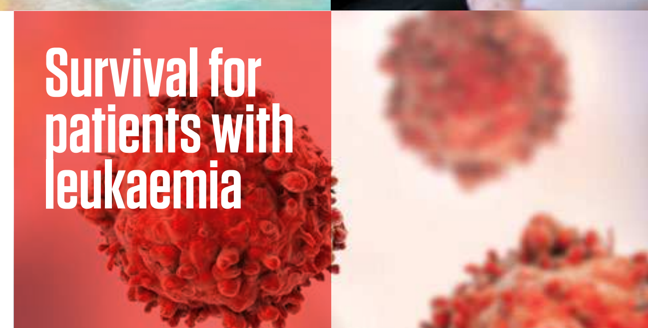
STORIES OF AUSTRALIAN SCIENCE 2017

Unravelling atoms

Faster communication and better solar cells

Drones protecting humans and sharks

A new heart



Survival for patients with leukaemia

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Welcome to Stories of Australian Science 2017

Making motorcycle clothing safer, a robotic arm for stroke rehab, prospecting for gold using prehistoric volcanoes—these are some of the highlights of the past year featured in *Stories of Australian Science 2017*.

Australian scientists are making silk-derived implants to fix damaged eardrums, and working to stop people going into flood waters. They're flying unmanned drones to record our reefs in incredible detail, and teaching bots to search out and destroy crown-of-thorns starfish. They're working to keep stored red blood cells in shape, testing water safety with fingernail-sized sensors, expanding the net for gravitational waves, and much more.

Australians are also working with colleagues in the USA, Indonesia, and Japan. We've got special features on these collaborations, including: 'blood tests' for big machines; developing new artificial hearts; using a radar-in-a-suitcase to make bridges safer; and making chewing gum that reverses tooth decay.

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Enjoy this dose of science!

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After 160 years, it's time to throw away the needle and syringe

Professor Mark Kendall is planning to dispatch the 160-year-old needle and syringe to history. He's invented a new vaccine technology that's painless, uses a fraction of the dose, puts the vaccine just under the skin, and doesn't require a fridge.

The Nanopatch is a 1 cm square piece of silicon with 20,000 microscopic needles engineered on one side. Coat the needles with dry vaccine, push it gently but firmly against the skin, and the vaccine is delivered just under the outer layer of skin.

It's a technology he invented in response to a call from the Bill and Melinda Gates Foundation seeking ideas for delivery of vaccines in developing countries—where it's a challenge to keep conventional wet vaccines cold to the point of delivery.

Mark went back to first principles and invented the Nanopatch

Mark had been working on PowderJect, a device that released vaccine particles at twice the speed of sound, allowing them to penetrate just under the skin to an important community of immune cells.

While delivery via the skin reduced the required dose and increased efficiency, this technology was too expensive for the Gates Foundation. So Mark went back to first principles and invented the Nanopatch.

Mark has had to push the science and business worlds to see the value of his new approach to vaccine delivery. It took 70 presentations before he secured funding for the University of Queensland spin-out company Vaxxas, which now employs 50 people.

Human trials of Mark's Nanopatch are underway in Australia, and the concept has broad patent coverage. It's being supported by the Bill and Melinda Gates Foundation, Merck and the WHO.

For his work reinventing vaccinations Mark was awarded the $25,000 CSL Young Florey Medal—which recognises mid-career achievements in biomedical science and human health advancement.

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Aussie kit detecting threat of toxic algal blooms

Toxic algal blooms can now be detected up to two weeks before they become a serious health hazard, thanks to an early warning system developed through an Australian university-industry partnership.

The kit, which was first developed in Sydney and trialled in Tasmania, is now being used by seafood farmers in China, the USA, France, and regulatory bodies and farmers in the UK and Australia.

Microalgae are invisible to the naked eye, but the neurotoxins they produce can have serious consequences for human health and the seafood industry.

"While it's not possible to stop these blooms, it is feasible to predict them," says Professor Shauna Murray, of the University of Technology Sydney. Shauna, along with PhD student Rendy Ruvindy and industry partner Diagnostic Technology, designed DinoDTec, a detection kit for the microalgae species *Alexandrium*. It allows farmers to prepare—for example harvesting shellfish earlier, or switching to harvest an unaffected area.

Microalgae are invisible to the naked eye

Alexandrium can produce large amounts of paralytic shellfish toxin (PST) when they go through a massive growth phase, commonly known as an algal bloom. When commercially important species such as clams or lobsters feed on the algae the toxins accumulate in their bodies, making them unusable by the seafood industry. In 2012 alone an algal bloom cost the Tasmanian seafood industry nearly $23 million.

In 2016, mussel farmer Phil Lamb switched production to their Victorian sites when they detected a potential algal bloom using the kit.

"We now run DinoDTec weekly. Relying solely on sending meat samples interstate for testing, which can take up to five days, puts us at risk. During this time, the product may be harvested, distributed and even consumed," Phil says.

Photos: Professor Mark Kendall (UQ), winner of the CSL 2016 Young Florey Medal

For more information: Australian Institute for Bioengineering & Nanotechnology, Mark Kendall, +61 7 334 64203, m.kendall@uq.edu.au; University of Technology Sydney, Marea Martlew, +61 2 9514 1766, marea.martlew@uts.edu.au

Drone swarms that can think for themselves

Flocking birds and schooling fish are the inspiration for creating a swarm of drones that can pilot themselves, and relay critical information to combat soldiers when other communication channels aren't available.

Defence researchers are building the software to make this a reality, as part of the Self-organising Communications and Autonomous Delivery Service project.

While they're currently working with octocopter drones (a drone with eight rotors), the software could also be used in self-driving buggies and underwater vehicles.

It's based on the concept of emergent behaviour.

Building the software to make this a reality

"Emergent behaviour can be seen when you look at a large group of things in nature, when each individual is following their own simple, local rules," says Dr Robert Hunjet from the Defence Science and Technology Group.

Those rules could be as simple as flying forward without crashing into the drone in front.

"What can happen is that when everybody acts on their own simple rules, the flock exhibits something that's far more complicated than just the rules they're following."

So instead of having to tell every drone where it needs to be all the time—which uses a huge amount of communication resources—drones of the future will be able to figure that out for themselves, to best complete the mission they've been given.

"That's the beauty of it: the drones will make use of whatever information is available," Robert says.

The team is currently planning a series of trials with the US Navy Postgraduate School to test the software further.

Using algorithms to predict flu outbreaks

A computer algorithm originally developed to model the West African Ebola pandemic in 2014 is being used to predict flu outbreaks in Australia months in advance, and could help in the fight against bioterrorism.

Developed by Australian Defence scientists, the tool was originally used to forecast the number of people infected with Ebola up to two months in advance.

The numbers predicted by the algorithm closely matched the cases later reported by the World Health Organization.

So the scientists adapted the algorithm to model other infectious diseases, such as influenza.

"We're taking advantage of the more sophisticated electronic health data becoming available," says Tony Lau from the Defence Science and Technology Group.

By mining data already being collected by health organisations and public authorities the team can predict flu outbreaks up to seven weeks ahead.

This allows them to provide weekly flu forecasts to public health authorities.

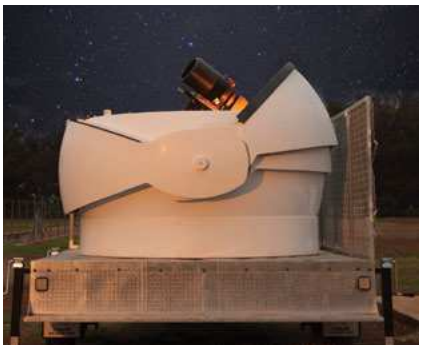
The tool has outperformed surveillance systems

Improving our capacity to predict flu peaks also aids our ability to detect bioterrorism attacks.

When people are exposed to conventional biological warfare agents they initially show flu-like symptoms, making it important to distinguish between a naturally-occurring flu epidemic and a biological attack so authorities can respond accordingly.

"We are the first ones to use this type of approach for the detection of a biological warfare agent release," Tony says.

The tool has outperformed surveillance systems currently used by the US military, and the US Department of Defense is now funding the research.



Tracking space junk

Algorithms normally used to track aircraft, ships and other vehicles are being used to monitor space junk and predict where it will go.

Currently the US Department of Defense tracks around 17,300 objects the size of a baseball or larger, orbiting around the Earth at speeds of up to seven kilometres per second. They can cause serious damage if they collide with something else. Last year a tiny paint fleck caused a crack in a window of the International Space Station.

Reduce the number of space junk collisions

While you can use radar to track objects in low Earth orbit, for anything further out you need to use optical sensors, which are typically telescopes with cameras attached to them.

"The sensor works by taking an image when the telescope's location is in darkness but the satellite is still illuminated by the Sun, so it will resemble a star," says Travis Bessell from the Australian Defence Science and Technology Group.

Image processing software can detect which dots in an image are objects versus which are real stars, but it can't identify the object. That's where the algorithms come in.

"Basically, the algorithms we're looking into can stitch the dots together over time," Travis says.

The algorithms can determine the location of an object, join the dots from multiple images to determine its orbit, then predict where it's going to be in the future.

Making better predictions about an object's future location could reduce the number of space junk collisions.

The team is collaborating with researchers in the US, UK, Canada and New Zealand.

Photos: Thomas Stevens configuring the autonomous drones, credit: Defence Science and Technology Group; Tony and his team are developing a bio-surveillance portal, credit: Defence Science and Technology Group; Defence's relocatable telescope used for space junk research, credit: Defence Science and Technology Group

For more information: Defence Science and Technology Group, Darryl Johnston, +61 2 6128 6385, Darryl.Johnston@dst.defence.gov.au

Australian Government
Department of Defence
Science and Technology

How to stop people entering floodwater

People continue to enter floodwater in vehicles and on foot, despite many knowing the risks.

Researchers from the Bushfire Natural Hazards CRC and Risk Frontiers, Macquarie University, analysed the who, when and why of flood fatalities, so they could target information to high-risk groups and hopefully prevent further deaths.

A one-size-fits-all risk communication approach doesn't work

Of the 1,859 deaths due to floods from 1900 to 2015, 79 per cent were male, almost half of whom were attempting to cross a bridge, road, or similar.

"People think they're in a big car that's built to drive through floodwaters," says research leader Dr Katharine Haynes.

"Often, they don't realise that the road may be washed away, there could be lots of debris in the water, or it's flowing deeper and faster than it looks."

Fatalities in vehicles, particularly four-wheel drives, increased sharply during the last 20 years, and a high number occurred when visibility was poor—at twilight or night-time.

"Aside from better education, this highlights the need for structural measures like better signage, lighting and road design, as some people are unaware that they are entering floodwater until its too late," Katharine says.

Their research is informing the latest safety campaign from the NSW State Emergency Service. New funding from the CRC will also help them investigate the best way to tailor information to target groups.

"A one-size-fits-all risk communication approach doesn't work," Katharine says.

"The most effective material is developed with people at risk themselves, so we're going to work with those groups and put people in a room, give them different sorts of risk communication, run them through realistic disaster scenarios, and see how they behave."

The sweet side of sulphur: cheap mercury clean-up

A cheap and simple material, using sulphur from petroleum industry waste and plant oils from the food industry, is being tested to clean up mercury pollution from soil and water.

The rubbery material will undergo field tests in 2017 in Australian mining and sugarcane sites, the latter of which use fungicides that contain mercury. The work is supported by funding from the National Environmental Science Programme's emerging priorities funding.

"Our technology is about as simple as it can get: mix sulphur with plant oils and heat, then add the resulting material into the contaminated area," says lead researcher Dr Justin Chalker, of Flinders University.

Pellets of the material can be put into pipes, water filters or tanks, or milled into contaminated earth. Toxicity testing has shown that the material is non-toxic even once it has bound with the toxic metal—essentially neutralising the mercury.

"Our long-term goal is to see it used in mine sites in developing countries where liquid mercury in small-scale gold mining is widespread.

"In these mines, liquid mercury is used to extract gold from ore. To isolate the gold, the mixture that forms is often processed by hand without any safety precautions, and burned to vaporise the mercury. Toxic waste can also end up in rivers. Approximately 15 million people—including child-miners—are involved in this practice globally, with developing nations disproportionately affected," Justin says.

Mercury can do severe damage to the nervous system and cause developmental defects in developing babies. It can also be deadly.

Justin and his laboratory and collaborators are working with several non-profits internationally, in the hope of providing an environmentally friendly solution that's far cheaper than any mercury-capture technology currently available.

@ausscistories

Photos: Katharine's work is informing the latest safety campaign from the NSW State Emergency Service, credit: Country Fire Authority; PhD student Max Worthington (left) and Justin examine one form of the mercury-binding material, credit: Ashton Claridge

For more information: Bushfire & Natural Hazards CRC, Nathan Maddock, +61 3 9412 9602, nathan.maddock@bnhcrc.com.au; Flinders University, Justin Chalker, justin.chalker@flinders.edu.au, www.chalkerlab.com

A scarce Sarah: new blood group making transfusions safer

Further research into a rare blood type will continue to make transfusions and pregnancies safer.

"Now families with the SARA blood type can be tested for the gene and this will help safely manage future pregnancies," says Associate Professor Catherine Hyland of the Australian Red Cross Blood Service.

"This genetic testing has implications for others, particularly since similar problems can occur during transfusion or pregnancy for people with similar rare blood types."

SARA was first recorded in Australia 20 years ago.

Blood types are more complex than simply combinations of 'positive' and 'negative' with A, B, O, or Rh—there are hundreds of different antigens (proteins and sugars on the surface of our cells) across the 36-plus blood groups.

In the 1990s, the Australian Red Cross Blood Service realised the antigens on a special donor named Sarah's red blood cells weren't like any previously recorded. But it wasn't until 2010 that the unusual antigen was investigated again: the Canadian Blood Service reported that a pregnant woman's immune system had begun attacking her foetus, which they suspected had inherited the same rare blood type recorded in Australia.

Rhiannon McBean, who was then a PhD student with the Blood Service, made use of the advances in genetic sequencing technology to compare masses of data from samples from both the Canadian and Australian families, to finally isolate the gene responsible for the blood type.

"We had this wonderful 'Eureka' moment," says Catherine, who was Rhiannon's co-supervisor.

The discovery was recognised by a vote at the International Society of Blood Transfusion, and officially endorsed as a new blood type, named 'SARA', in honour of the donor.

Catherine and her colleagues at the Blood Service are working with Australian samples to determine how frequent SARA and other unusual blood types are, and would like to expand the research internationally.

What happens to red blood cells in storage?

Understanding why red blood cells get out of shape during storage could help improve the effectiveness and safety of blood transfusions.

So, Marie-Anne Balanant and Sarah Barns are combining biological and engineering expertise, to create a model of how different parts of ageing red blood cell membranes react when a force is applied.

They hope to propose strategies to improve blood storage practices and create better transfusion outcomes for patients.

> **During storage, the shape of the cells changes**

For storage, blood is separated into red cells, platelets, and plasma, which all have differing shelf-lives. Red blood cells can typically be stored for six weeks (though the Blood Service is conducting clinical trials on a deep-freeze process that extends storage for blood components to 10 years).

During storage, the shape of the cells changes. "They develop little spikes on the membrane, and in the final stages, they're so stiff they can't flow through the circulation," Marie-Anne says.

This shape change also happens naturally in the body, but there are processes to clear these damaged cells out.

"In blood bags, there's no mechanism to clear them out—so they are quickly removed from circulation after transfusion, meaning the transfusion won't be as effective," Sarah says.

Both Sarah and Marie-Anne are PhD students with the Red Cross Blood Service and the Queensland University of Technology.

Measuring risk of Aussie Zika outbreak

Conditions have been right for Zika virus to spread during the warmer months of past years in Townsville, Cairns and Rockhampton, according to research led by the Australian Red Cross Blood Service.

Using temperature data from January 2015 to December 2016, the team modelled the ability of mosquitoes to spread the virus in four Queensland cities. Brisbane (the fourth city) was the only site where the risk was low.

"If locations experience outbreaks of dengue, the conditions would also be right for outbreaks of Zika," says lead researcher Dr Elvina Viennet.

The findings emphasise the need for imported cases to be reported immediately, Elvina says.

"We need increased investment in monitoring mosquito populations, and preventative strategies to address the ongoing risks presented by Zika and similar viruses."

Infected *Aedes aegypti* and *Aedes albopictus* mosquitoes are the main transmitters of the disease (along with dengue and chikungunya viruses). Between 50 to 80 per cent of infected people don't show symptoms, posing challenges for detection and risk management.

Their analysis included estimating average daily biting rate of the mosquitoes, temperature, probability per bite of virus transmission, mosquito death rate, and the incubation period (time from infection to showing symptoms).

"We're now using a more complex equation involving future climate change scenarios—because if the temperature is warming, the model and how quickly the virus is transmitted may also change," says Elvina.

In Australia, the risk of transmission via blood transfusion is extremely low. The Blood Service has very strict prevention measures in place, including a questionnaire asking where people have recently travelled.

Australian governments fund the Blood Service to provide blood, blood products and services to the Australian community.

