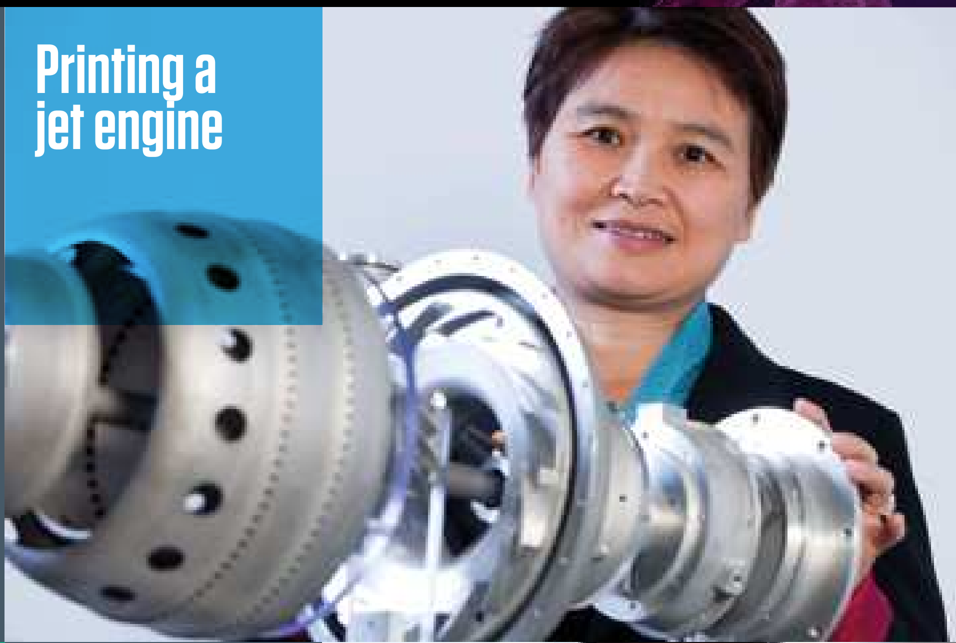
STORIES OF AUSTRALIAN SCIENCE 2015

Could your lab have the next antibiotic?

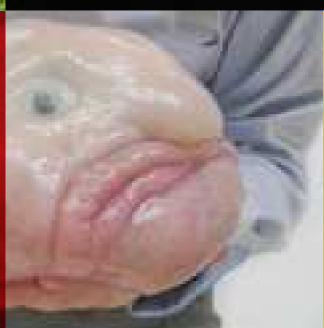


Printing a jet engine

Turning groundwater into wine

Australian crystals clean gas, food, air...

Who cares about the blobfish?



Pain relief from tarantulas

Welcome to Stories of Australian Science 2015

The printed jet engine, pain relief from tarantula venom, teaching stem cells to forget, searching for dark matter in a gold mine, better bread, and a new Pony Express. These are some of the highlights of the past year featured in *Stories of Australian Science 2015*.

And we have a special feature on Australia–Japan collaboration: how researchers are collaborating on malaria, corals, earthquake detection and much more.

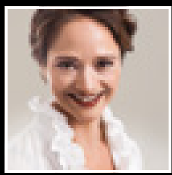
Around the world lives are being transformed by Australian ideas: the bionic ear; the cervical cancer vaccine Gardasil; chewing gum that repairs teeth; the astronomical ideas that have made wi-fi fast and reliable; and dozens of mining technologies.

Science drives economic, social and cultural change. And science tells us how our world is changing, and what we can do about it, if we choose to. But science needs stories and science needs to celebrate its heroes. We believe this collection of stories helps. It's a taste of the best of Australian science.

All the stories are online at **www.scienceinpublic.com.au/stories**.

Please feel free to share the stories with your own audiences. Everything is cleared for reproduction and you can search through hundreds of yarns from our past collections.

Enjoy this dose of science!



