

With atmospheric CO_2 levels rising, less water will be required to produce the same amount of grain. Fitzgerald estimates about a 30% increase in water efficiency for crops grown under eCO_2 conditions.

But nutritional content suffers. "In terms of grain quality, we see a decrease in protein concentration in cereal grains," says Fitzgerald. The reduction is due to a decrease in the level of nitrogen (N_2) in the grain, which occurs because the plant is less efficient at drawing N_2 from the soil.

The same reduction in protein concentration is not observed in legumes, however, because of the action of rhizobia – soil bacteria in the roots of legumes that fix N_2 and provide an alternative mechanism for making N_2 available.

"We are seeing a 1–14% decrease in grain-protein concentration [for eCO_2 levels] and a decrease in bread quality," says Fitzgerald.

"This is due to the reduction in protein and because changes in the protein composition affect qualities such as elasticity and loaf volume. There is also a decrease of 5–10% in micronutrients such as iron and zinc."

This micronutrient deficiency, referred to as "hidden hunger", is a major health concern, particularly in developing countries, according to the International Food Research Policy Institute's *2014 Global Hunger Index: The challenge of hidden hunger*.

There could also be health implications for Australians. As the protein content of grains diminishes, carbohydrate levels increase, leading to food with higher caloric content and less nutritional value, potentially exacerbating the current obesity epidemic.

The corollary from the work being undertaken by Fitzgerald is that in a future CO_2-enriched world, there will be more food but it will be less nutritious. "We see an increase in crop growth on one hand, but a reduction in crop quality on the other," says Fitzgerald.

Fitzgerald says more research into nitrogen-uptake mechanisms in plants is required in order to develop crops that, when grown in eCO_2 environments, can capitalise on increased plant growth while maintaining N_2, and protein, levels.

For now, though, while an eCO_2 atmosphere may be good for plants, it might not be so good for us.

WWW.PICCC.ORG.AU
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Pests and disease

While higher CO_2 levels boost crop yields, there is also a link between eCO_2 and an increase in viruses that affect crop growth.

Scientists at the Department of Economic Development, Jobs, Transport and Resources have been researching the impact of elevated CO_2 levels on plant vector-borne diseases, and they have observed an increase of 30% in the severity of the Barley Yellow Dwarf Virus (BYDV).