For more information: Australian Red Cross Blood Service, contact: Alison Gould, +61 2 9234 2390, agould@redcrossblood.org.au

Photos: Marie-Anne Balanant and Sarah Barns are combining biological and engineering expertise, credit: QUT;
The mosquitoes that can transmit dengue and other diseases can also spread Zika, credit: Muhammad Mahdi Karim

Australian Red Cross BLOOD SERVICE

Touch of silk to repair ruptured eardrums

A transparent, silk-derived implant that looks like a contact lens and can fix damaged eardrums is giving hope to millions who suffer from recurrent ear infections.

Creators of the device—from the Australian Research Council's Future Fibres Research Hub and the Perth-based Ear Science Institute Australia (ESIA)—secured funding to start human clinical trials with it in Australia in 2018.

The implant, called ClearDrum, is made from silk protein that forms a see-through scaffold on which cells can grow to close eardrum perforations.

Surgeries to repair eardrums often use a patient's cartilage from the outer ear, which is shaped into a membrane that blocks the perforation. This acts as the middle ear's barrier against infection.

Operations can be lengthy and require repeat procedures. But the new device will enable quicker, less invasive surgeries and offer a 'window' into the middle ear to assess healing and potential infection. It is super-thin, strong, flexible, biodegradable and unlikely to cause rejection.

"Even if you use the strongest cartilage, it's opaque so surgeons can't see through it into the middle ear. The silk implant provides comparable strength with transparency and vibrates as well as a human eardrum," says Deakin University's Dr Rangam Rajkhowa.

Up to 330 million people worldwide suffer from middle ear disease, which can damage eardrums. About 10 per cent of indigenous Australian children under the age of 14 experience chronic burst eardrums from infection. This can lead to hearing loss and learning and employment difficulties.

The team, led by Hub Director Professor Xungai Wang, won a three-year grant of just under four million dollars from UK-based charity The Wellcome Trust.

Converting body heat into useable electricity

Imagine if your exercise clothes could generate enough electricity to power your workout gadgets. This could be a reality in a few years with the development of a flexible, self-charging, non-leaky battery (or thermocell) that could convert body heat into power for devices such as fitness trackers.

Traditional batteries are unsuitable for this use as they are inflexible, can leak, and need to be regularly recharged. Now researchers from Deakin University's Institute for Frontier Materials have created a more sustainable option that works by harvesting moderate temperatures using a thermocell containing materials including cellulose—the key ingredient of paper.

Most thermocells contain liquid electrolytes, but the gel-like cellulose version prevents leakage and has the potential to contour to the body within the fabric of a garment.

Recycle heat from sources like power stations and car exhausts

"Working on the assumption wearable electronics have quite a low power demand, if we can connect lots of thermocells together—for example to cover a chest area—then we could conceivably power these devices," says Deakin's Associate Professor Jenny Pringle, Chief Investigator at the Australian Research Council Centre for Excellence for Electromaterials Science (ACES).

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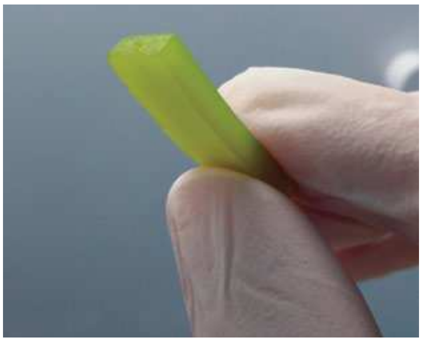


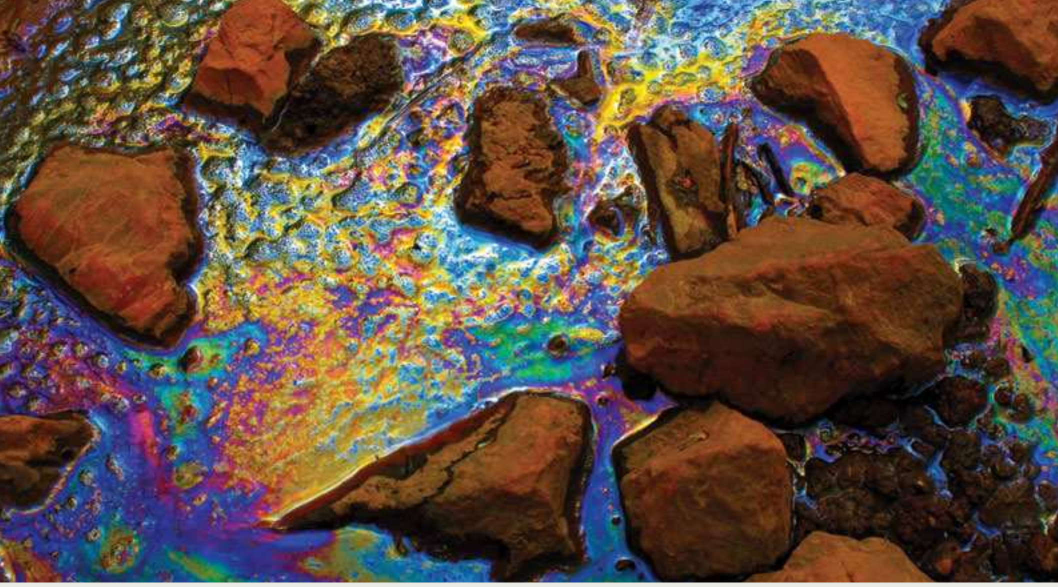
Thermocells make power from heat using two electrodes in contact with an electrolyte. As long as one electrode remains hot and the other cold, energy conversion is continuous. A valuable renewable energy option, they can recycle heat that would normally be wasted from sources like power stations and car exhausts.

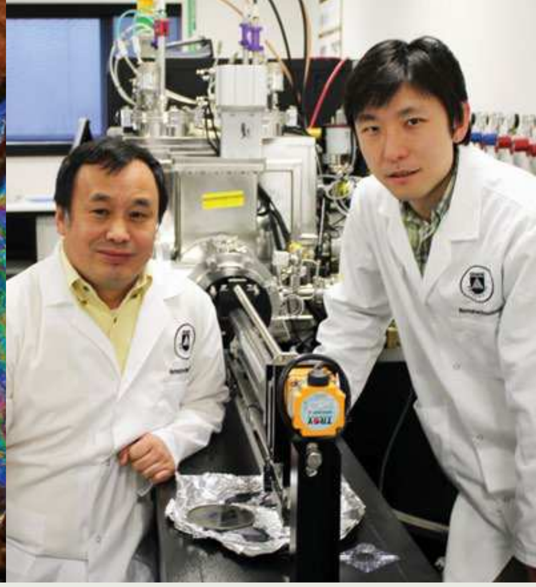
Their continuous power production makes them ideal for use in remote locations like oil rigs or the outback, where replacing dead batteries is challenging. The next step is to link multiple cells together, using 3-D printing technologies at ACES, to achieve increased power using body heat.

The implant is clear so surgeons can see through into the middle ear

Photos: This flexible thermocell developed by Deakin researchers has the potential to convert body heat into power for wearables, credit: Dr Liyu Jin; Dr Ben Allardyce is helping develop silk eardrum scaffolds, credit: Deakin University; Professor Ying Chen (left) and Dr Luhua Li fine-tuning ultra-sensitive sensing techniques; Graphic explaining the 'trip, grip, slip' phases of a motorbike fall; Dr Chris Hurren is testing bike pants made from denim and other fabrics to assess their durability in accidents.

For more information: Institute for Frontier Materials, Deakin University, Robin Taylor, +61 3 5247 9255, Robin.t@deakin.edu.au





When boron nitride outshines gold and silver

Ultra-thin boron nitride outshines gold and silver when used to detect contaminants in smart sensing technology. It is 100 times more effective at detecting dangerous materials in our food and environment than noble metals.

Traditionally, detection surfaces of these devices have been made using gold and silver. But covering these metals with a microscopically thin layer of boron nitride greatly enhances their performance.

The findings are by a team from Deakin University's Institute for Frontier Materials, Japan's National Institute for Materials Science and China's Wenzhou University.

Researchers around the world have been racing to develop the most super-sensitive detectors for settings such as border control, forensics, defence industries, food safety and medical research.

Deakin's Professor Ying Chen, Dr Luhua Li, Dr Qiran Cai and their colleagues found the ceramic boron nitride was superior to noble metals in current detection technology that harnesses light scattering off surfaces to identify even minute traces of toxins, pollutants, proteins and DNA.

The new detection system is cheaper and simpler to produce than previous models, is highly adsorbant (clings well to molecules), resists corrosion and is unaffected by high temperatures. This enables quick 'intense heat' cleaning and reuse.

Vying with carbon for its versatility, boron nitride has potential to be used in a wide range of industries. For example, Deakin scientists with USA-collaborators are trialling boron nitride in sponge-form to mop up oil spills.

Cheaper and simpler to produce than previous models

"Devices using boron nitride nanosheets could be used to detect narcotics in saliva in drug tests and even cancer cells in blood and breath samples," Luhua says.

Making motorcycle clothing safer

Most motorcycle clothing is not as protective as you might think. But from next year it will be easier to identify the safest gloves and garments, thanks to a rating system developed by Deakin University researchers.

Keen biker Dr Chris Hurren and his colleague Dr Liz de Rome, of the university's Institute for Frontier Materials, tested fabrics used in biker clothing—such as denim and synthetic protective liners—to measure breathability and durability. More than 60 per cent performed poorly.

Fabrics were dragged across a belt sander running at 28km/hr to assess how long they would take to rip. Thicker, denser materials (like leather and terry loop knitted para-aramid) performed best, with thin, stretchy and water-resistant garments bursting more readily on impact.

Surprisingly, material ruptures quicker at slower speeds due to the 'grip' element of a fall compared to the subsequent, less abrasive 'slip' motion which starts earlier in high-speed accidents. This is concerning as European statistics show most bike incidents happen below 50km/hr.

Reduce the severity of bike-related injuries

Some clothing carries European (CE) standards but there is confusion in Australia with non-labelling and misleading descriptions such as 'ballistic nylon'.

"It turns out that if you sell clothing in a motorcycle store it only needs to be protective if you claim it as protective," Chris says.

Soon European standards are set to slide. Materials will only have to withstand damage within one second after impact compared to the previous four-to-seven second rule.

This research, backed by the Australian Motorcycle Council, aims to reduce the severity of bike-related injuries and introduce a comfort and protective rating system.

IFM INSTITUTE FOR FRONTIER MATERIALS

DEAKIN UNIVERSITY

Seeing medical devices from concept to commercialisation

It's difficult to get medical devices out of academia and industry and into end-users' hands. But a South Australian researcher developed a way to do it—and the program is now set to expand nationally, thanks to funding from the Medical Technologies and Pharmaceuticals Industry Growth Centre.

Devices the program has supported include the U-stand Frame—which helps hospital patients or the elderly stand from a bed with minimal assistance—and a device placed in urinals that gives instant feedback on hydration, to address the impact of heat stress on worker safety.

Professor Karen Reynolds' Medical Device Partnering Program has been connecting industry and scientists with research and development experts in South Australia since 2008.

"The decrease in car manufacturing in South Australia has seen quite a few people looking for new opportunities," says Karen, who is Director of the Medical Device Research Institute at Flinders University.

Take the idea to pieces and see if it's feasible

"This program facilitates the connections necessary for product development that many small companies don't have. The devices and assistive technologies we support need to have both a commercial and research opportunity."

They put the client in a room with eight to 10 diverse experts—for example engineers, clinicians, manufacturers, and government—to take the idea to pieces and see if it's feasible.

Then they plan and provide expertise on a short project (up to 250 hours), such as building a prototype or trialling the device in the hands of clinicians, and deliver a 30-hour external market intelligence assessment which can be later used to craft a commercialisation strategy.

Karen is now working on a model for the national program, which she says will help ensure the best medical technologies reach the market, and could be rolled out within a couple of years if they secure enough funding.

Improving carbon fibre production

Making higher quality carbon fibre will be easier thanks to Australian research using infrared technology to capture the most detailed 3-D images to date of its formation.

The tough fibre, which is 10 times stronger and five times lighter than steel, is made by heating a synthetic product called polyacrylonitrile (PAN) in temperatures up to 600°C. Some aircraft, high performance cars and the new electric BMW i3 are partly made with it. But slow and costly manufacturing methods currently deter the mass use of carbon fibre in automotive and aeronautical industries.

It was thought PAN transformed into carbon fibre from the outside layers inwards. But the team revealed the core turns into carbon fibre first and that quick, high temperatures can weaken outer layers.

"We have been able to look at the chemical structure inside the fibres which wasn't previously possible, and this allows us to improve the production process," says Dr Mark Tobin, the Australian Synchrotron's Principal Scientist (Infrared).

To improve the fibre's strength and reduce energy use in production, a team from Carbon Nexus, Deakin University's carbon fibre research hub, including PhD student Srinivas Nunna and Dr Claudia Creighton, collaborated with the Australian Nuclear Science and Technology Organisation (ANSTO) and colleagues from Swinburne University of Technology.

At ANSTO's Australian Synchrotron, the scientists imaged cross-sections of PAN fibres one hundredth of a millimetre thick. The process involves focusing infrared beams onto fibres via a magnifying lens made of germanium—a silicon-like crystal.

The research, published in the Journal of Materials Chemistry A, was initiated and led by Swinburne University's Dr Nishar Hameed.

Stories of Australian Science

Slow and costly manufacturing methods currently deter the mass use of carbon fibre

Photos: Mr Allan Perriam (Executive Director of INNOVO Healthcare) using the U-stand Frame with a patient, credit: Flinders University

For more information: Flinders University, Karen Reynolds, +61 8 8201 5029, mdpp@flinders.edu.au, www.mdpp.org.au; Australian Synchrotron, Mark Tobin, +61 3 8540 4172, mark.tobin@synchrotron.org.au

Saliva or blood tests may one day be used to detect when we're too tired to drive or think clearly.

Towards a portable test for tiredness

A team of scientists has found specific biological markers linked to reduced alertness, including eye movement patterns, blood-based metabolites, and various speech parameters. If these can be used to develop a test, they hope to see it on the road and in the workplace within two-to-five years.

"We've conducted studies in a variety of settings including controlled laboratory environments, occupational settings and on-road driving. This is a major step in the pathway to developing objective tests of fitness to work or drive," says Professor Shantha Rajaratnam, Sleep Program Leader at the Monash Institute of Cognitive and Clinical Neurosciences (MICCN), and the Cooperative Research Centre for Alertness, Safety and Productivity (Alertness CRC).

Nearly 20 per cent of all Australian serious motor vehicle accidents are caused by a drowsy driver.

"People just keep working or driving despite having difficulty staying awake. They don't recognise their symptoms of drowsiness and the danger these represent," Shantha says.

Shantha is working with Alertness CRC collaborators, including Associate Professor Clare Anderson (also of MICCN), and Associate Professor Mark Howard from the Institute for Breathing and Sleep at Austin Health.

"Biomarkers of sleepiness will provide the foundation for more effective road safety laws and public education about when an individual is too sleepy to drive," Shantha says.

They will form the basis of future technologies and devices that can become part of alertness tests in the workplace and in roadside settings.

The right juice for your heart

Beetroot juice and exercise are being investigated as a treatment for cardiovascular problems.

Professor Jason Allen and PhD student Mary Woessner from Victoria University hope the combination could lead to other, more sophisticated therapies.

Beetroot juice contains relatively high levels of inorganic nitrate, which the body breaks down to use as a source of nitric oxide, a versatile chemical messenger. One of its most important roles is triggering blood vessel dilation. That makes it a handy treatment for atherosclerosis-related conditions, where fatty material or plaque builds up on blood vessels' inner walls, decreasing blood flow.

Exercise is an effective long-term therapy for several cardiovascular diseases. But in arteries narrowed by plaques, the ability to increase the supply of blood and oxygen to working muscles can be limited. If the plaques are in the legs it's known as peripheral arterial disease (PAD), which can be painful and limit physical activity.

Working at Duke University in the US, they found nitric oxide and its precursors decreased during exercise in PAD sufferers, and drinking a high nitrate beverage such as beetroot juice a couple of hours before exercise could 'resupply' some of these precursors. This had a large beneficial effect on exercise performance.

Mary's looking at the problem in those who suffer from chronic heart failure, where the heart can't pump enough blood and oxygen. Subsequent research will try to clarify the mechanisms at work, and when treatment would be most effective.

Turning off toxic T cells in MS clinical trial

Switching off T cells before they begin to damage the nervous system is the basis of an Australian therapy for multiple sclerosis (MS), which is expected to begin clinical trials by the end of 2017.

Developed by researchers at Victoria University in western Melbourne and the University of Patras in Greece, it brings together peptides, or protein fragments, with a biochemical delivery system already shown to be effective in cancer vaccine clinical trials.

In MS, a condition which affects more than 23,000 Australians and two million people worldwide, the body's immune system T cells attack myelin, the fatty sheath that protects the central nervous system and helps nerve impulse transmission.

"We don't want to get rid of T cells," says Professor Vasso Apostolopoulos of the University's Centre for Chronic Disease.

"We want to switch them off so they no longer secrete the toxic granules that break down myelin or the cytokines—chemical messengers—that recruit other destructive cells to the site."