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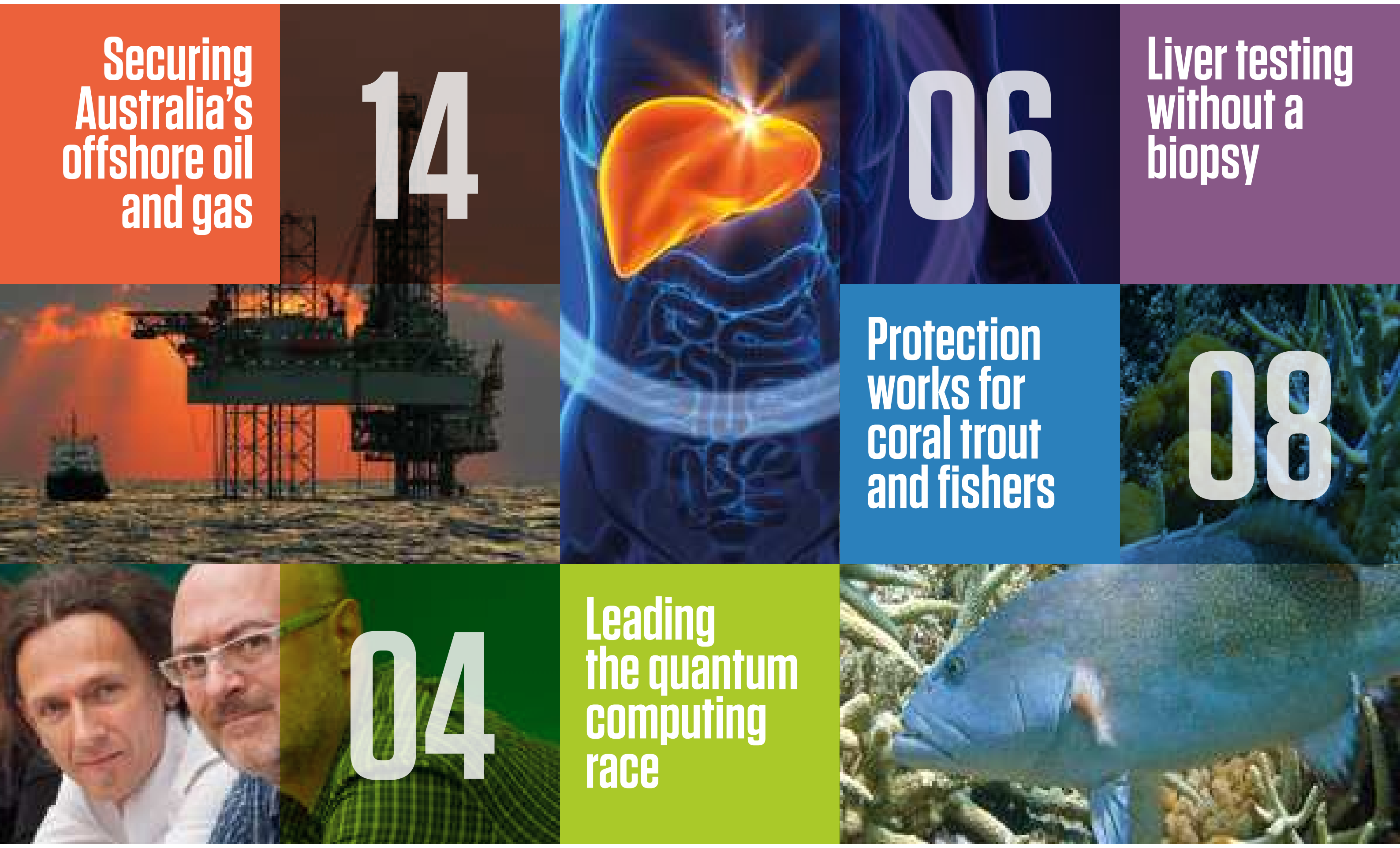

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SCIENCE IN PUBLIC

Looking for dark matter in a gold mine

Deep underground in rural Victoria, Matteo Volpi is searching for evidence of the cosmic glue that holds the Universe together: dark matter.

Matteo is taking the initial measurements for the study at Stawell Gold Mine where an international team is set to construct a $3.5 million laboratory more than a kilometre underground.

Understanding dark matter is regarded as one of the most important questions of modern particle physics.

"If we nail it, it's a Nobel Prize–winning experiment," says the project leader Elisabetta Barberio, a University of Melbourne physicist and chief investigator of the Australian Research Council Centre of Excellence for Particle Physics at the Terascale (CoEPP).