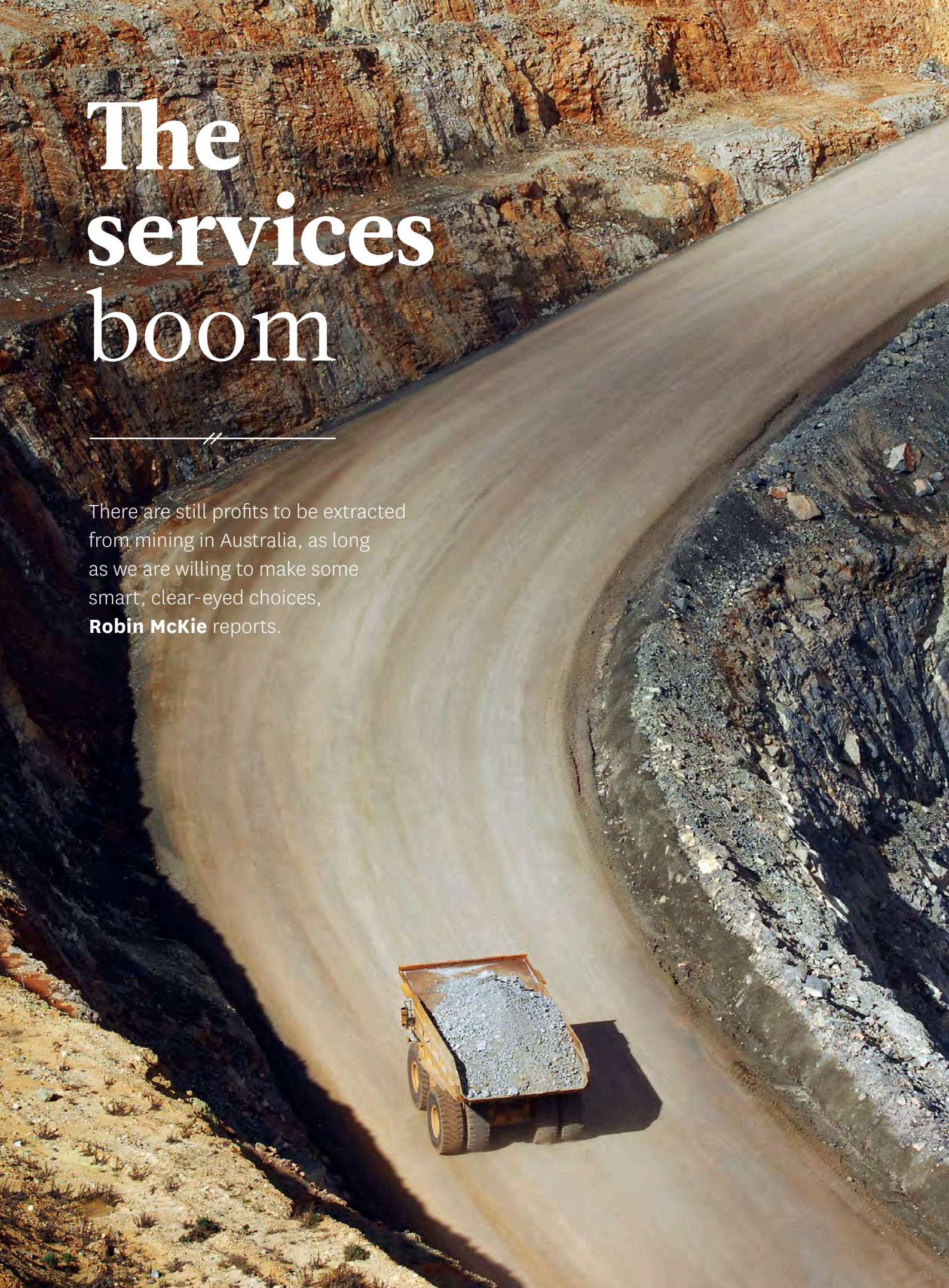
Spread by aphids, BYDV is a common plant virus that affects wheat, barley and oats, and causes yield losses of up to 50%.

"It's a really underexplored area," says Dr Jo Luck, director of research, education and training at the Plant Biosecurity Cooperative Research Centre. "We know quite a lot about the effects of drought and increasing temperatures on crops, but we don't know much about how the increase in temperature and eCO_2 will affect pests and diseases.

"There is a tension between higher yields from eCO_2 and the impacts on growth from pests and diseases. It's important we consider this in research when we're looking at food security."

The services boom

There are still profits to be extracted from mining in Australia, as long as we are willing to make some smart, clear-eyed choices, **Robin McKie** reports.



AUSTRALIA'S MINING INDUSTRY stands at a crossroads. This presents new opportunities for the industry, says one of the experts in the field: Dan Sullivan, CEO of METS Ignited, the new government-backed body charged with building the fortunes of one of the nation's most important revenue earners – the mining equipment, technology and services industry (METS).

"Mining has to improve its productivity. The industry's boom years are over," says Sullivan. "But we have to make a choice about how we are going to do that. Either we find new reserves of high-grade ore or we invest in innovations that will make existing mines more productive."

Sullivan says that if the first course of action is chosen, it will inevitably take the industry overseas. "In Australia, the easy-to-find resources have largely been discovered. If we want high-grade ores, we'll have to go deep underground or to other mineral rich countries in Asia like Laos." However, when mining companies go overseas they have to deal with issues of sovereignty and politics over which they have little control.

"The mining industry is on the cusp of a transformation, and where there is change there is opportunity."

The alternative is to become much more efficient at locating, extracting and processing ores in Australia – but to do that the industry must innovate. Hence the creation of METS Ignited, one of six Industry Growth Centres set up by the Australian Government to improve the nation's industrial competitiveness.

The six Growth Centres are dedicated to food and agri-business; medical technologies and pharmaceuticals; oil, gas and energy resources; advanced manufacturing; cybersecurity and METS.

These Growth Centres are charged with facilitating better links between scientists and researchers; to harmonise regulations that control industry; to make better use of human capital – the workforce and management of companies; and to get better access to global supply chains. "These centres are led by industry, but are government-funded," adds Sullivan, who served as Australia's Consul-General in Lima and who worked for the Australian Trade Commission in Chile where he led a team that worked on developing business opportunities for Australia.