Vasso came to Victoria University from the Austin and Burnet Research Institutes, where she was head of the Immunology and Vaccine Laboratory, following work at Oxford University and the Scripps Institute in San Diego. She was instrumental in developing the world's first vaccines against breast and ovarian cancer, which are injected and delivered using sugars as a carrier.

This delivery system attracted peptide chemist Professor John Matsoukas and his colleagues in Greece, who had synthesised a series of compounds to modulate the behaviour of T cells.

"We will start the trials with one peptide, but we're investigating combining several into a cocktail," Vasso says.

She is also working on developing vaccines against prostate cancer, mental health conditions such as depression, and even as blockers of crystal methamphetamine, the drug known as ice.

A biochemical delivery system already shown to be effective in cancer vaccine clinical trials

Photos: Currently, there are no objective tests for tiredness, credit: Monash Institute of Cognitive and Clinical Neurosciences; Vasso wants to turn off dangerous T cells before they cause damage, credit: MediaXpress/Victoria University

For more information: Monash Institute of Cognitive and Clinical Neurosciences, Susan Waterer, +61 3 9903 4506, susan.waterer@monash.edu; Victoria University, Teyah Marney, +61 3 9919 5577, Teyah.Marney@vu.edu.au

Tiny dots testing water safety; pollution sponges; bridging the digital divide; and more: RMIT University

Making pollution sponges out of nanoparticles

Special sponges that can clean toxic pollutants from waterways are being developed by Australian scientists.

The sponges get their pollution absorbing powers from titanium dioxide—the same stuff that's in your mineral sunscreen—which is cheap and abundant in Australia and environmentally safe to use.

It can be modified to collect toxic metal ions from water, and can act as a photocatalyst, breaking down organic chemicals. But individual titanium dioxide nanoparticles are hard to control in solution.

Dyes can be broken down into harmless molecules

Professor Rachel Caruso, Director of the Enabling Capability Platform for Advanced Materials at RMIT University, and her team have harnessed the nanoparticles' powers by building them into controllable structures. They take sponge materials as a template, layer them with nanoparticles, and then remove the template, ending up with 'nanoporous-sponges'.

This way scientists have excellent control over the porosity and surface area of the material. "If I'm putting this material into a polluted water stream, the more surface area I have, the more contact I have for collecting or reacting with the pollutant," Rachel says.

Potential applications for these sponges are in textile industries that use chemical dyes to colour fabrics and then need to clean the run-off. Dyes can be broken down into harmless molecules through contact with the nanoparticles.

"Rather than allowing that dye to pollute the water stream, you would treat the water before it's released," Rachel says. Other applications include soaking up environmental pollutants, or use in batteries and solar cells.

Testing water safety with tiny nanodot sensors

A fingernail-sized sensor with nanodots that can detect the presence of heavy metals has been developed by Victorian scientists.

It offers a cheap and simple method of testing whether water is drinkable.

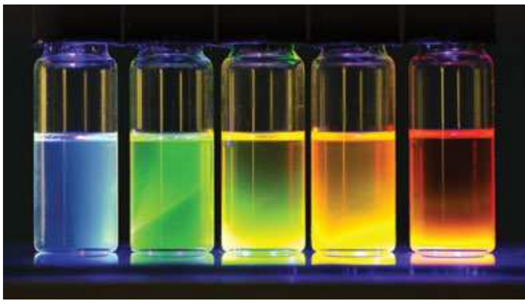
"The dots are extremely small, so several different ones can be embedded in a tiny plastic film, detecting for a range of heavy metals all at once," says Professor Ivan Cole, Director of the Enabling Capability Platform for Advanced Manufacturing and Fabrication at RMIT University.

Because of their quantum properties, shining light on the nanodots causes them to fluoresce at a specific wavelength. Researchers use this quirk to look for colour changes if a heavy metal binds to the nanodot.

"By monitoring the colour, we can then monitor the concentration of heavy metals," Ivan says.

The sensor is simply dipped in water and placed in a pocket-sized device that shines light on it and detects the fluorescence of the dots.

"It would give you red or green lights to determine whether the water is drinkable," Ivan says. This could make environmental sensing much cheaper while still being accurate."



These sensors are so cheap researchers hope their use will become widespread in testing polluted water systems, such as those in China. The technology also has potential uses in agriculture, to spot-test soil and determine which areas of a field need more fertiliser.

The work is a collaboration between CSIRO and RMIT. Researchers are currently working to improve the nanodot accuracy, and Ivan expects the new sensors will hit the market in three to four years.

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Photos: Red or green lights indicate whether the water is drinkable, credit: Dr Trinchi (CSIRO)

Teaching search engines to know what you need

Information scientists are figuring out how to make search engines better at listening, so they can give us search results before we even ask.

Quizzing Siri or Alexa on the weather forecast or latest football results is common these days. But if we're going to have fluent and intuitive conversations with future search engines, they will need to be built differently.

This challenge has captivated Professor Mark Sanderson, Director of the Enabling Capability Platform for Information and Systems (Engineering), and his team at RMIT University.

They're trying to better understand how we talk about information to each other, to develop search engines that can do the same. The next step is building a new kind of search engine—one that listens in on people.

PhD student Johanne Trippas from RMIT and Dr Hideo Joho from the University of Tsukuba, Japan, have been analysing dialogues in which people are planning trips together, talking about bookings and potential holiday activities.

By breaking conversations down into 'information needs', researchers can establish the technological features needed for a next-generation search engine.

"A really clever search engine might listen to our conversation and, for example, throw up a video that I've been talking about," Mark says.

Instead of choosing menu options and typing in queries, this work on conversational search engines is taking us to a future where we'll be able to have a casual chat with a computer.

"Obviously, there are privacy issues," Mark says. "The idea of a computer just continually listening sounds a bit scary, but the initial question is—can we make this work or not?"

Mobile games are for paws, too

It turns out that Aussie pets love playing mobile games and watching TV, just as we do.

In a three-year study of mobile gaming and digital media in Australian households, researchers were surprised to find animals frequently joining in on the fun with technology.

"We have observed cats playing with iPads and keyboards, dogs watching television or participating in Skype calls," says Distinguished Professor Larissa Hjorth, Director of the Enabling Capability Platform for Design and Creative Practice at RMIT. She co-leads the research with Associate Professor Ingrid Richardson from Murdoch University.

Australians have one of the highest rates of pet ownership in the world and we view and include our four-legged friends as significant members of the household.

We include our four-legged friends as significant members of the household

"Humans and their pets are entangled in various forms of intimacy and kinship, often in digitally mediated ways," Larissa says.

This was the first-ever longitudinal study of mobile gaming in Australia. Due to be completed in mid-2017, the work highlights the social and cultural aspects of mobile media, bringing much-needed nuance to public discussion about the impact of modern technology. "People adapt media in ways that are often unexpected, creative and playful," Larissa says."Media practices can tell us a lot about our values, ideologies, and ways of knowing in the world."

The dream to get every Australian connected online

A new index on digital inclusion is setting out a path for all Australians to get the vital benefits that come with internet access.

Information and communication technologies have become near-essential for everyday life, but many people in low income, remote and vulnerable communities can't access them.

This creates a 'digital divide' where people don't get the services many of us take for granted—finding jobs online, accessing critical government information, free education, and more.

"The digital divide has been a huge problem in public policy for many years," says Professor Julian Thomas, Director of the Enabling Capability Platform for Social Change at RMIT University.

His team is investigating this digital divide with a goal to close the gap. In 2016, the researchers published the first digital inclusion index, which found that three million Australians are still not online, especially those aged over 65.

"When we can measure something, we can change it," Julian says. The work is in collaboration with Telstra and the Centre for Social Impact at Swinburne University. An updated digital inclusion report is coming out next year, and the results are already put into practice by local stakeholders.

Three million Australians are still not online

"We have had many meetings with state governments, regional organisations, local councils, social service organisations and libraries," Julian says.

"Our aim is to put useful data in the hands of organisations that have a stake in improving digital inclusion outcomes. We want everybody to share the benefits of the digital economy."

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RMIT UNIVERSITY

Mapping liveability across cities

A new city liveability study will soon map the health and wellbeing of residents across increasingly populated Australian cities, helping the government to design healthier living spaces.

Australian cities are growing incredibly fast, and large state capitals such as Melbourne and Sydney are creaking at the joints under the massive annual influx of new residents.

Most city dwellers in Australia settle in far-flung suburbs that lack services and infrastructure including public transport, education and health and services, according to Distinguished Professor Billie Giles-Corti, Director of the Enabling Capability Platform for Urban Futures at RMIT University.

Her team of researchers is analysing these places to find the most pressing issues that have both health and economic costs for all of us.

"We're looking at the concept of liveability," Billie says.

"It includes a number of different dimensions, such as access to affordable housing, shops and services, social infrastructure, public transport and public open space as well as walkability."

Work on designing healthier urban spaces for everyone

"Hopefully by the middle of 2017 we'll have a liveability index for Melbourne that brings all these things together. We're mapping these indicators across all Australian capital cities to find who the winners and losers are, and hope to replicate the index for other cities in the future."

With a tailored Australian liveability index on hand, government authorities and advisory groups involved in city planning will then have evidence to work on designing healthier urban spaces for everyone.

"'What can we do to fix this?' is the question I want to challenge people with," Billie says.

A new city liveability index will soon map the health and wellbeing of residents across increasingly populated Australian cities

How social media can help businesses get ahead

Scientists from RMIT University are helping businesses across Europe and Australia harness the power of social media to become more innovative in a competitive market.

"Social media will help businesses develop innovations and promote novelties faster, with a competitive advantage," says Professor Anne-Laure Mention, Director of the Enabling Capability Platform for Global Business Innovation at RMIT University.

With colleagues from Sydney, Geneva, and Luxembourg, Anne-Laure's team is analysing the use of social media for open innovation practices in businesses around the world.

"We're looking at the types of social media organisations use, and to what extent they support the openness of the innovation process," Anne-Laure says.

This will lead to a set of recommendations and tools for managers, so they can approach social media in an evidence-based fashion.

Businesses already use social media to connect with customers, getting their input on new products or features. But there's also scope to connect with suppliers, government bodies and research organisations, according to Anne-Laure. She says social media can be used to crowdsource and connect ideas, connect R&D initiatives, seek independent expert advice, and more.

Her work focuses on open innovation—using external knowledge to develop in-house novelties and find new paths to the market through spin-offs, alliances, or joint ventures.

"We explore public social media such as Twitter or LinkedIn, proprietary solutions like IBM, and innovation intermediary platforms such as InnoCentive and NineSigma. The latter are like a dating system," Anne-Laure says.

"You could be developing a material for a specific industry, and at the same time it could be applicable in another industry. You can use social media platforms to find links between the two."

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How the ice plant thrives in high-salt areas

Plants need water, but if that water also comes with a hefty dose of salt it can kill the plant.

But the ice plant, *Mesembryanthemum crystallinum*, has a clever way of storing salt in special cells, allowing it to thrive in saline coastal areas.

"We want to understand why crop plants aren't very salt-tolerant. The ice plant—which is a halophyte, meaning it actually grows better in the presence of salt—is a great model to study," says Associate Professor Bronwyn Barkla of Southern Cross University, who led the research.

She noticed the plant has modified versions of the hair-like structures found on the leaves of most plants (think of tomatoes). Known as epidermal bladder cells, these accumulate salt from the water the plant absorbs.

"These cells are quite large, and they can accumulate salt (sodium), at a concentration of up to 1.2 molar—from the ones we've measured so far. Seawater is around 450 millimolar sodium, so it's quite a large amount." The plant may also be useful in phytoremediation—using plants to clean up land and make it productive again.

"For example, you might grow the plant on land that's been salinised due to over-cropping and irrigation, and harvest them before they die and release their salt back to the soil," Bronwyn says.

She's also working with an industry partner looking at developing an edible line of these plants. She says they're quite tasty and crunchy, and have become popular as a gourmet salad item in China.

Part of this research was published in *BMC Plant Biology* in 2016.

Drones protecting humans and sharks

Drones could be the key to safer beaches for swimmers, surfers, snorkelers—and sharks.

An intensive trial monitoring New South Wales beaches has shown that drones mounted with cameras can reliably detect the big fish.

"This could provide a way to reduce bites without harming sharks or other marine animals," says Associate Professor Brendan Kelaher of Southern Cross University.

> **The cameras can also be better than the human eye**

A team from the University and the NSW Department of Primary Industries flew drones for six 20-minute patrols over numerous beaches, during school holidays in 2016 and 2017.

They monitored the footage and notified surf life savers who then decided how to act, for example by closing the beach if it was a dangerous shark.

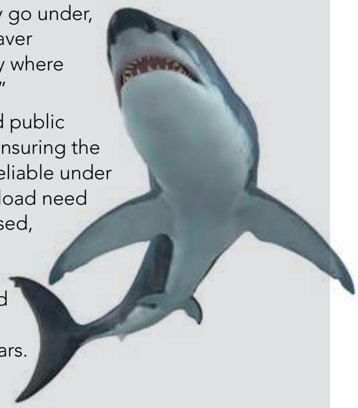
"We've shown it works—it's not fail-safe and there are days the weather is too bad for drones or the water visibility is poor, but it still reduces the overall risk," Brendan says.

They're currently working with companies trying to develop drone-based technology to detect sharks without people, similar to facial recognition software.

"So it might give people a shortlist of video clips to decide on. The cameras can also be better than the human eye, if we move to sensors like hyperspectral cameras," Brendan says.

"The other opportunity is in combining technologies—for example with a drone that sits above a drowning person so that if they go under, the surf life saver knows exactly where to find them."

Issues around public privacy and ensuring the hardware is reliable under a heavy workload need to be addressed, but Brendan hopes the method could be in place within five years.



Mangroves' message from the grave

Mangroves help fight climate change but they're at serious risk from its effects. That's one of the findings from a study of a massive mangrove dieback that occurred in late 2015.

Local fishermen reported mangroves were dying along hundreds of kilometres along the Gulf of Carpentaria coastline, an area known for its barramundi fishing and high value commercial fisheries.

This caught the attention of Dr Damien Maher of Southern Cross University, who is interested in the chemistry of mangroves—how they store carbon in their soils, remove planet-warming nitrous oxides from the atmosphere, and neutralise ocean acidification by releasing alkaline chemicals into nearby waters.

Damien and his colleagues studied the dead zones, as well as adjacent areas that survived.

"The dead areas were emitting carbon dioxide to the atmosphere straight from the soils. The carbon cycle had shut down because the trees weren't locking up carbon anymore."

And the dead areas were no longer exporting alkalinity, a loss of the buffering benefits for marine life nearby that are vulnerable to ocean acidification, such as coral and shellfish.

Damien says this event is a warning of how increasing climate-linked stressors might affect these important ecosystems in coastal zones world-wide.

"Mangroves are valuable habitat that supports fisheries, and provide a natural defence against storm damage during tropical cyclones," Damien says. "We think a perfect storm of factors led to this dieback: monsoon seasons with very low rainfall, record high temperatures, and a strong El Niño event with lower sea levels, which prevented toxicity being flushed from soils."

Photo: Scientists had a rare opportunity to study the chemistry of mangrove dieback in the field, credit: Damien Maher

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Southern Cross University

Using stars to overpower superbugs

A star-shaped polymer is being harnessed by a University of Melbourne team to kill superbugs.

Professor Greg Qiao and his colleagues from the Melbourne School of Engineering have created an amino acid polymer that kills antibiotic-resistant bacteria by ripping apart their cell walls.

The rise of antibiotic-resistant superbugs is one of the world's greatest health threats, according to the World Health Organisation, which predicts 10 million deaths due to superbugs by 2050.

"The world urgently needs to find a replacement that bacteria won't become resistant to," Greg says.

Greg and his team discovered their polymer was successful at killing the top six most significant superbugs. It was also successful at killing bacteria in infected mice.

Significantly, the bacteria showed no sign of developing resistance to the polymer. A strength of the polymer is it targets bacteria via several pathways, which includes ripping apart cells walls, unlike conventional antibiotics which only use one pathway.

The polymer is also non-toxic, requiring 100 times the dose that kills bacteria before it starts to show toxicity against a red blood cell.

The discovery is the culmination of several years' work involving a cross-disciplinary team of both engineers and medical researchers, Greg says.

The team plans to develop the formula and prepare for phase one human trials in the next five years.

The robotic arm improves the ratio of patient-to-clinician time

Robotic arm to help stroke patients regain movement

A robotic arm is the key to a radical new stroke treatment, helping patients regain upper body movement.

Associate Professors Denny Oetomo, Ying Tan, and the team at The University of Melbourne together with Royal Melbourne Hospital have developed a device that helps stroke patients learn to use their bodies again by tracking their movements while performing exercises. Arm movements can be displayed on a computer screen, and the activities turned into a game.

"It also improves the ratio of patients to clinician time as the clinicians can handle multiple patients at one time," Denny says.

A common outcome of a stroke is limb paralysis. While many patients learn to walk again, rehabilitation is costly and time-consuming, so many never recover arm movement.

The robotic arm straps onto the patient's arm and is hooked up to a clinician-monitored computer. It can recognise patient effort and help provide the appropriate level of assistance or challenge to complete a movement.