The lure of detecting dark matter has even drawn the local Northern Grampians Shire Council into assessing the mine's suitability for the project.

In the 1930s, astronomers recognised that all the matter they could see—the galaxies, stars, planets, dust clouds and comets—did not have enough gravitational pull to hold the Universe together.

There's not enough visible matter to hold the Universe together

This led to the hypothesis of an invisible matter that made up about 85 per cent of all matter in the Universe. This was dubbed dark matter because it doesn't interact with light.

Since then, the hunt has been on for dark matter particles, which can be detected through their actions as they bump into and move other things.

The physicists at Stawell are hoping dark matter particles will reveal themselves by causing nuclei in sodium iodide crystals to absorb energy and recoil.

To undertake this study, Matteo, a postdoctoral fellow in The University of Melbourne's School of Physics, and his CoEPP colleagues are collaborating with Princeton University in the US, the Australian Nuclear Science and Technology Organisation and the Italian Institute for Nuclear Physics, which will run a parallel experiment inside an Italian mountain.

Read about the Centre's search for disappearing antimatter on page 19

Read about Monash University's work printing body parts, and their 21st Century microscope on page 18

Printing a jet engine

The world's first 3D-printed jet engine was presented at the Australian International Airshow in early 2015. The creation of the engine, by Monash University researchers in collaboration with CSIRO and Deakin University, has already led to partnerships with international aerospace industries.

In fact, the researchers have printed two engines—the second is on display in Toulouse at the French aerospace company Microturbo (Safran).

The engines are a proof of concept that's led to tier one aerospace companies lining up to develop new components at the Monash Centre for Additive Manufacturing in Melbourne, Australia. The project is also creating advanced manufacturing opportunities for Australian businesses large and small.

Microturbo provided an older—though still in service—gas turbine engine to copy. This is an auxiliary power unit, used in aircraft such as the Falcon 20 executive jet, and was chosen because Microturbo was willing for the internal workings to be displayed.

"Printing the engine was a chance to show what we could do," says Xinhua Wu, Director of the Monash Centre for Additive Manufacturing.

Printing this engine has already led to partnerships with international aerospace industries

The Centre is already working on reducing the weight of the engine, as well as other projects such as developing surgical instruments and helping local businesses.

The Centre, their spin-out company AMAERO and the jet engine project have been supported by the Australian Government via the Australian Research Council (ARC), the Cooperative Research Centre program, Commercialisation Australia, the Science and Industry Endowment Fund, Monash University and Safran.

Photos: Matteo Volpi is looking for dark matter in the Stawell Gold Mine, credit: Michael Slezak; Xinhua Wu led the project to print a jet engine, credit: Monash University

For more information: ARC Centre of Excellence for Particle Physics at the Terascale, Caroline Hamilton, caroline.hamilton@coepp.org.au, coepp.org.au;
Monash Centre for Additive Manufacturing, Xinhua Wu, Xinhua.Wu@monash.edu, platforms.monash.edu/mcam

In your face: new role found for blood vessels

Blood vessels act as tissue engineers during facial development, guiding the formation of jaw structures in mice, according to research from South Australia.

Quenten Schwarz and Sophie Wiszniak at the Neurovascular Research Laboratory led the research, which revealed the role of blood vessels extended beyond simply being tubes that deliver oxygen and nutrition around the body.

"Our research shows that blood vessels are critical to set up the right environment for cartilage growth in the jaw," Quenten says.

In humans and other mammals, the jaw takes shape during embryonic life when a scaffold-like structure known as Meckel's cartilage forms. Sophie found that Meckel's cartilage only grows correctly in mice when normal jaw blood vessels become established and release molecules that guide cartilage-forming cells.

"We think it's a growth factor or maybe a cytokine that is released," Sophie says.

It looks like a similar process guides human jaw development. By studying people with hemifacial microsomia—a condition in which the lower half of one side of the face is underdeveloped—the researchers found poor jaw growth coincides with incomplete formation of the mandibular artery, the main blood vessel that runs along and within the jaw.

This novel finding may improve understanding of why common craniofacial abnormalities occur, but could also guide new treatments for defective cartilage in conditions like arthritis, or following injury.