Launched in October 2015, METS Ignited is preparing a 10-year strategic plan to promote Australian mining innovation and support stronger collaboration between companies and research organisations. The plan should also ensure that Australian mining technology companies – the firms that build the sensors, drill heads, pipes, trucks and other machines that make mining possible – hold a strong position in global supply chains.

"The mining industry is on the cusp of a transformation, and where there is change there is opportunity," says Sullivan.

During the early years of the 21st century, the Australian mining industry – fuelled by demands from China for our ore and minerals – went through an extraordinary boom.

It was "one of the largest shocks to the Australian economy in generations", says Peter Tulip, senior research manager at the Reserve Bank of Australia.

Average incomes across the country rose substantially, while the boom triggered a large appreciation of the Australian dollar.

More importantly, Australia's deposits of iron, gold and copper were aggressively mined.

The output of these mines has declined significantly since the boom, and operators now have to use 70% more energy because they have to dig deeper to access deposits.

Despite the extra effort, mine output has continued to decline. In 2000, goldmines produced 3 g of gold for each tonne of basic ore. By 2010, they produced under 2 g. "Productivity was already declining at the turn of the century," says Sullivan. "The boom just masked it."

Today Australia, which depends heavily on its mineral wealth, is expending more and more energy to dig up less and less iron, gold and other ores and minerals. Given the massive importance of mining to the Australian economy, this is cause for concern. The problem is that more than 80% of Australia's mineral production comes from mines that are more than 30 years old, says Professor Richard Hillis, CEO of the Deep Exploration Technologies CRC (DET CRC). "We haven't found new mines to develop – which is why we're mining our old ones so severely."

The situation is summed up by Elizabeth Lewis-Gray, Chair of METS Ignited: "The mining industry is facing challenges – deeper mines, lower grades, community opposition and more remote operations." At the same time, there has been a relentless drive to cut costs.

"These challenges require solutions," adds Lewis-Gray, who is also co-founder and chair of Gekko Systems, which specialises in designing and manufacturing mineral processing equipment.

"A mine that is operating in the middle of a remote desert has a lot to learn from a NASA program placing robot vehicles on Mars."

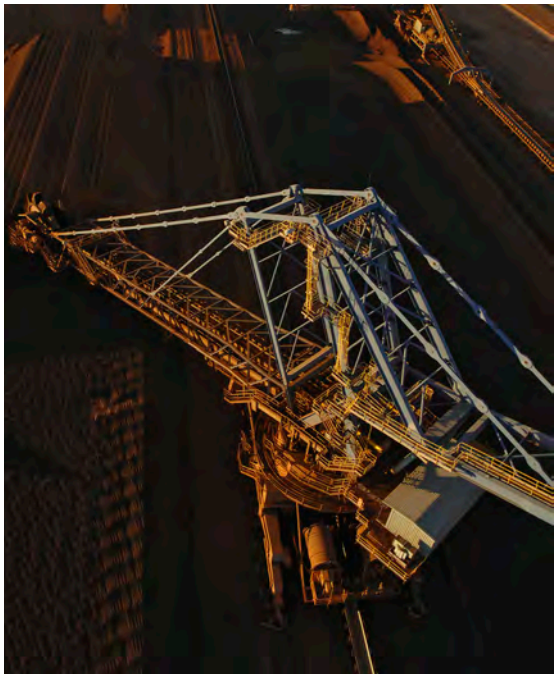
One approach is to focus on exports of Australian mining technology, says Lewis-Gray. At present, this market is worth about $15 billion. The aim of the METS Growth Centre is to double the exports so they reach about $30 billion by 2030. "This is one of the reasons for branding the centre with a new METS Ignited Australia," says Lewis-Gray.

What is needed, says Sullivan, are more sensors in mines, and more data, robotics and analysis of the total operation of finding, extracting, transporting and processing of minerals.

But this will require considerable investment. "The good news," says Sullivan, "is that much technology already exists in other industries. If you look at the manufacturing or aerospace industries, materials and activities are sensed and analysed to maximise activity. The mining industry is just beginning to implement this sort of technology."

Australia is ranked highly for its research in mining technology. Consider the example of the work of Hillis with DET CRC. It devised a system to simplify the lengthy process involved in cutting a rock core and sending it for analysis to an assay laboratory.