It provides patients with varied exercises and reduces face-to-face clinician guidance, allowing more independent exercises to be carried out, thus increasing the chances that they'll continue with treatment. This leads to a much-improved rehabilitation process—the more a patient exercises, the faster they rewire their neural pathways.

The computer compiles detailed records that can be used to improve treatment regimes.

Denny is now looking at commercialising the robotic arm and hopes to obtain funding in the next 12 months. He hopes that eventually patients will use the robotic arm at home.

Sharpening vision in bionic eyes

A PhD student at The University of Melbourne has discovered a technique to improve the resolution of bionic eyes for people who suffer from retinal conditions such age-related macular degeneration and retinitis pigmentosa.

"Implants are really limited in how much resolution they can provide. I'm trying to improve that," says Kerry Halupka, who works with the Bionics Institute.

A bionic eye consists of a video camera mounted on glasses, which sends data via a computer chip to electrodes inserted at the back of a person's eye. The electrodes stimulate the remaining healthy cells in the retina, sending a signal to the brain, which interprets the image.

Improve the resolution of bionic eyes

Currently only one version of the implant is available to patients (in the United States and Europe), and for specific diseases only. But research at The University of Melbourne is hard on its heels.

Early retinal implants avoided stimulating a lot of electrodes at once because it resulted in unpredictable effects such as image distortion. Kerry is investigating how to improve the resolution by stimulating many electrodes at once without the unpredictable effects.

She built a computer model to predict outcomes of interactions between electrodes. It then suggests the best electrode stimulation pattern for improved vision.

"It's like taking a low-definition TV and making it high-definition without increasing the number of pixels," Kerry says.

While the research still needs to be refined, they hope human trials might be possible in under five years.

Photos: Kerry hopes her model will help improve the resolution in bionic eyes, credit: Thomas Spencer

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THE UNIVERSITY OF MELBOURNE

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Honey for your wounds?

The benefits of using medical-grade honey to treat and prevent infection in wounds has been confirmed by Sydney researchers.

Dr Nural Cokcetin tested more than 600 Australian honey samples and documented the antibacterial activity, which strongly corresponds to the levels of methylglyoxal (MGO), one of honey's most active ingredients.

"We have found there are regional and seasonal differences in the MGO concentration in honey from the same hive, so now want to understand whether the plant's growing conditions effects the composition," says Nural, a postdoctoral researcher at the ithree institute, University of Technology Sydney (UTS).

MGO acts by preventing bacteria attaching and spreading at a site of infection, but that's not the whole story.

"The reason honey is such a powerful treatment is that it has several modes of action so that, unlike a conventional antibiotic that has one mode of action, bacteria haven't been able to develop resistance," explains Nural.

Preventing bacteria attaching and spreading

Honey is a complex product that can reduce inflammation and, due to its sugar structure, draws moisture, making the environment less favourable for bacterial growth.

There are also enzymes in the honey that generate hydrogen peroxide—an antiseptic—and several other molecules with antibacterial action that they are still studying.

The ithree researchers hope that honey-impregnated wound dressings and treatments will begin to gain greater acceptance in mainstream medical practice.

The hidden infection causing infertility

One in five cases of infertility are caused by scars due to past infections with chlamydia, but in most cases people don't know they were ever infected. Researchers at the University of Technology Sydney have discovered that a specific set of our genes switch on within half an hour of infection, which could lead to new treatments.

"We're much closer to finding new biomarkers for detecting asymptomatic infections as well as new treatment targets," says Associate Professor Garry Myers, from the UTS ithree institute.

Chlamydial infections are the most common sexually transmitted disease that, if left untreated, can lead to infertility in men and women. The symptoms of infection are often undetectable.

"Up to 10 percent of people aged 20-39 are likely to have chlamydia," Gary says.

The bacterium *Chlamydia trachomatis* also triggers an immune response that induces wound repair processes that don't get shut down when treated with antibiotics. Moreover, some women have a stronger inflammatory response and are more likely to develop pelvic inflammatory disease—another consequence of chlamydial infection.

This overzealous healing process creates ongoing inflammation, tissue damage and scarring in the reproductive tract as well as a form of infectious blindness called trachoma found in developing countries.

Symptoms of infection are often undetectable

Manipulating *Chlamydia* in a lab is tricky as it only survives when growing inside a cell. But Gary created a system to track every gene contributing to different stages of the infection.

By comparing *Chlamydia* species, they've also separated a core response from species-specific responses.

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For more information:

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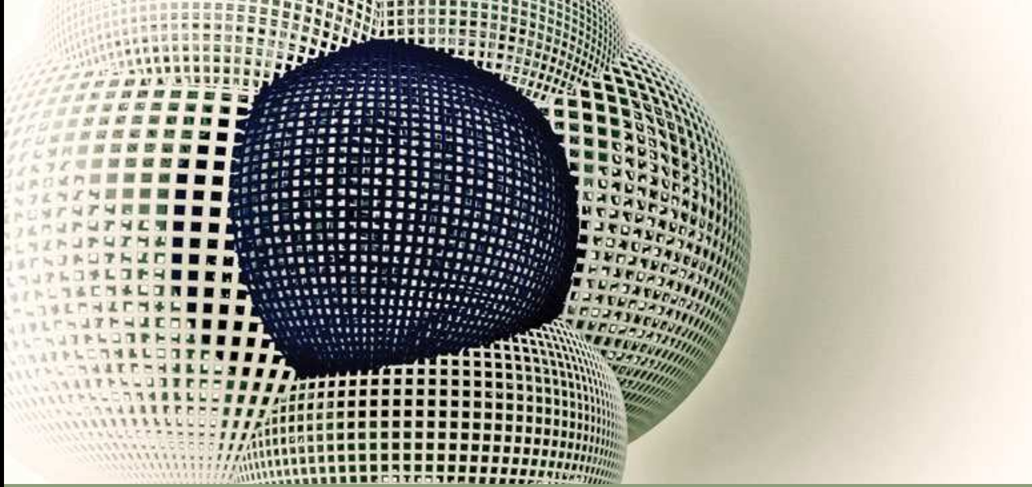


Nucleons are composed of quarks bound by gluons

Unravelling atoms: the Centre for the Subatomic Structure of Matter

Almost all matter we can see and touch is made up of the protons and neutrons. But what are protons and neutrons composed of? The simple answer is quarks, of which there are six distinct kinds, held together by gluons.

The 'strong force' carried by gluons is about 100 times stronger than electromagnetism, which governs the interactions of atoms. It's a major focus of the ARC Special Research Centre for the Subatomic Structure of Matter (CSSM).

Established 20 years ago at the University of Adelaide, the Centre is investigating the ramifications of quantum chromodynamics (QCD), the theory which describes the strong force interactions that are fundamental to how our world works.

Three quarks become five

Electrons within atoms can become excited when energy is injected—a phenomenon that forms the basis of photosynthesis and lasers. So can protons, neutrons and their exotic relatives. Now CSSM physicists have shown that this can lead to a total rearrangement in their internal structure, which may well give rise to unusual properties.

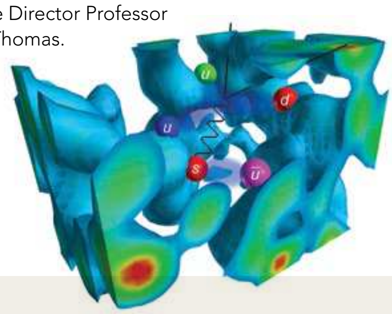
Almost all matter we can see and touch is made up of protons, neutrons and other baryons. These subatomic particles are composed of three quarks held together by gluons. There are six types of quark but we only encounter two, the up and down quarks. The next simplest three-quark particle is the Lambda particle, where one of the quarks in a proton or neutron is replaced by another type, the strange quark. Lambda particles can form on Earth in accelerator facilities or when cosmic rays strike. But they are unstable and decay almost immediately.

It was recognised in the 1960s that the energy of the lowest excited state of the Lambda particle is much lower than that calculated on the basis of an internal structure composed of just three quarks. This was recognised as a problem for QCD theory.

Using supercomputers CSSM researchers have now been able to calculate what should happen directly from first principles of QCD.

The team found the lower energy level is explained by the three quarks rearranging into a five-quark system—including an antiquark.

"The internal structure went from a single atom into something more molecular with two different quark-structures bonded tightly together," says CSSM Associate Director Professor Derek Leinweber, who conducted the work with colleagues including PhD candidate Ben Menadue, senior research fellow Dr Waseem Kamleh, and Centre Director Professor Tony Thomas.



Towards stable superheavy elements

Physicists imagine the atomic nucleus simply as a weakly-bound collection of protons and neutrons (nucleons).

But protons and neutrons have an internal structure, and building this into models of how atomic nuclei are constructed can lead not only to a different and better understanding of the world around us, but also to predictions of new forms of matter, says CSSM director, Professor Tony Thomas.

In the 1970s, it was recognised that nucleons are composed of quarks bound by gluons. Given the relativistic forces at play between these subatomic elements, and how closely the protons and neutrons are packed, a suggestion arose that this internal structure might change as they bind together.

The diameter of a nucleon is about a hundred thousandth that of an atom, Tony says. And in the nucleus of an atom of lead, for instance, the distance between them is about the same.

"They are almost touching," Tony says. "So, they must be feeling the forces of the other quarks and gluons in nearby protons and neutrons." Tony and three international colleagues have done calculations reflecting this and recently published them in the leading American physics journal, *Physical Review Letters*. They found that by incorporating such forces and the resulting internal changes, the outcomes closely matched the known binding energies of nuclei across the whole Periodic Table. In fact, their results grew even more accurate as atoms became heavier. The group is now awaiting confirmation of this remarkable new picture of the atomic nucleus from measurements at Jefferson Lab in the US.

As physicists generate ever-heavier nuclei, the new elements they form become increasingly unstable. But, based on this picture of changes of internal structure as protons and neutron bind, Tony thinks it possible we will find a group of stable superheavy elements—if we just go high enough.

Photos: An artist's rendition of the structure of the Lambda 1405 baryon resonance, credit: Derek Leinweber, CSSM, University of Adelaide

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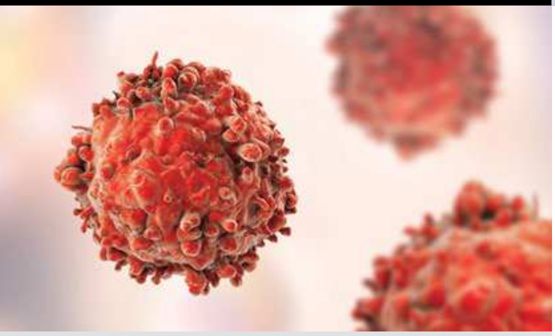
Improving survival for patients with acute leukaemia



Today, 85 per cent of children with leukaemia can be cured, but the outlook for patients over 60 is bleak.

Only 10 per cent survive beyond one year as their cancer adapts to weather the storm of standard chemotherapy treatments. Associate Professor Steven Lane wants to change that.

Steven and his team at the QIMR Berghofer Medical Research Institute have developed a method to rapidly profile the genetics of different leukaemia types—of which there are hundreds—and model them in the lab. This allows them to work with many types simultaneously, providing a cheaper, faster and more accurate model of the leukaemia.

Resistance to standard chemotherapy treatments occurs in most patients with acute myeloid leukaemia, and it's particularly common in those patients over 60.

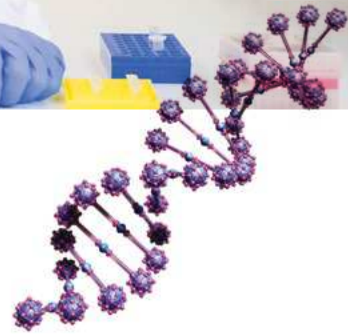
A cheaper, faster and more accurate model of the leukaemia

Steven's previous research revealed that rare leukemic stem cells allow the cancer to last through treatment then later grow out, driving the relapse in these patients.

Working with cells from patients with resistant cancers, and with mice, he has mapped the effectiveness of individual chemotherapy treatments against the genomes of individual cancers.

With the help of a CSL Centenary Fellowship, he's looking at tailoring treatments to individual patients. Specifically, to identify new drug pathways and explore repurposing existing drugs to target resistant leukaemia types.

Are memories stored in DNA?



The idea that long-term memory might be stored in our brain's DNA is being tested by Professor Geoff Faulkner, using brains affected by Alzheimer's.

Geoff has already shown that the DNA in our brains is different to the DNA in the rest of our bodies and that it changes as we learn. He's proposing that these changes are associated with how we store our long-term memories.

More recently, he's linked these differences to the function of genes in the hippocampus, the part of the brain that controls memory and spatial navigation, and has been implicated in memory loss with ageing, schizophrenia and Alzheimer's disease.

With his colleagues at the University of Queensland, Geoff is going to examine brain tissue donated by Alzheimer's patients to determine if DNA is involved in memory formation, and what the implications of this might be for people living with Alzheimer's.

His research is moving us closer to an understanding of life's blueprint and how we manage diseases like schizophrenia and Alzheimer's.

Longer term, he's interested in answering the basic questions of how changes to DNA during life affect how the brain functions, and whether we need the changes in the DNA in the brain for the brain to work.

Moving us closer to an understanding of life's blueprint

Geoff received one of the inaugural CSL Centenary Fellowships and will undertake this work at the Mater Research Institute-University of Queensland (MRI-UQ) and the Queensland Brain Institute (QBI).

Stories of Australian Science

The DNA in our brains is different to the DNA in the rest of our bodies

Photos: Geoff wants to know how changes to DNA during life affects how the brain functions, credit: Mater Research Institute-University of Queensland (MRI-UQ)

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Graphene lenses; harnessing the Internet of Things; and more: Swinburne University of Technology

Gravitational waves—looking further

The brainpower of 18 institutions and more than $30 million are expanding the net to detect gravitational waves, and cement Australia's role in the emerging field.

Gravitational waves have captivated the world since their first detection by the US-based Laser Interferometer Gravitational-Wave Observatory (LIGO) in 2016. Australian scientists played important roles, including developing coatings and polishing techniques for the 40kg mirrors (which reflect high-power lasers), and building a mini-LIGO experiment to study the instability the lasers cause in the mirrors.

Now, OzGrav (the Australian Research Council Centre of Excellence for Gravitational Wave Discovery) will be interpreting LIGO data and concentrating on types of signals LIGO isn't 'tuned' to detect—including ripples with longer wavelengths and the death-cries of supermassive black holes.

Swinburne University of Technology's Professor Matthew Bailes leads OzGrav, and many of its chief investigators supported the original discovery. They'll help validate the prototype pulsar processors developed at Swinburne for the giant Square Kilometre Array radio telescope, and Professor Jarrod Hurley is designing a $3.5 million supercomputer to run simulations and process observational data.

OzGrav is a partnership between Swinburne, Australian National University, Monash University, University of Adelaide, The University of Melbourne, University of Western Australia, 10 overseas groups, and other collaborating Australian organisations.

Lenses a fraction of a hair's width, faster communication and better solar cells

A lens just a billionth of a metre thick could transform phone cameras. Swinburne researchers have created ultra-thin lenses that cap an optical fibre, and can produce images with the quality and sharpness of much larger glass lenses.

"Compared with current lenses, our graphene lens only needs one film to achieve the same resolution. In the future, mobile phones could be much thinner, without having to sacrifice the quality of their cameras. Our lens also allows infrared light to pass through, which glass lenses don't," says Professor Baohua Jia, a research leader at Swinburne's Centre for Micro-Photonics.

Could soon replace conventional batteries

Producing graphene can be costly and challenging, so Baohua and her colleagues used a laser to pattern layers of graphene oxide (graphene combined with oxygen). By then removing the oxygen, they produced low-cost, patterned films of graphene, a thousand times thinner than a human hair.

"By patterning the graphene oxide film in this way, its optical and electrical properties can be altered, which allowed us to place them in different devices," Baohua says.

Warm objects give off infrared light, so mobile phones with graphene lenses could be used to scan for hotspots in the human body and help in the early identification of diseases like breast cancer.

By attaching the lens to a fibre optic tip, endoscopes—instruments that are currently several millimetres wide—could be made a million times smaller. Baohua's work on graphene lenses was published in 2015 in *Nature Communications*.

The team is also investigating graphene's amazing properties for their potential use as supercapacitors, capable of storing very large amounts of energy, which could soon replace conventional batteries.

Baohua's work has also contributed to the development of speedier telecommunications, and cheaper and more efficient solar cells.

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Quantum computers with photons

The idea behind quantum computing has been around for almost half a century, but getting to a point where quantum effects can be created experimentally has taken a long time.

Now that materials physics and photonics have caught up, the race is on to devise and construct a quantum device that can out-compute today's solid-state silicon supercomputers.

And Swinburne is leading the way with the use of photons. Professor David Moss, Director of Swinburne's Centre for Micro-Photonics, has been using light to develop better devices for data communications and processing, and his research has taken him to the leading edge of quantum technology.

In collaboration with colleagues around the world, David and his team have demonstrated a computer chip that overcomes two of the most challenging obstacles to commercial realisation of quantum technology—generating a continuous high-volume supply of quantum particles, and producing the device using conventional mass-fabrication techniques.

"Our device represents an unprecedented leap in the quality, sophistication and sheer number of quantum entangled photon pairs that can be generated on an integrated chip, and we did it using a chip that is compatible with conventional integrated circuit fabrication methods," David says.

"Realising quantum functions on photonic integrated chips or circuits will be critical to moving quantum technologies out of the laboratory and into the real world."

Tuning out our internal voices

Hearing voices is normal, says Swinburne's Professor Susan Rossell. But sometimes those voices can cause extreme disruption.

Susan suspects our brain's ability (or inability) to tune out our internal voice may be involved in the auditory hallucinations experienced by many with schizophrenia.

She's using powerful new imaging technology to see what happens inside the brain just before the onset of voices, and what can be done to help manage it.

"We all have internal dialogue but we can choose to listen to our thoughts or not," Susan says.

Her previous work has shown that this internal dialogue activates the same regions of the brain—the language processing centres—as when someone real is talking to us. Most people can tune this voice out, along with all the other superfluous sounds we're constantly exposed to, such as traffic noise or other conversations.

"We think people who hear voices can't correctly filter out the noise in the world around them, and included in that is their own internal dialogue."

Her colleagues Associate Professor Neil Thomas and his PhD student Imogen Bell are using smartphones to look at what might be happening outside the brain at that same moment.

Harnessing the data from everything that's online

From cars that know when they need a mechanic and where to find one, to improving transport links between affordable housing and employment centres—Professor Dimitrios Georgakopoulos wants to harness the mass of information generated by the internet of things (IoT). This consists of every device or 'thing' (including people) connected to the internet and each other.

Dimitrios' cloud-based platforms and real-time data analysis engines have boosted productivity in farming and renewable power generation.

While at CSIRO, Dimitrios was approached by the High Resolution Plant Phenomics Centre and the Grains Research and Development Corporation to develop a sensor-based system to take the legwork out of crop trials conducted in approximately two million test plots around the country.

After struggling with logistics and costs of deploying just 150 compatible sensors, "we had the idea to leave the selection, purchase and deployment of the sensors to the growers and plant scientists," Dimitrios says.

His team developed an IoT-based data collection and analysis system that could use data from almost any such sensor, which quickly grew to include thousands of plots and more than 65,000 sensors. He now plans to work with the manufacturing industry to make IoT tools a reality for the next generation of factories. And, through work with authorities, citizens, and service providers in cities across the world, he hopes to improve transport, energy generation, and disaster response, as well as sustainability.

For more information:
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Photos: The graphene lens achieves the same resolution as glass with only one film, credit: Eamon Gallagher; David is using light to improve data communications, credit: Eamon Gallagher; Susan is studying why some people hear voices, credit: Eamon Gallagher

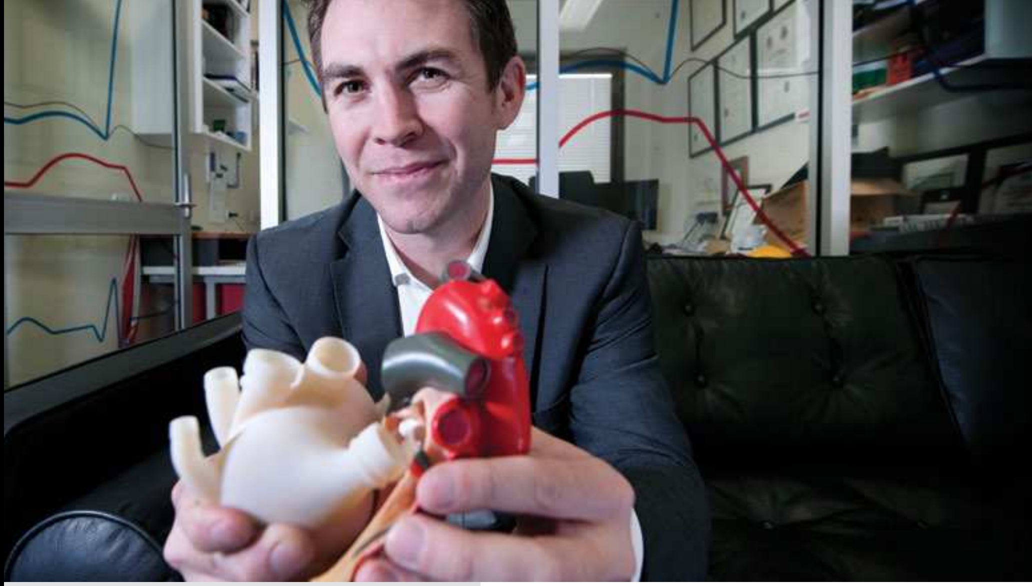
SWINBURNE UNIVERSITY OF TECHNOLOGY

America and Australia: partners in innovation

Australia and the USA have long been close partners in research and innovation. And Australian inventions have had a huge impact on American lives. The bionic ear is introducing children to the hearing world. Vaccines are protecting against cancer. Chewing gum is repairing tooth decay. And Australian astronomy helped make Wi-Fi fast and reliable. Here we feature some of the latest collaborations and achievements. These stories were written by Science in Public for the Australian Embassy in Washington DC.

Read more about these, and other Australia-US partnerships at stories.scienceinpublic.com.au/usa including:

- Creating quantum computers
- Extended-wear contact lenses
- Protecting grain from insect attack
- Clean air underground
- Plastic mirrors on Ford trucks



A new heart

Soon, US patients with heart failure who don't have a donor heart lined up could have the option of a new heart.

In 2015 a team at the Texas Medical Center gave a sheep a new heart. Within six hours of the operation it was on its feet and eating. The heart was the invention of a Brisbane researcher, Dr Daniel Timms.

Propelling blood through the device and around the body like a fan

The BiVACOR artificial heart weighs half a kilo, and is small enough for a child while also being powerful enough for an adult. It's made up of a titanium outer shell with a small spinning disk inside that levitates within a magnetic field, propelling blood through the device and around the body like a fan.

Daniel dreamed up the idea of an artificial heart as a 23-year-old, and went on to develop and create the technology at the Queensland University of Technology.

From car batteries to grid storage

There's still life in lead batteries. East Penn Manufacturing operates the largest single-site, lead-acid battery manufacturing facility in the world in Berks County, Pennsylvania.

They argue that their new lead batteries are 99 per cent recyclable and ideal for large-scale storage.

To prove it, they're developing a 3MW power storage system using the UltraBattery technology invented by Australia's CSIRO.

By combining lead-acid technology with a supercapacitor, the UltraBattery not only charges and discharges rapidly, but lasts four to five times longer than an ordinary battery.

Boeing has adopted a CSIRO paint technology that is easier to apply, and safer for workers and the environment

Paint fit for a Dreamliner

Next time you board a Boeing Dreamliner, take note of its Australian paint. Developed by researchers at CSIRO, 'Paintbond' has now been adopted across the entire Boeing jetliner fleet. Why is it better? The new spray-on topcoat paint technology saves time, reduces the impact on the environment, and is safer to use.

The polyurethane topcoat paint traditionally used on commercial aircraft protects them from rain, hail, sand, and dust. But the paint needs regular re-coating and that's a time-consuming process.

Before Paintbond, this involved sanding down the old coat of paint before applying a new top coat—a slow process that has a high injury rate for workers, produces harmful particles, and has the potential to damage the aircraft. Paintbond can be sprayed on and followed by a fresh coat of paint just 30 minutes later.

@ausscistories

Protecting phones, robots and governments

Your smartphone is likely being protected from cyberattacks and software faults by Australian software that works within the kernel of the phone's operating system.

Now CSIRO's Data61 Group are working to secure America's growing fleets of autonomous machines, with 'microkernel' software known as seL4.

In a recent trial, Boeing's unmanned Little Bird Helicopter was protected from cyberattacks by the software, which is also being used on autonomous US Army trucks being developed with the support of the DARPA High-Assurance Cyber Military Systems program.

The genius of seL4 lies in its isolation between software compartments.

"If your software runs the seL4 kernel, you have a guarantee that if a fault happens in one part of the system it cannot propagate to the rest of the system, in particular the critical parts," Dr June Andronick from Data61 explains.

The genius of seL4 lies in its isolation between software compartments

Heading into deep water

Out in the Gulf of Mexico Chevron are operating a $7.5 billion platform recovering oil and gas from two-kilometre-deep ocean.

It's the largest and deepest operation in the Gulf, with over 146km of pipeline bringing oil and gas to refineries.

But pipelines operating at extreme depths in cold water and crushing pressure are prone to blockage. University of Western Australia researchers are helping Chevron keep oil and gas flowing.

Deep ocean blockages are difficult and expensive to fix

Ice-like solids known as gas hydrates can form in pipelines when water and natural gas are exposed to high pressures and the low temperatures of the ocean floor.

"Deep ocean blockages are difficult and expensive to fix. You can't send divers down," says Eric May, the Chevron Chair in Gas Process Engineering at the University of Western Australia.

"We've shown that new pipeline heating technologies are safe for both preventing and removing hydrate blockages. Working with Chevron Energy Technology Company in Houston, Texas, we've made software available to industry to help assess the risk of blockage."

The UWA team have established the Australian Centre for LNG Futures with the support of GE Oil and Gas, Clough Engineering, and the Australian Government.

'Blood tests' for big machines

Mining companies across America are giving their big machines regular health tests and comparing the results with a global database for that machine.

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

Dingo maintenance support has improved the engine life of a widely used family of CAT mining trucks by an average of 61 per cent.

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

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

Dingo's health checks are like a blood test for trucks

Photos: The BiVACOR device could act as an alternative to a heart transplant, credit: Queensland University of Technology; Australian researchers are helping Chevron keep oil and gas flowing through deep-water pipes, credit: Chevron Australia

Japan and Australia: partners in innovation

Chewing gum that reverses tooth decay; giant robot trucks carrying ore; searching for new malaria drugs—Japan and Australia have a long history of collaboration in science and innovation. Here we profile some recent examples.

These stories and videos were produced by Science in Public for the Australian Embassy in Tokyo.

Harnessing the sun

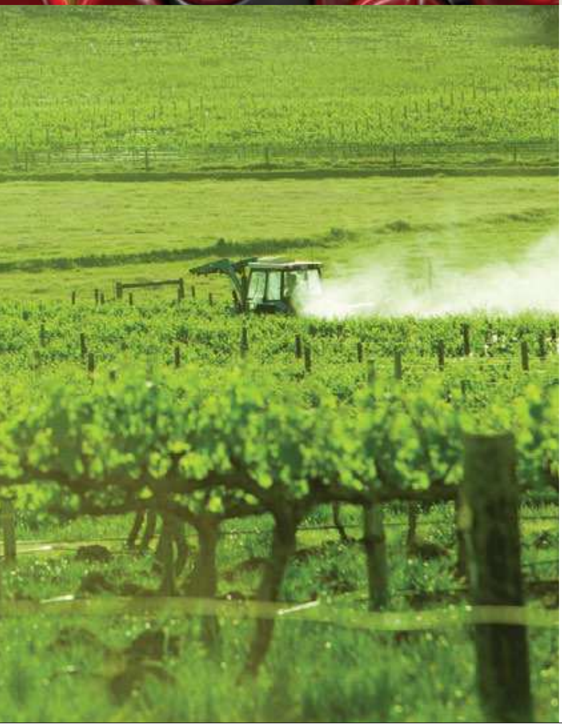
Mitsubishi Heavy Industries have built a pilot concentrated solar power plant in Yokohama. It uses CSIRO technology now being manufactured by South Australian company Heliostat SA.

"We're making seven and a half metre square solar mirrors," says David Linder-Patton, the CEO of Heliostat SA. They focus the sun's energy into a tower receiver which generates heat which can be used in industries such as steel manufacturing, brick processing and mineral refining.

The Mitsubishi plant will test their technology on receivers they have developed and also CSIRO's suntracking technology and heliostat manufacturing.

"Working with companies the size of Mitsubishi helps us to get to industrial scale a lot quicker than we could do otherwise," says David.

Seven and a half metre square solar mirrors



Improving agriculture, together

A new approach to horticultural spraying could be the result of a collaboration between design students from Kyoto Institute of Technology and Swinburne University in Melbourne.

"Yanmar is a manufacturer of farm machinery, and they asked us to solve a big problem for grape-growers," says Natsumi Takamatsu, a design student at Kyoto.

"What we developed was a sprayer to mitigate the drift of sprayed agricultural chemicals. Really it was the actual viticulturists when we interviewed them and they were saying things like 'If only I had something like this.'"

"Australia and Japan enjoy the seasons at opposite times of the year so we can conduct field research in the vineyards all year," says Yoshiro Ono from Kyoto Institute of Technology.

Making mining safer

In Western Australia's Pilbara iron ore mines a fleet of robot trucks are moving more than a billion tonnes of dirt and rock. The giant trucks carry 350 tonnes in every load. They've been developed over the past decade in partnership with Komatsu.

"Rio Tinto and Japan's Komatsu came together to produce not just the robots but a technology that is immensely useful to Rio Tinto. Putting those things together has produced a fantastic result," says Tetsuji Ohashi, the CEO of Komatsu.

"Mining in the future is all about moving lots and lots of material more efficiently," says Michael Gollschewski, the MD of Rio Tinto's Pilbara mines.

"Today we've got controllers sitting in the operation centre in Perth, overseeing 72 autonomous trucks 1500 km away in the Pilbara across three different sites. It's amazing," he says.

Giant robot trucks carry 350 tonnes in every load

Repairing teeth together

Across Japan teeth are being made stronger with chewing gum and other products using an ingredient discovered in Australian dairy milk. Now an innovative Japanese company is taking the Australian discovery to dental surgeries around the world.

"Our discovery was based on milk, to develop a delivery system of calcium phosphate to make teeth stronger," says Eric Reynolds, from The University of Melbourne.

Clinical trials of the chewing gum showed that it helps stop tooth decay and helps reverse early stages of tooth decay.

"The Recaldent chewing gum was very successful in Japan and the leading dental supply company in Japan, GC Corporation, then became interested in the technology.

"We've developed materials for repair of tooth decay and damage but now we're focusing on prevention and protection collaborating with Melbourne University," says Satoshi Tosaki from GC Corporation.

"One of those products is a cream, in Australia it's called Tooth Mousse, that's sold to dentists to strengthen patients' teeth and that's now sold in over 50 countries worldwide," he says.

"I've really enjoyed working with GC because I've learnt a lot from them in terms of business. But I think the most gratifying thing is that their products actually help people, and substantially reduce the burden of oral disease," says Eric Reynolds.

Fighting disease together

Malaria kills 500,000 people every year. And 90 per cent of those are children. Griffith University researchers are screening hundreds of thousands of compounds supplied by Japanese companies to find the right compound with activity against the malaria parasite.

Japan's Global Health Innovative Technology Fund is supporting the research as part of their search for new ways to fight malaria.

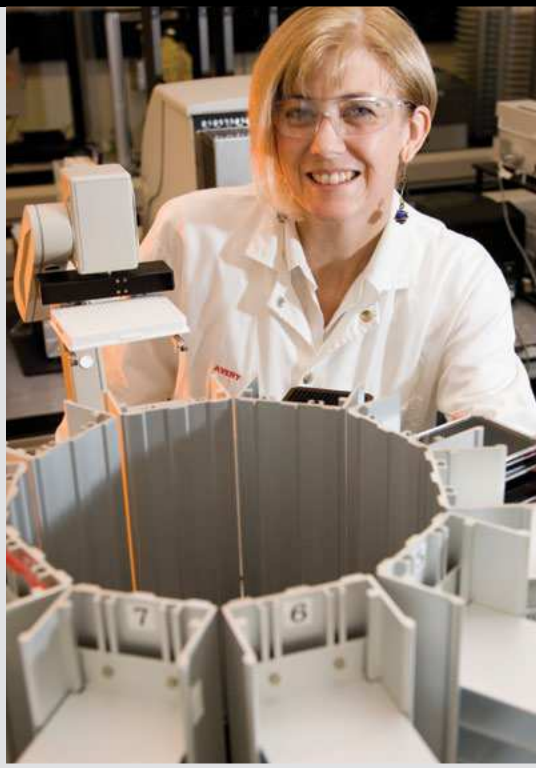
"GHIT is a fund that invests in partnerships between Japanese and non-Japanese entities," says BT Slingsby, the Executive Director of GHIT.

"Many of those entities are in Australia including The University of Melbourne, The Walter and Eliza Hall Institute, and Griffith University."

"Currently we're working with companies such as Daiichi-Sankyo, Takeda, Mitsubishi Tanabe, and Eisai," says Griffith University's Vicky Avery.

Search for new ways to fight malaria

They bring those compounds to us. We then dispense them into plates which contain the parasite we're trying to kill. After they've been incubated for a period of time we then look to see whether they've had an effect in killing the parasites.



"Once one defines a hit, usually it's the pharmaceutical company that drives forward the further development of that compound to create a drug.

"This collaboration is fantastic in that it has three groups who complement each other," Vicky says.

The Japanese pharma companies bring expertise in drug discovery and development. GHIT has managed to pull together significant funding from both global partners as well as the Japanese Government. And Griffith University brings the biology expertise.