DET CRC's researchers developed sensors that lie behind the drill bit and can analyse, in real time, the material that is being dug up, and assess if it contains worthwhile amounts of gold or copper. "It means you can stop drilling immediately if you find a deposit is worthless, without having to wait months for the assay report," says Hillis. This is impressive, and gives an indication of the innovative quality of



Australian R&D in mining technology.

Less auspicious, however, is Australia's reputation for commercialisation. This a key factor to improve the industry focus and commercial rate of Australian mining innovation.

Sullivan points to the example of the Anglo-American mining corporation, which is holding open forums with NASA experts and advisers in advanced manufacturing and other industries to stimulate ideas. "A mine operating in a remote desert has a lot to learn from a NASA program placing robot vehicles on Mars," he says.

Many mining innovations have already made it, of course. Caterpillar trucks are fitted with sensors that can tell when a driver is fatigued. Other devices can monitor tyre pressure, and can tell when a bucket is unbalanced because it has a huge rock inside it.

But not enough care is taken to study the data to create patterns revealing routes to further innovations. "The data is not being pooled and so cannot be optimised," says Sullivan.

"It's not rocket science. It's really just a matter of getting the mining industry to aggregate the data it acquires so it can learn and go on to develop new products that will improve efficiency and cut costs."

METS Ignited's main challenge is finding a way to change the mining industry's perception of itself as 'a fast follower'; an industry that lets others experiment and take the risks before it then adopts the successful outcomes.

Such an approach means that, at its heart, the industry is reluctant to innovate. The function of METS Ignited is therefore going to involve helping the Australian mining sector make choices that will put it on the road to success.

"It's a challenge, but it is certainly an achievable one," says Sullivan.

DETCRC.COM.AU

Australia's biofuture

Australia is well positioned to take advantage of opportunities in the economic growth area of biocommodities, **Laura Boness** reports.

QUT is supporting the Queensland Government to develop a strategy, including the creation of a 10-year Biofutures Roadmap, for the establishment of an industrial biotechnology industry in Queensland.

Associate Professor Ian O'Hara, principal research scientist at QUT's Centre for Tropical Crops and Biocommodities (CTCB), says we are facing big challenges: the world needs to produce 70% more food and 50% more energy by 2050, while reducing carbon emissions.

At the same time, says O'Hara, there are opportunities to add value to existing agricultural products. "Waste products from agriculture, for example, can contribute to biofuel production."

QUT funded a study in 2014 examining the potential value of a tropical biorefinery in Queensland. It assessed seven biorefinery opportunities across northeast Queensland, including in the sorghum-growing areas around the Darling Downs and the sugarcane-growing areas around Mackay and Cairns.

O'Hara says they mainly focused on existing agricultural areas, taking the residues from these to create new high-value products.

> **"We need strong collaboration between research, industry and government to ensure that we're working together to create opportunities."**

But he sees more opportunity as infrastructure across north Queensland continues to develop.

The study found the establishment of a biorefinery industry in Queensland would increase gross state product by $1.8 million per year and contribute up to 6500 new jobs.

"It's an industry that contributes future jobs in regional Queensland – and by extension, opportunities for Australia," O'Hara says.

The biorefineries can produce a range of products in addition to biofuels. These include bio-based chemicals such as ethanol, butanol and succinic acid, and bio-plastics and bio-composites – materials made from renewable components like fibreboard.

O'Hara says policy settings are required to put Queensland and Australia on the investment map as good destinations. "We need strong collaboration between research, industry and government to ensure we're working together to create opportunities."

The CTCB has a number of international and Australian partners. The most recent of these is Japanese brewer Asahi Group Holdings, who CTCB are partnering with to develop a new fermentation technology that will allow greater volumes of sugar and ethanol to be produced from sugarcane.

"The biofuels industry is developing rapidly, and we need to ensure that Queensland and Australia have the opportunity to participate in this growing industry," says O'Hara.

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O'Hara at the Mackay Biocommodities Pilot Plant. He is pictured inside the plant with the giant vats used for fermentation.
Photo: QUT Marketing and Communication/Erika Fish

Taking a waste solution to market

ANSTO's Synroc team is a leader in the global nuclear community for nuclear waste immobilisation and treatment technology, **Laura Boness** reports.

Synroc technology is an innovative and versatile waste management solution developed by the Australian Nuclear Science and Technology Organisation (ANSTO).