More Japan stories and videos at stories.scienceinpublic.com.au/japan

Photos: Hundreds of thousands of compounds are being tested for their malaria-fighting abilities, credit: Melissa Sykes; The mirrors focus the sun's energy for manufacturing and more, credit: CSIRO; Drift of sprayed agricultural chemicals is a big problem for growers, credit: Swinburne University of Technology/ Kyoto Institute of Technology; robot trucks are moving tonnes of dirt and rock, credit: Komatsu; The gum helps reverse tooth decay, credit: Oral Health CRC; Vicky Avery studies the treatment and prevention of malaria, credit: Griffith University

Radar in a suitcase; rain gardens to stop floods; earthquake-proofing ports: The Australia-Indonesia Centre

The Australia-Indonesia Centre and its supporters are funding collaborative research in energy, health, infrastructure, urban water, and food and agriculture. Here are some highlights. Find out more about Australia-Indonesia Centre partners and projects at www.australiaindonesiacentre.org

Growing food and stopping floods with rain gardens

Small urban 'rain gardens' are popping up all around Australia and Indonesia to keep waterways free from pollutants, stop flooding and erosion, and to grow food.

Although they may look similar to a normal garden, beneath the surface rain gardens are a sandwich of layers of sand, gravel, roots and microbes through which polluted water passes and clean water exits, which can then be used for irrigation or washing.

"Rain gardens are one of the best landscaping design ideas to come out of Melbourne—they are easy to maintain and water saving," says Associate Professor David McCarthy from Monash University's Environmental and Public Health Microbiology Laboratory.

Supported by The Australia-Indonesia Centre, David is working with Professor Hadi Susilo Arifin of Bogor Agricultural University to bring rain garden technology to communities in Bogor, Indonesia.

Hadi and his team are working with three communities in Bogor to adapt Melbourne's rain garden technology, and hope to educate people about water hygiene in the process. He also hopes that villagers will self-organise to use the better-quality water in creative ways.

Earthquake-proofing ports

Researchers from The University of Melbourne are learning how to modify existing Indonesian and Australian ports so earthquakes don't do such devastating damage to sea trade.

"What we currently have is a recipe for disaster. Some of the port infrastructure is over 100 years old and wasn't designed to cope with the loads they are currently bearing, let alone an earthquake," says Dr Massoud Sofi.

He's a member of The Australia-Indonesia Centre's Infrastructure Cluster, which is leading this project. They're collecting data on the deterioration and load capacity of Port Teluk Lamong in Surabaya, the Port of Melbourne and Port of Hastings in Australia, as well as natural features of the surrounding landscapes. They'll use this to develop a computer model to subject to earthquakes.

Radar-in-a-suitcase making bridges safer

Assessing ageing bridges just got safer and easier, thanks to a high-tech radar device that fits inside a suitcase.

Developed by Dr Lihai Zhang of The University of Melbourne as part of a collaborative research project supported by The Australia-Indonesia Centre, the IBIS-S radar technology can scan a bridge in 15 minutes from a kilometre away, quickly assessing its condition and stability.

"Just like humans, bridges fatigue and deteriorate and need to be looked after," Lihai says.

"Using radar-in-a-suitcase, we can better predict when bridges need maintenance and repairs so workers will be safer and budgets will be more effectively spent."

Using structural drawings provided by VicRoads, the radar-in-a-suitcase measurements, and soon a drone that can 'see' cracks in bridges using image recognition, Lihai and his team have built 3D computer models that can predict how the bridge, in its current condition, would respond to damage and disaster.

He'll be taking his suitcase to Surabaya to work with Professor Benjamin Lumantarna of Petra Christian University to assess the health of Indonesia's bridges.

The project is supported by The University of Melbourne, Petra University Institut Teknologi Bandung, Benjamin Gideon and Associates, Institut Teknologi Sepuluh Nopember, and VicRoads.

Find out more about Australia-Indonesia Centre partners and projects at www.australiaindonesiacentre.org

Photos: Drainage pipes directly from shower/toilet room to the river, credit: Hadi Susilo Arifin; Drones will help engineers efficiently assess cracks in concrete bridges, credit: Lihai Zhang

For more information: The Australia-Indonesia Centre, Andrew Tijs, andrew.tijs@australiaindonesiacentre.org

Prehistoric volcanoes to prospect for metals

The remains of volcanoes from billions of years ago are helping scientists identify both bygone continental boundaries and new places to find mineral resources in Australia.

Volcanoes often form where continental plates collide. Small amounts of water and carbon dioxide in an ocean crust forced under another continent can cause the mantle—the solid interior of the planet—to melt at several hundred degrees lower than normal. When these melts move to the surface, they erupt as volcanoes.

Predict the kinds of rocks and resources that may be found

"Specific types of volcanoes have specific mineral resources associated with them. For example, gold is strongly associated with volcanoes in island arcs," says Professor Stephen Foley, a petrologist and geochemist at the ARC Centre of Excellence for Core to Crust Fluid Systems.

Stephen studies the melts that move around the Earth's mantle at depths of up to 200 kilometres below the crust. By looking at the volcanoes and melt compositions that occur on modern Earth, he can identify where rift valleys and volcanoes used to be, and predict the kinds of rocks and resources that may be found there.

"Many of the mineral resources and metals we're looking for in Australia, such as nickel or gold, were formed in the first half of Earth's history, about 2.5 to three billion years ago," Stephen says.

"We're looking for evidence of fault lines and former rift valleys where volcanoes or particular types of melts would be concentrated.

"The volcano may be long gone because of erosion, but we can still find the feeder dykes that took the melts up to the surface. These feeder dykes and their composition help us know where to look for which mineral resources."

Many of the mineral resources and metals we're looking for in Australia, such as nickel or gold, were formed about 2.5 to three billion years ago

Detection of cancer and PTSD

By 2020, multiple sites worldwide will be trialling a non-invasive test for post-traumatic stress disorder (PTSD). The machine can determine if soldiers and emergency workers are prone to the disorder, and if so, they may be rested and not immediately deployed again.

An early warning for changes leading to breast cancer is undergoing clinical evaluation in four Australian hospitals, using the same technology. Years before breast cancer strikes, the technology, an elaboration of MRI known as magnetic resonance spectroscopy (MRS), detects the cellular changes that prepare the way.

As well as assisting early intervention, this would allow the 50 per cent of women at high risk for breast cancer, but not carrying BRCA breast cancer genes, to know if they have deregulation in their tissues.

The research is led by Professor Carolyn Mountford, the Translational Research Institute (TRI) CEO, who has worked on MRS for nearly 30 years at several Australian universities and the Harvard Medical School. Its transformation into a medical technology is in collaboration with the Draper Laboratory at the Massachusetts Institute of Technology and Siemens Healthcare.

MRS provides information about the chemical environment in tissues and organs, identifying the presence of specific chemicals such as those formed when the breast or brain undergoes 'deregulation' in the case of breast cancer or PTSD.

Early warning for changes leading to breast cancer

Other applications include measuring chronic pain or showing the damage caused by repeated concussion in contact sports.

"The breast cancer and PTSD projects are good examples of what TRI is about, getting innovation out there for public use," Carolyn says.

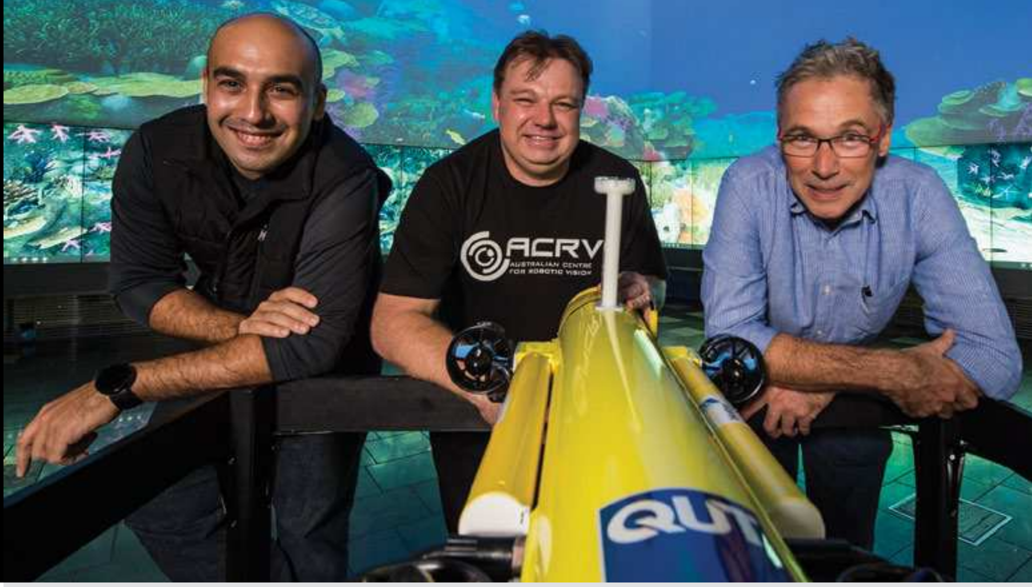
"A big, multidisciplinary, international team has worked on this for a long time. The people who have made it possible, however, are Australian clinicians—some of the best on the planet—who have given their time free."

Photos: The same technology is being used to find early warning signs for breast cancer and PTSD, credit: Translational Research Institute

For more information: ARC Centre of Excellence for Core to Crust Fluid Systems, Macquarie University, Stephen Foley, +61 2 9850 9452, stephen.foley@mq.edu.au; Translational Research Institute, Carolyn Mountford, +61 7 3443 7715, oce@tri.edu.au

Technology to save the reefs

Mapping reefs with drones; robots destroying crown-of-thorns starfish; coral as a rain-maker; and more—researchers at the Queensland University of Technology (QUT) are investigating new technologies to protect Australia's reefs.



The hidden reef made of giant algae doughnuts

A hidden reef exists behind the Great Barrier Reef—but it's three times bigger than previously thought, constructed by algae, and made up of doughnut-shaped mounds.

Uncovering the true scale of the 6,000 km^2 structure was made possible by airborne laser mapping technology LiDAR, provided by the Royal Australian Navy. It has implications for the Great Barrier Reef's habitat mapping and conservation zoning, as well as providing possible insights into past climates.

Halimeda is a common green alga made of living calcified segments and is responsible for the doughnut-shaped mounds, each 200–300 metres wide and up to 20 metres thick at the centre. When *Halimeda* die the calcified segments create limestone flakes that build up and over time create the reef-like mounds, called bioherms.

"While it was known that these structures existed in the northern Reef, their true shape and extent was unknown," says lead author Mardi McNeil of QUT.

"This is the first time that *Halidema* bioherms have been mapped in 3D. It raises questions into their role in carbon storage, providing habitat for reef creatures, and whether they're susceptible to impacts from ocean acidification—since *Halimeda* is a calcifying organism."

Their true shape and extent was unknown

The team has begun analysing sediment cores taken from the mounds. Future work will include field surveys of the surface and sub-surface of the seafloor across the bioherms.

Researchers hope to learn what the bioherm's sediments can reveal about reef evolution, past climates and environmental change on the Reef over a 10,000-year time-scale.

Robo reef protector

A fleet of autonomous robots is being developed by Queensland scientists to kill crown-of-thorns starfish (COTS), and monitor the health of the Great Barrier Reef.

Dr Matthew Dunbabin and Dr Feras Dayoub of QUT are working with the Great Barrier Reef Foundation to create the RangerBot, following successful field trials of QUT's COTSBot in 2016. RangerBot, a lower-cost version of COTSBot, will be used to monitor coral health, water quality and temperature, pest species, pollution and silt. It received the $750,000 People's Choice award in the 2016 Google Impact Challenge Australia.

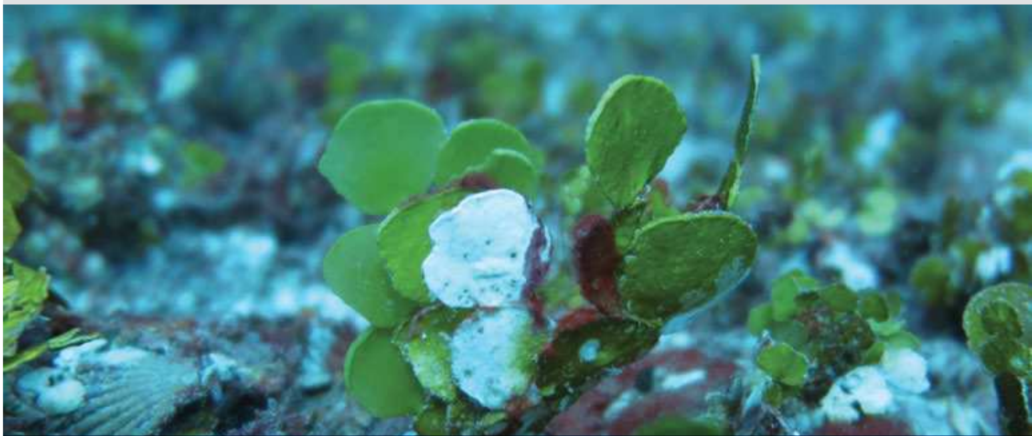
Underwater almost three times longer than a human diver

COTSBot has an inbuilt injection system to deliver a fatal dose of bile salts into crown-of-thorns, using machine learning to identify and inject the starfish. Crown-of-thorns are thought to be responsible for 40 per cent of total coral cover decline on the Reef. The robot was designed to sweep an area for all but the most hard-to-access starfish, which specialist human divers pick up.

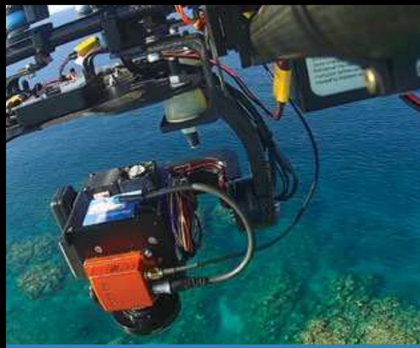
RangerBot will be smaller than COTSBot and have a set of vision-based sensors and attachments for its monitoring activities.

Unlike current single-purpose marine robots—which are manually operated, expensive, and use acoustic technologies—it will be built using only vision-based technologies.

The RangerBot will be designed to stay underwater almost three times longer than a human diver, be capable of working day and night and travelling up to 14 times further than divers.



For more information:
Queensland University of Technology, Institute for Future Environments, +61 7 3138 9500, ife@qut.edu.au



Hyperspectral cameras are being sent over our reefs to collect more detailed vision

Mapping species and coral bleaching by drone

Advanced, miniature cameras on drones are capturing details of landscapes that have previously been invisible. QUT researchers are using them to fly low over reefs, capturing almost 100 times the colours captured by standard cameras.

"High-altitude surveys of reefs may lack the resolution necessary to identify individual corals or bleaching effects," says Associate Professor Felipe Gonzalez, who is leading a team of researchers and unmanned aerial systems (UAS) engineers from QUT in a partnership project between QUT and the Australian Institute for Marine Science (AIMS).

"Normal cameras record images in three bands of the visible spectrum—red, green and blue—and mix those bands together to create colours as humans see them.

"A hyperspectral camera captures 270 bands in the visible and near-infrared portions of the spectrum, which provides far more detail than the human eye can see.

"Since we're flying it on small UASs—commonly known as drones—at 30 – 100m over the water, we can get an incredibly high resolution," Felipe says.

The team has used the drones over Western Australia's Ningaloo Reef, and collected vision from the Great Barrier Reef while AIMS conducted complimentary underwater surveys.

QUT is now working on building underwater housing for a hyperspectral camera so the technology can be used in marine robots.

"The huge amount of information we can get will allow us to classify coral species, sand and algae, or coral bleaching based on unique spectral signatures, which act much like fingerprints," Felipe says.

Provides far more detail than the human eye can see

Researchers are building artificial intelligence algorithms to automatically recognise and classify the signatures, so these can be added to a database for future research. This kind of analytic software could also be used in detecting invasive plants and crop diseases.

Does coral help create rain?

Researchers have found that coral reefs may play a key role in cloud formation. Now they're working to make climate modelling more accurate.

Australian and international scientists, led by QUT's Professor Zoran Ristovski, spent a month in late 2016 collecting data on airborne particles emitted from the Great Barrier Reef, which they are now analysing.

Corals produce large amounts of dimethyl sulphide (DMS), a natural aerosol which can form cloud-seeding particles. But when coral is under stress, the amounts it produces varies.

Understanding the cloud-forming role of coral

"Aerosol particles play a key role in regulating global climate, by scattering and absorbing radiation from the sun and by taking up water vapour from the atmosphere to start cloud droplet formation," Zoran says.

Previously, oceanic algae and phytoplankton were thought to be the main marine sources of DMS. Understanding the cloud-forming role of coral will also improve our understanding of how ocean water evaporates, rises, becomes part of a cloud, and falls as rain.

"We still don't know for sure if coral is a significant source of these particles in the atmosphere over the Reef," Zoran says.

The team used the Australian Research Vessel *Investigator* and a mobile, land-based laboratory at Mission Beach to capture the particles.

The project involves researchers from CSIRO, Southern Cross University, Bureau of Meteorology, The University of Melbourne, University of Technology Sydney, National Institute for Environmental Studies (Japan), Fudan University (China), and NIWA and Auckland University (New Zealand).

@ausscistories

Photos: Dr Feras Dayoub, Dr Matthew Dunbabin, Professor Peter Corke with the COTSBot, credit: Sonja de Sterke, QUT; The new RangerBot will be multipurpose, credit: Richard Fitzpatrick for QUT; The mounds may reveal information on past climates, credit: Dr Emma Kennedy, UQ; Hyperspectral cameras on drones capture far more detail than the human eye can see, credit (both): QUT Research Engineering Facility; The team is studying the natural aerosol produced by corals, credit: Zoran Ristovski

For more information: Queensland University of Technology, Novella Moncrieff, +61 3 8540 4172, novella.moncrieff@qut.edu.au

QUT

2016 Prime Minister's Prizes for Science

For complete profiles, photos and videos, and more information on the Prime Minister's Prizes for Science, visit www.science.gov.au/pmscienceprizes

Conservation that works for government, ecosystems and people

Associate Professor Kerrie Wilson can put a value on clean air, water, food, tourism and the other benefits that forests, rivers, oceans and other ecosystems provide.

With that, she can calculate the most effective way to protect and restore those ecosystems. For example, in Borneo she and her colleagues have shown how the three nations that share the island could retain half the land as forest, provide adequate habitat for the orangutan and Bornean elephant, and achieve an opportunity cost saving of over $50 billion.

Around the world she is helping governments to make smart investments in conservation. For her work with the Australian Research Council Centre for Excellence for Environmental Decisions, Kerrie received the 2016 Frank Fenner Prize for Life Scientist of the Year.

The most effective way to protect and restore

Defending Australia's snakes and lizards

Northern Australia's peak predators—snakes and lizards—are more likely to survive the cane-toad invasion thanks to the work of Professor Richard Shine.

Using behavioural conditioning, Rick and his team have successfully protected these native predators against toad invasion in WA.

He has created traps for cane toads, taught quolls and goannas that toads are 'bad,' and now plans to release small cane toads ahead of the invasion front, a counterintuitive 'genetic backburn' based on 'old-school' ideas that his hero Charles Darwin would have recognised.

For his work using evolutionary principles to address conservation challenges, Richard, from The University of Sydney, was awarded the 2016 Prime Minister's Prize for Science.

Ideas Charles Darwin would have recognised

Making stock markets fair and efficient

Professor Michael Aitken developed a software program that's made global stock markets fairer and more efficient. Now he's applying the same technology framework and markets know-how to improve health, mortgage and other markets.

He says there are billions of dollars of potential savings in health expenditure in Australia alone, which can go hand in glove with significant improvements in consumers' health.

A powerful advocate of scientific and technological innovation, Michael, from Capital Markets Cooperative Research Centre, was awarded the 2016 Prime Minister's Prize for Innovation.

Billions of dollars of potential savings

Creating new manufacturing jobs by replacing glass and metal with plastic

Dr Colin Hall has created a new manufacturing process that allows plastic to replace glass and metal, making aircraft, spacecraft and even whitegoods lighter and more efficient.

His team's first commercial success is a plastic car side-mirror. And it all started with spectacles.

For his contribution to creating a new manufacturing technology, Colin, from the University of South Australia, received the inaugural 2016 Prize for New Innovators.

@ausscistories

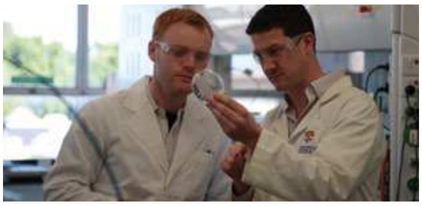
Turning teachers and students onto science

Suzy Urbaniak is a geoscientist who has turned classrooms into rooms full of young scientists, giving them the freedom to develop their own investigations and find their own solutions. Suzy received the 2016 Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools.

Gary Tilley is mentoring the next generation of maths and science teachers to improve the way these subjects are taught in primary schools. At Seaforth Public School in Sydney, he's encouraged excitement and a love for science in his students who have painted almost every wall in their school with murals of dinosaurs and marine reptiles. Gary received the 2016 Prime Minister's Prize for Excellence in Science Teaching in Primary Schools.

Freedom to develop their own investigations

Re-engineering nature to fight for global health



Professor Richard Payne is re-engineering nature to fight for global health. He makes peptides and proteins.

He sees an interesting peptide or protein in nature, such as in a blood-sucking tick, then recreates and re-engineers the molecule to create powerful new drugs, including anti-clotting agents to treat stroke. His team at The University of Sydney is developing new drugs for the global health challenge including tuberculosis, malaria and antibiotic-resistant bacterial infections.

For his revolutionary drug development technologies, Richard was awarded the 2016 Malcolm McIntosh Prize for Physical Scientist of the Year.

Photos: Rick is helping protect Australia's native predators, credit: The University of Sydney; all other images, credit: Prime Minister's Prizes for Science/WildBear

Macquarie University researchers are exploring the earth, oceans, fire and sky to answer big questions of the past and future

Read more about their work at science.mq.edu.au, including:

- Saving the Tasmanian devil's parasites. Can the devil survive without the suite of bugs that has lived with it for millennia?
- Reducing volcano risks in Indonesia and the Pacific 'Ring of Fire', and understanding their impact on climate
- Solving the wireless spectrum crunch—keeping us connected and ensuring the absolute reliability of wireless connections for hospitals, transport, power stations, and more
- How can we image and treat moving tumours—measuring radiation dose in three dimensions
- Mapping the Earth's deep crust and hunting for gold, all with grains of zircon found on the surface
- Using arrays of camera lenses to detect ultra-faint astronomical sources of light
- Asking whether new medicines are worth the dollars—using statistics to determine their effectiveness and value.

@ausscistories

The mystery of leaf size solved

Why is a banana leaf a million times bigger than a common heather leaf? Why are leaves generally much larger in tropical jungles than in temperate forests and deserts? The textbooks say it's a balance between water availability and overheating.

But it's not that simple.

A global team of researchers led by Associate Professor Ian Wright from Macquarie University revealed that in much of the world the key limiting factor for leaf size is night temperature and the risk of frost damage to leaves.

Ian, and 16 colleagues from Australia, the UK, Canada, Argentina, the USA, Estonia, Spain, and China analysed leaves from more than 7,600 species, then teamed the data with new theory to create a series of equations that can predict the maximum viable leaf size anywhere in the world based on the risk of daytime overheating and night-time freezing.

"The conventional explanation was that water availability and overheating were the two major limits to leaf size. But the data didn't fit. For example, the tropics are both wet and hot, and leaves in cooler parts of the world are unlikely to overheat," Ian says.

They'll use the findings to create more accurate vegetation models. This will be used by governments to predict how vegetation will change locally and globally under climate change, and to plan for adaptation.

The research was published in September as a cover story in *Science*.

For more information:
Macquarie University, Barbara Messerle, fse.execdean@mq.edu.au

Reinventing the laser

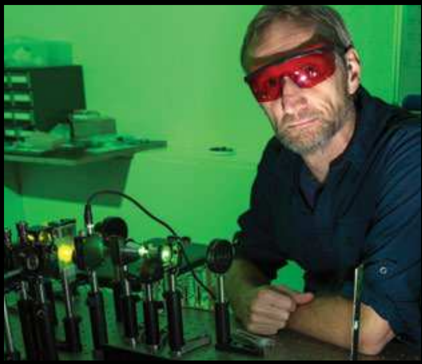
High-power lasers have many potential applications: from medical imaging to manufacturing, shooting down drones or space junk, or powering deep space probes. But current laser technologies overheat at high power.

Associate Professor Rich Mildren and his team have developed a technique to make diamond lasers that, in theory, have extraordinary power range. Five years ago, their lasers were just a few watts in power. Now they've reached 400 watts, close to the limit for comparable conventional lasers.

Their calculations suggest that their diamond laser technology could handle over a thousand times the current power. They've also shown that they can use diamond to focus multiple laser beams into a single beam. And they can create almost any frequency of light.

Diamond is an outstanding optical material and exceptionally good at dissipating heat. But it's not very good at generating a laser beam as its dense structure makes it difficult to introduce the impurity additives normally needed to amplify light. Until now.

Rich discovered that he could use light scattering (the Raman effect). When light shines on the diamond crystals, some of it is scattered at a single frequency. His team has developed a suite of techniques to enhance this effect in diamonds to create their high-power lasers.



The first applications of Rich's work are on their way. UK company M Squared Lasers has licenced the technology to create lasers for quantum computing and biological imaging.

US and Australian defence researchers are major investors in the research, which has the potential to be used to tackle drones, boat swarms, and missiles.

Protecting surfers from shark attacks

Macquarie University researchers discovered that most sharks are colour blind, and used that knowledge to create patented wetsuit camouflage designs that are now on the market. Now the team is looking at how sharks perceive surfboards.

Associate Professor Nathan Hart, his students and collaborators are taking a new look at the sensory world of sharks. Using a range of physiological, genetic and behavioural methods, they have obtained the clearest view yet of how sharks, including notorious predators such the great white shark, see the world around them.

One of the most surprising discoveries has been that many, if not all, sharks are completely colour blind. While a total lack of colour vision is relatively rare, it is seen in marine mammals such as seals, dolphins and whales.

This triggered a collaboration with wetsuit manufacturers to design camouflaged wetsuits for divers that should reduce the likelihood of a shark attack. The patented wetsuit technology is now available commercially and field testing is ongoing.

More recent research has investigated the role of object shape and motion in triggering shark's predatory behaviour. Working with collaborators in South Africa, Nathan and his team observed the way white sharks interacted with seal-shaped decoys towed behind a boat. They've also compared the appearance of seals, surfboards and swimmers from the point of view of a shark, under controlled conditions at Taronga Zoo. This could lead to new surfboard designs that alter the dark silhouette of the surfboard when viewed from below.

Modern humans were in Southeast Asia 20,000 years earlier than previously thought

Dating of ancient human teeth discovered in a Sumatran cave site suggests modern humans were in Southeast Asia 20,000 years earlier than previously thought.

The international research, led by Dr Kira Westaway from Macquarie University and published in Nature, has pushed back the timing of when humans first left Africa, their arrival in Southeast Asia, and the first time they lived in rainforests.

This evidence of humans living in the Sumatran rainforest more than 63,000 years ago also suggests they could have made the crossing to the Australian continent even earlier than the accepted 50,000 to 60,000 years ago.

The site in western Sumatra called Lida Ajer contains fossils of two human teeth, along with rainforest animal fossils. It was originally excavated by Dutch palaeoanthropologist Eugene Dubois in the late 1880s, and revisited a hundred years later by Jon de Vos and Randy Skelton.

But until now, the significance and validity of these human remains had not been widely accepted.

"This cave has been shrouded in doubt since it was first excavated," Kira says.

Kira's team dated the sediment around the fossils, the overlying and underlying rock deposits in the cave, and associated mammal teeth.

"We employed a range of dating techniques from different institutions to establish a robust chronology that would, after 120 years, finally put an end to the uncertainty associated with the age and significance of these teeth."

Other Australian universities involved include the Australian National University, the University of Queensland, the University of Wollongong, Griffith University and Southern Cross University.

Photos: Wet autumn Fraxinus, credit: Ian Wright; Licuala ramsayi in Queensland, credit: Peter Wilf; A young Dipteris leaf at Mount Kinabalu, credit: Peter Wilf; Rainforest leaves, Panama, credit: Ian Wright; The sky isn't the limit for this laser technology, credit: Chris Stacey; The team want to know whether some shark attacks might be the result of mistaken identity; Kira's work has helped our understanding of human evolution, credit: Chris Stacey

MACQUARIE University SYDNEY · AUSTRALIA

AUSTRALIAN ACADEMY OF SCIENCE 2016

Career awards

Professor Jeffrey Reimers applies chemical quantum theory to photosynthesis and consciousness. He received the 2016 David Craig Medal.

The discovery and development of the Lisheen lead-zinc mine in the Republic of Ireland, leadership in the recognition and characterisation of a new type of mineral deposit, and the origin of the sediment-hosted copper deposits of Central Africa—**Professor Murray Hitzman** received the 2016 Haddon Forrester King Medal.

Past sea level changes, coastal evolution and what marine mollusc shells can tell us about environmental changes—**Professor Colin Vincent Murray-Wallace** received the 2016 Mawson Medal.

Scientia Professor Martin Green and his team have led the world in silicon cell efficiency since 1983, paving the way for the solar panels used on our homes. Dubbed "the father of photovoltaics," Martin received the 2016 Ian Wark Medal.

Professor Graham Farquhar's models of plant biophysics have been used to understand cells, plants, forests, and to create new water-efficient wheat varieties. His latest project will determine which trees will grow faster in a high carbon dioxide world. He received the 2016 Macfarlane Burnet Medal.

Early-and-mid-career awards

Professor David Wilson is recognised internationally for his work in mathematical modelling, impact evaluation and public health strategy development, developing innovative approaches to HIV monitoring and reporting, viral hepatitis and sexually transmitted infections. David received the 2016 Gustav Nossal Medal for Global Health.

Associate Professor Katherine Kedzierska identifies key factors that drive the severe and fatal influenza disease in high-risk groups, including the young, elderly, pregnant women, immunosuppressed individuals and Indigenous Australians. Katherine received the 2016 Jacques Miller Medal for experimental biomedicine.

Dr Elena Belousova and her colleagues at the ARC Centre of Excellence for Core to Crust Fluid Systems developed TerraneChron®, a tool that dates zircons in geological samples, helping define patterns in how Earth's crust evolved. It can also be used to find where many mineral deposits such as gold, nickel and diamond are, and is widely used by global mining giants including BHP Billiton. Elena received the 2016 Nancy Millis Medal for Women in Science.

Professor Paolo Falcaro engineers nano-materials to bring materials with exceptional functional properties to our everyday life, including magnetic materials for the decontamination of water from carcinogens and heavy metals, and new carriers for the encapsulation, preservation and release of pharmaceuticals. Paolo received the 2016 John Booker Medal.

Associate Professor Jane Elith asks where are the plants and animals we want to conserve, and the invaders we want to control? She develops and evaluates species distribution models, and her guides and novel tools for modelling species and ecological communities have been used by government and environmental management agencies in Australia and internationally. Jane received the 2016 Fenner Medal.

Associate Professor Geoffrey John Faulkner combines computers with high-throughput machines to analyse the DNA found in individual human cells. His work has major implications for how we view healthy brain function, and may provide opportunities to better understand mental health and neurodegenerative conditions. Geoffrey received the 2016 Ruth Stephens Gani Medal.

Professor Ostoja Steve Vucic has identified important processes that contribute to the triggering of amyotrophic lateral sclerosis (ALS), leading to the identification of novel therapeutic targets and therapeutic approaches, and invented a diagnostic technique for ALS, enabling an earlier diagnosis at a point where the disease may be amenable to neuroprotective therapies. Ostoja received the 2016 Gottschalk Medal.

Professor John Paterson uses Australian fossils to answer major questions relating to evolution, biogeography and palaeoecology during the two greatest radiations in the history of animal life—the Cambrian explosion and the Great Ordovician Biodiversification Event. John received the 2016 Anton Hales Medal.

How are waves—from acoustic ones to those in the ocean—affected by objects, either solitary or in groups, in their paths? **Dr Luke Bennetts** is a mathematician applying computational methods to real-world problems, such as how ocean waves interact with ice floes in the polar seas, and his work is applicable to climate forecasting. He was awarded the 2016 Christopher Heyde Medal.

Dr Andréa Sardinha Taschetto's research has substantially advanced our understanding of the role of the oceans on regional climate variability, from seasonal to multi decadal timescales and future projections. Andréa was awarded the 2016 Dorothy Hill Award.

Associate Professor Ilya Shadrivov is creating new kinds of metamaterials—composites with properties not found in nature—for uses such as next-generation security cameras and radar-type sensors to increase car safety. Ilya was awarded the 2016 Pawsey Medal.

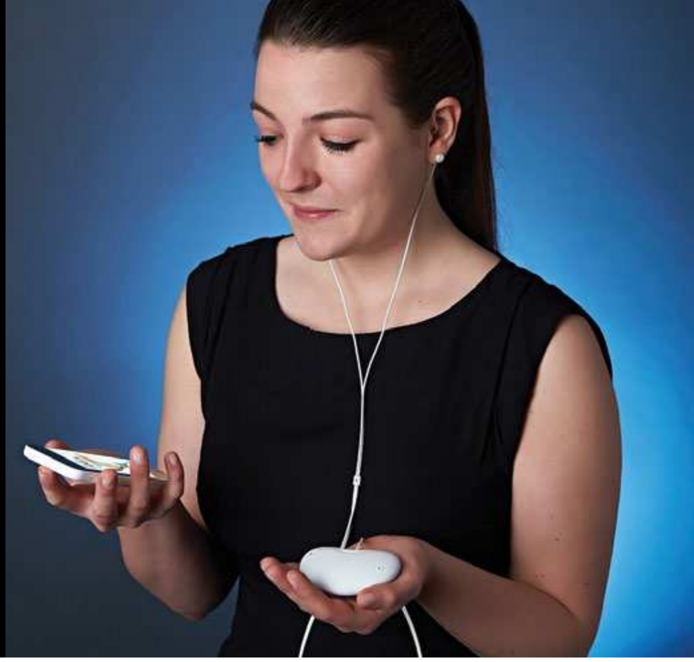
Associate Professor Michael James Ireland develops optical and infrared technology to probe the lifecycles of stars and planets, and to create tools to understand how planets form and evolve. He's shown dying solar-type stars shed their outer layers in a wind of molecules and tiny transparent dust grains, and is building astronomical instruments for Australian and international telescopes to detect planets around other stars. He was awarded the 2016 Frederick White Prize.