ANSTO's Synroc technology locks up radioactive elements in 'synthetic rock' allowing waste, like naturally occurring minerals, to be kept safely in the environment for millions of years.

Synroc technology offers excellent chemical durability and minimises waste and disposal volumes, decreasing environmental risks and lowering emissions and secondary wastes.

ANSTO's Synroc team is developing a waste treatment processing plant using Synroc technology for Australia's molybdenum-99 (Mo-99) waste; Mo-99 is the parent nuclide for technetium-99m, the most widely used radioisotope in nuclear medicine. The plant will be the first of its kind, and will lead the world in managing nuclear wastes from Mo-99 production.

"Synroc is by far the best option to treat and appropriately dispose of nuclear wastes without leaving a burden to future generations."

Dr Daniel Gregg, leader of the Synroc waste form engineering team at ANSTO, says the plant will demonstrate Australia's commitment to providing technology solutions to the global nuclear community.

"We hope to partner with others and build several more plants around the world using Synroc technology," he says.

Gregg says several countries are looking to build new Mo-99 production facilities, and regulators want assurances that facilities will be able to treat the resulting waste streams.

"With national regulators around the world putting more and more pressure on waste producers to deal with nuclear wastes, opportunities exist for Synroc as a leading option for nuclear waste treatment." This places Synroc and Australia in an enviable position, adds Gregg.

"Synroc is a cost-effective, environmentally responsible option to treat and appropriately dispose of nuclear wastes without leaving a burden to future generations."

In developing the plant, the Synroc team has designed process engineering technology and a fully integrated pilot plant that can treat large volumes of waste under a continuous process mode.

The team is also collaborating with national laboratories around the world to demonstrate strategies to treat radioactive waste for commercial benefit.

The focus is on waste streams – such as the growing stockpiles of long-lived nuclear waste – that are problematic for existing treatment methods. The real advantage, says Gregg, is Synroc's ability to immobilise these problematic waste forms.

"Waste producers are required to immobilise nuclear wastes, and Synroc and Australia will be at the forefront of waste management technology."

WWW.ANSTO.GOV.AU/SYNROC

Synroc processing technology immobilises radioactive waste in a durable, solid rock-like material for long-term storage. Photo: ANSTO

Growing success

$1.16

AUSTRALIAN GROSS DOMESTIC PRODUCT IS CUMULATIVELY $1.16 HIGHER AS A RESULT OF EACH DOLLAR INVESTED IN THE CRC PROGRAM.

$7.5b

THE NET EFFECT OF THE CRC PROGRAM WAS TO GROW THE ECONOMY BY MORE THAN $7.5 BILLION BETWEEN 1991 AND 2017.

36,434

JOURNAL ARTICLES PUBLISHED FROM CRC RESEARCH BY MARCH 2015.

3600

PHD CANDIDATE GRADUATES OVER THE CRC PROGRAM'S LIFETIME.

THE STUDY ALSO IDENTIFIED A TOTAL OF

$14.45 billion

OF DIRECT ECONOMIC EFFECTS FROM THE PROGRAM

CRC OUTCOMES

Under the CRC program, the cumulative value of education outcomes achieved is $163 million.

There have been 12,684 patents held, in Australia and overseas, over the CRC program's lifetime.

The CRC program was the largest source of doctoral graduates outside of the Group of Eight universities.

On average, there have been 21.5 active PhD students in a CRC in any given year.

CRC achievements

The cochlear hybrid system, produced by the HEARing CRC, has restored hearing to more than 140,000 people.

Tooth mousse that helps repair dental enamel, developed by the CRC for Oral Health, is now sold in more than 50 countries.

The Capital Markets CRC developed technology to detect fraud, abuse and waste in Australia's private health insurance markets.

The Future Farm Industries CRC developed three new farming systems that will increase Australia's farm profits by $1.6 billion by 2030. The Future Farm Industries CRC's EverGraze Project assisted in the production of four million extra kilograms of lamb and 20 million extra kilograms of beef.

CRCMining developed the Oscillating Disc Cutter for cutting very hard rock with lightweight mining equipment; one of the gains is an up to 20% increase in productivity.

The Sheep CRC has helped improve the use of pregnancy scanning data and increase the uptake of testing, leading to an additional 500,000 lambs being born per year.