Associate Professor Cyrille Boyer uses light to make new and complex polymers. It's the latest in a series of techniques that have enabled him to create materials which are being applied in areas as widespread as non-stick coatings, anti-fouling technology, precision drug delivery, medical diagnosis and imaging. Cyrille was awarded the 2016 Le Févre Memorial Prize.

Photos: Credit: Prime Minister's Prizes for Science/WildBear; Credit: The University of Sydney; Credit: Prime Minister's Prizes for Science/WildBear; Credit: Julia Galin; Credit: University of New England

Australian Academy of Science

AUSTRALIAN SCIENCE PRIZES 2016



Clunies Ross Awards

Dr Elaine Saunders has made premium hearing aids more affordable and easier to use. She and her team have built on Australia's bionic ear technologies to create a system where you can: test your hearing online; buy your hearing aid online and receive it set up ready for you; and adjust the hearing aid with your smartphone while you're at the pub, dancing, or watching TV.

Professor Maree Smith hopes to change the lives of millions of people worldwide who live with chronic pain. She's the inventor of the new EMA401 oral drug, currently in clinical trials, to treat neuropathic pain and chronic inflammatory pain. The drug avoids the central nervous system side-effects commonly produced by pain medicines. Maree holds 11 patents in pain relief, with analgesics technologies licensed to three University of Queensland spin-out companies.

Professor Peter Murphy has led an industry-focused research team specialising in thin-film coating science to develop a plastic automotive rear-view mirror. The Plastic Mirror is the world's first light-weight, injection-compression moulded polycarbonate automotive rear-view mirror. It's half the weight of traditional glass mirrors, distortion-free, shatterproof, resistant to UV weathering, abrasion resistant, withstands temperature extremes and offers design freedom and a simplified assembly process not possible with glass. More than 1.5 million mirror assemblies have been manufactured in Adelaide and exported to the USA.

The Clunies Ross Awards are presented by the Australian Academy of Technology and Engineering.

2016 Eureka Prize highlights

FANTOM5 project: 260 specialists from 20 countries, including 22 Australian researchers, are mapping the sets of genes expressed in each of our cell types to interpret genetic diseases and engineer new cells for therapeutic use.

Protecting Australian soldiers: Traditional light-weight military vehicles are susceptible to battlefield damage from Improvised Explosive Devices and small arms fire. The new Hawkei, developed by Thales, provides Australian soldiers with potentially life-saving protection against roadside bombs and other threats by combining several existing technologies to produce a novel design.

A kidney in a dish: Professor Melissa Little and Dr Minoru Takasato of the Murdoch Childrens Research Institute recreated human kidney tissue from stem cells, opening the door to disease modelling, drug screening, and ultimately replacement organs.

Other winners included:

Identifying the sources and distribution of marine debris at a national scale around Australia's coastline—CSIRO Marine Debris Team.

Understanding the connections between plate tectonics, past ocean chemistry and the evolution and extinction of life on Earth—CODES - ARC Centre of Excellence, University of Tasmania; Flinders University; Russian Academy of Science; and University of California.

Using the colour of cells and tissues as a non-invasive medical diagnostic tool—Professor Ewa Goldys, Macquarie University and ARC Centre of Excellence for Nanoscale BioPhotonics; and Dr Martin Gosnell, Quantitative Pty Ltd.

For more on the 2016 Australian Museum Eureka Prizes visit http://australianmuseum.net.au/eureka

State awards

Protecting Australia's snakes and lizards: **Professor Rick Shine** was the 2016 NSW Scientist of the Year. More on p.28.

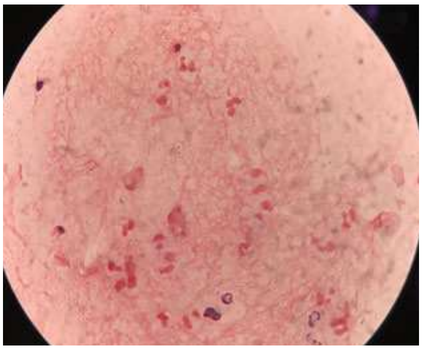
Professor Kingsley Dixon discovered the chemical in smoke responsible for germination in Australian species—finally explaining why the Australian bush blooms after fire. Kingsley was the 2016 WA Scientist of the Year.

Understanding of the human immune system—how T-cells recognise foreign tissues during transplant rejection, drug hypersensitivities and the wheat allergy that causes celiac disease: **Professors Jamie Rossjohn** and **James McCluskey** were jointly awarded the 2016 Victoria Prize (Life Sciences).

Nanophotonics, biophotonics, optical data storage and solar cells: **Professor Min Gu** is an expert in three-dimensional optical imaging theory and was awarded the 2016 Victoria Prize (Physical Sciences).

Detailing the first genome of an extinct species, reconstructing the genomic history of Europe, and creating detailed pictures of climate change, human history, and disease—**Professor Alan Cooper** was the 2016 SA Scientist of the Year.

Photos: Credit: Blamey Saunders hears; Credit: The University of Sydney



Fresh Science

Fresh Science helps Australian early-career researchers find their story and their voice.

Over the past 20 years Fresh Science has trained and empowered more than 500 future leaders in science to engage with the community, media, government and industry.

In 2016, we chose 60 researchers around the country, trained them, and gave them the chance to present their science in pubs, school talks and to the media. Here are a few of their stories.

You can read more online at freshscience.org.au, including:

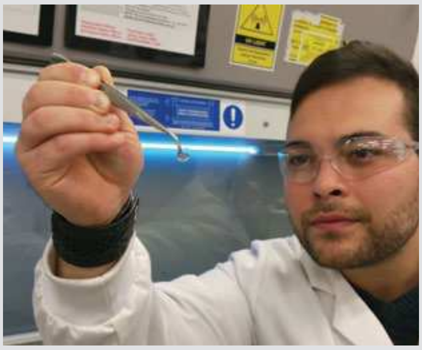
Heating carbon fibre in the microwave (VIC)

Exercising before prostate surgery helps recovery (WA)

Pneumonia bug distracts immune system (NSW)

Far out! New map of Mars' surface (SA)

New diabetes app to provide faster, more accurate and cheaper care for Australia's 1.5 million+ sufferers (QLD)



Curing blindness by repairing corneas with invisible films

A patented treatment could restore eyesight for millions of sufferers of corneal disease.

The University of Melbourne-led team of researchers have grown corneal cells on a layer of film that can be implanted in the eye to help the cornea heal itself. They have successfully restored vision in animal trials and are aiming to move to human trials in 2017.

Our new treatment performs better than a donated cornea

More than 2,000 corneal transplants are conducted in Australia each year. But globally there's a shortage of donated corneas, and the resulting loss in vision affects about 10 million people worldwide.

"The hydrogel film we have developed allows us to grow a layer of corneal cells in the laboratory," says Berkay Ozcelik, who developed the film working at The University of Melbourne.

"Then, we can implant that film on the inner surface of a patient's cornea, within the eye, via a very small incision."

Once in place, the new cells restore the cornea's vital water-pumping activity, so that the cornea once more becomes transparent.

"We believe that our new treatment performs better than a donated cornea, and we hope to eventually use the patient's own cells, reducing the risk of rejection," Berkay says.

Perth community can help save Carnaby's cockatoo

Endangered Carnaby's cockatoos are adapting to urban life in Perth suburbs. And new research has shown how the community can help save them by creating cockatoo-friendly suburbs.

A world-first study used satellite technology to track the wild cockatoos, which are found only in Australia's south-west and are often spotted in the suburbs of Perth.

Dr Christine Groom of the University of Western Australia attached satellite devices to 23 of the distinctive black cockatoos to track their movements around Perth.

The population in urban areas has dropped

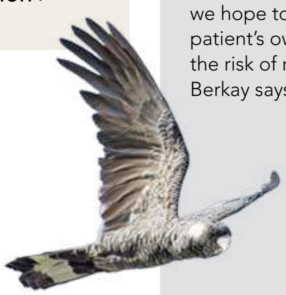
She discovered that they travel about 5.5km from night roosts to forage every day and can fly up to 70km between night roosts.

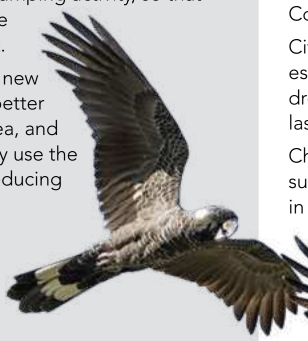
She is encouraging people to create cockatoo-friendly suburbs by growing food plants in gardens, planting roosting trees around recreation areas, and providing water sources.

Carnaby's cockatoos are in decline, largely because of a loss of habitat on the Swan Coastal Plain and elsewhere.

Citizen science project the Great Cocky Count estimates the population in urban areas has dropped at least 10 per cent per year for the last six years.

Christine hopes planting cockatoo favourites such as candlestick banksia and liquidambar in backyards, schools, or anywhere there is space, will help ensure Carnaby's cockatoos grace Perth skies for decades to come.





Photos: Berkay Ozcelik holds up the corneal cell film he developed with colleagues from The University of Melbourne; High doses of Omega-3 in pregnancy may help reduce allergies; Carnaby's cockatoos are adapting to life in Perth's suburbs, but their numbers are in decline, credit: Christine Groom; A new class of drugs developed at University of New South Wales is helping people with HIV to fight cancer; Amanda Neilen has found a way to keep cow piss out of our rivers, and improve pasture instead, credit: Econnect Communication

Fighting dust-mite allergies with fish oil

Kids born to mums who'd taken high doses of fish oil in pregnancy were less likely to have some types of allergies, Adelaide researchers have found.

The trial, run by the South Australian Health and Medical Research Institute (SAHMRI), was the largest in the world to look at the effects of Omega-3—commonly found in fish oil—on allergies in children.

More than four million Australians suffer from allergies

At one-year-old, children of mothers who had taken a high dose of fish oil in pregnancy had less allergy to egg. They were also less likely to have eczema than those born to mothers who took capsules with no Omega-3.

And at six years of age they had 40 per cent less allergy to house dust mites and were also less likely to have hay fever. At three years of age there were no differences between the two groups.

"We'd really love to be able to develop dietary recommendations to help pregnant women prevent allergies in their children," says Dr Karen Best, of the South Australian Health and Medical Research Institute (SAHMRI).

"But there's a lot more work to be done to determine the ideal dose and full effects of taking a large amount of fish oil during pregnancy."

More than four million Australians suffer from allergies, and we're seeing more people developing allergies in Western countries all the time.

Immune boost for cancer patients with HIV

Cancer is the leading cause of death among people with HIV and yet cancer treatment can be risky as their immune system is already compromised.

Now, a new class of drugs developed at the Kirby Institute at the University of New South Wales is providing hope—demonstrating it is effective in treating the cancer and strengthening the immune response to that cancer.

"Most cancer treatments further damage the immune system even as they treat the cancer," says Dr Mark Polizzotto, the scientist leading the research.

"For people with HIV, they are already immune deficient, increasing the risks of treatment. But this medication actually helps the body to detect and fight the cancer."

In 2016, Mark was awarded a grant from the Cancer Institute of NSW to commence clinical trials of these immune modulatory anti-cancer drugs on people with HIV.

Helps the body to detect and fight the cancer

This is a step forward in itself as people with HIV have almost always been excluded from clinical trials for cancer-related drugs because of the complexity of their condition.

Whilst his work focuses on cancer in those with HIV, Mark believes work in these special populations of patients can teach us about the role of the immune system and cancer in ways that are useful for all cancer sufferers.

Taking the cow piss out of our waterways

Griffith University PhD student Amanda Neilen has discovered how to stop cow urine running off our paddocks into rivers and creeks.

If carbon is added to paddocks where cows urinate it can reduce the runoff of nitrogen into waterways, meaning more nutrients for pasture growth and cleaner creeks and rivers.

"Cow's urine is high in nitrogen and this can accumulate in the soil and then leach or wash off into waterways," Amanda says.

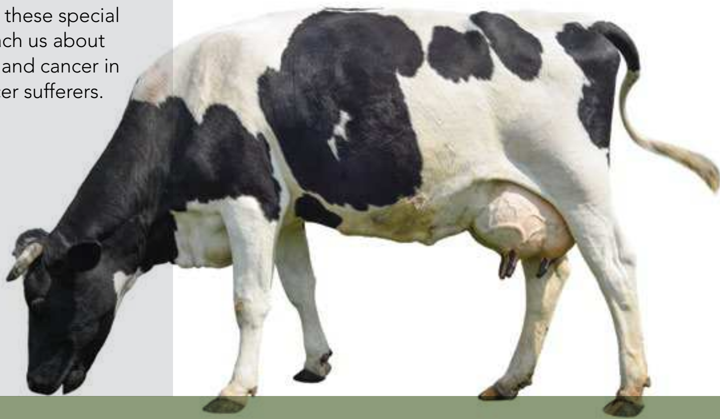
Cow's urine is high in nitrogen

High levels of nitrogen in our waterways cause the algal blooms that can choke the life out a river or smother a reef. Loss of nitrogen from farm paddocks means there are also fewer nutrients available for plant and animal growth.

Amanda's research discovered that grass-covered soil was three times less likely to have nitrogen runoff compared to bare soil.

"I found that by adding carbon to the soil it stimulated the activity of the soil microbes and stopped the nitrogen from leaching away," Amanda says.

Having more nitrogen available in the soil means more grass. This means a farmer can carry more cows in each paddock.



Having more nitrogen available in the soil means more grass

STORIES OF AUSTRALIA-INDONESIA INNOVATION

Australia and Indonesia have a rich history of collaboration in science and innovation. We worked together to understand foot-and-mouth disease and eradicate it from Indonesia in 1983. We've held joint expeditions to Antarctica. We've jointly investigated the foundations of human evolution and we've tackled global health issues together.

Today there are hundreds of research collaborations between our two nations.

Stories of Australia-Indonesia Innovation is just a taste of the diverse projects that are engaging Indonesian and Australian scientists in research that's changing both nations. The book is published with the support of The Australia-Indonesia Centre.

Story highlights include:

Stopping gastro from birth with a new rotavirus vaccine being developed by Universitas Gadjah Mada, Murdoch Children's Research Institute and Bio Farma.

Improving the efficiency of Indonesia's rail freight system with a special railcar that monitors the tracks. The project is led by Institut Teknologi Sepuluh Nopember and Monash University.

A window in an Indonesia ferry hull is revealing how to improve shipping efficiency thanks to Institut Teknologi Sepuluh Nopember and The University of Melbourne.

Sustainable designs for kaki lima ('five legs') street vendors, developed by architecture students from Institut Teknologi Bandung and The University of Sydney.

How to get healthcare for the 'missing middle': Universitas Indonesia and the Australian National University are researching why people fall through the gaps of national healthcare.

Yogyakarta residents started breeding mosquitoes in 2014 as part of a global campaign to eliminate dengue. The project is led by Universitas Gadjah Mada and Monash University and supported by the Gates Foundation and Yayasan Tahija.

Go online for more about these and other stories including: a secure future for Indonesian beef; carving out success in wooden exports; the little people of Flores; sunshine and pneumonia; new targets for tuberculosis vaccines; manta rays munching on micro-plastics, and more.

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Stories of Australian Science grew out of our work hosting the World Conference of Science Journalists in Melbourne in 2007, where we realised that there was a hunger for more stories about the best of Australian science.

These stories are in print, online, and on Twitter, Facebook, Instagram and LinkedIn.

Our thanks to the organisations who have supported the 2017 edition. If you'd like copies or you'd like to participate in 2018 please get in touch.

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- Australian Red Cross Blood Service
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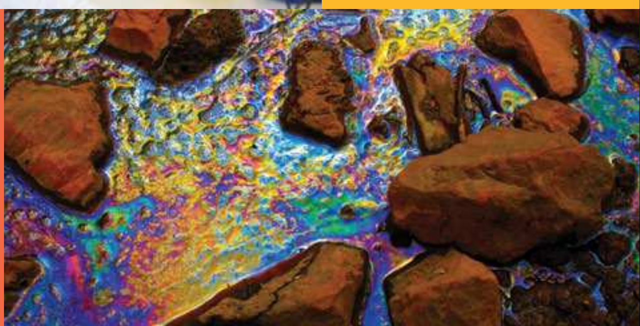

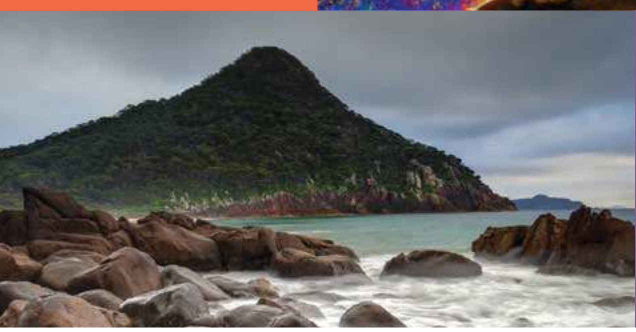

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