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Investing in small business

Charles Wessner

Commercialising quality research to compete effectively in the global economy requires innovative policy, and there are key lessons to take on from the USA, says **Charles Wessner**.

Innovation is recognised as a key to growing and maintaining a country's competitive position in the global economy. Australian scientists produce top-quality research and punch above their weight in terms of peer-reviewed publications; however, Australia is much less successful in creating innovative products and processes based on research investment. If we want more innovation, university and government policies need to change.

Part of this change requires learning from the successes of other nations. Successful policy changes include increased support for universities and research centres, growing funding for competitively awarded applied research, sustained support for small businesses, and a focus on partnerships among government, industry and universities in bringing research ideas to market.

The USA is the land of free-market capitalism, but it is also an active entrepreneurial state. A highly effective US government initiative, for example, is the Small Business Innovation Research (SBIR) program, which has been in existence for 25 years and was recently renewed by Congress.

> **"The Small Business Innovation Research program de-risks ideas to the point where private investors can step forward."**

Instrumental in this renewal was an assessment by the National Academy of Sciences, which found the SBIR program "sound in concept and effective in operation".

The program provides highly competitive, phased innovation awards to small businesses and start-ups to develop products that meet agency mission objectives or provide social value. The awards range from US$150,000 to more than US$1 million. The grants are often linked to the procurement process, for example in the case of military acquisition and support. In other fields, such as health and energy, grants provide a means to push good ideas to market.

SBIR has a strong track record. In recent years, it garnered 20–25% of the top 100 R&D awards for the US economy as a whole, and helped agencies like NASA address specific needs such as instruments for exploring Mars. SBIR doesn't replace venture capital, but rather augments it by de-risking ideas to the point where private investors can step forward. Reflecting its success in the USA, SBIR has been adopted by a number of other countries.

While SBIR is a success, it is not a panacea. Effective innovation policy is multidimensional, and a supportive policy framework that encourages universities to commercialise new products and processes is required. Policies that facilitate start-ups and encourage small to medium-sized businesses are also needed.

Governments need to invest in places where researchers and companies can meet, learn, cooperate and grow. For example, science and technology parks near universities, incubators, accelerator programs, and innovation awards that facilitate collaboration.

Adopting pro-innovation policies does not guarantee instant success – but not adopting them guarantees long-term stagnation.

Charles W. Wessner is a distinguished scholar and research professor in Global Innovation Policy at Georgetown University, and director of the Technology, Innovation and Entrepreneurship program at the National Academies.

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CRC ASSOCIATION
Tony Peacock CEO
Jordan Gardner Communications and Marketing Manager

FOR MEMBERSHIP INQUIRIES
02 6273 0624
1/10 Bourke Street, Barton ACT 2600
ww.crca.asn.au

FOR ADVERTISING AND EDITORIAL INQUIRIES CONTACT
Karen Taylor-Brown 0414 218 575
karen@refractionmedia.com.au

CONTACT US
PO Box 38, Strawberry Hills, NSW 2012
info@refractionmedia.com.au
www.refractionmedia.com.au

ABOUT
KnowHow is a magazine for science, business and industry, focused on Australian discovery and innovation, produced on behalf of the Cooperative Research Centres Association by Refraction Media, a custom publishing house based in Sydney.

The Cooperative Research Centres Program was established by the Australian government in 1990 to improve the effectiveness of Australia's research effort through bringing together researchers in the public and private sectors with the end users. The CRC Program links researchers with industry and government with a focus towards research application.

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Cover image of Darren Kelly, CEO of Fibrotech Therapeutics, by Tina Smigielski.

This issue went to press 18 February 2016.

Many investors are out of their depth and this whale can explain why.

Let's start with a question: how much do you think this sperm whale weighs? What's more interesting than your answer* is how you arrived at it. Did you rely on instinct? Or on what you know? QUT's Queensland Behavioural Economics Group (QuBE) believe the way we approach such questions says a lot about how we invest, particularly when it comes to highly complex products.

The Australian Securities and Investment Commission (ASIC) is using QUT's research to identify and communicate with investors who may suffer from overconfidence or 'the illusion of control'. Being able to identify risk-takers and tailor warnings could avoid catastrophic losses, not just for individuals, but for entire economies.

*An adult male sperm whale weighs approximately 40 tonnes.

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