Blood vessels play a key role in normal jaw development in mice

The study was performed at the Centre for Cancer Biology—an alliance between the University of South Australia and SA Pathology—in collaboration with the Australian Craniofacial Unit and University College London.

Is your city making you sick?

Fiona Bull can tell if your city is making you sick just by looking at how easy it is to walk around—and she plans to use this knowledge of good city design to help reduce global physical inactivity by 10 per cent by 2025.

More UWA stories on pages 6-7

As the director of the Centre for Built Environment and Health at the University of Western Australia, she is leading a team focused on designing walkable communities to help prevent disease and provide healthy places for young and old.

"A walkable city is almost a proxy for a healthy city," Fiona explains. "It should be well connected and easy to get around by walking, and should have a good mix of land types, including retail and residential areas, as well as a good number of public spaces like parks." But quality and function are at least as important as the number of parks in a community for improving the lifestyles of its residents.

Fiona was the first scientist to work out the role of physical activity in preventing chronic disease, such as cancer, heart disease and diabetes, and how best to measure people's physical behaviours.

Her 20 years of research provides much of the evidence used by the World Health Organization (WHO), which says physical inactivity is one of the four leading causes of chronic disease, along with smoking, alcohol and obesity.

Fiona recently went to the Middle East, which has some of the highest rates of physical inactivity in the world. She was helping to raise awareness of the importance of exercising and creating better designed cities to prevent chronic disease.

By making these and other cities more walkable, Fiona hopes to help reduce levels of physical inactivity globally by 10 per cent by 2025—a target developed through her work as a senior adviser to the WHO.

Fiona was awarded a Member of the Order of the British Empire by Prince William last year. She is also the president of the International Society for Physical Activity and Health.

Photos: The team suspect a similar process as they've seen in mice guides human jaw development, credit: Centre for Cancer Biology, University of South Australia;
Perth's Fiona Bull says good city design can keep you fitter, credit: Matt Galligan

For more information: Neurovascular Research Laboratory, Centre for Cancer Biology, South Australia, Quenten Schwarz, Quenten.Schwarz@health.sa.gov.au, centreforcancerbiology.org.au/members/quenten-schwarz;
The University of Western Australia, Fiona Bull, fiona.bull@uwa.edu.au, www.sph.uwa.edu.au/research/cbeh

Spooky action one. Einstein nil.

Albert Einstein famously dismissed quantum physics as "spooky action at a distance", but quantum science may have the last word, with researchers in Brisbane and Tokyo finally providing the missing experimental proof.

Researchers from the Australian Research Council (ARC) Centre of Excellence for Quantum Computation and Communication Technology (CQC2T) have proved this spooky action, by showing that measurements made on a photon's wavefunction in one lab affected the photon's quantum state monitored in another lab, metres away.

Proving spooky action at a distance

Einstein had previously dismissed the theory that a quantum particle could appear to be in many different locations at once.

A quantum particle could have a wavefunction spread over a huge distance, indicating its probability of existing in each location, but the particle would never actually exist anywhere until a measurement was made to determine its position. At that point the wavefunction would collapse; the particle would then appear at one location and disappear, instantly, everywhere else.

Einstein's "spooky action" dismissal has spurred almost nine decades of research.

But the CQC2T researchers cracked the 90-year old challenge by measuring the photon's wave properties in the first lab, rather than trying to detect its presence or absence.

"If we try to see where it is, we collapse the waveform—it can only be seen in one place at a time. But we sneak up on it by only measuring its wave properties instead," explains Howard Wiseman, leader of the Griffith University node of the Centre.

By monitoring the photon's quantum state in the second lab, they proved that the measurement choice in the first lab influenced the quantum state of the photon in the second lab.

Leading the quantum computing race

Physicists at the University of New South Wales are leading the race to build computers exponentially faster than any we currently use, according to an assessment published by the scientific journals group, Nature.

The assessment follows a series of four papers in this year's *Nature* journals, which show the team has achieved some key steps in creating quantum computers: accurately holding and processing quantum information in one qubit; passing information between two qubits; and optimising processing efficiency. Researchers at the UNSW node of the ARC Centre of Excellence for Quantum Computation and Communication Technology have achieved these steps using silicon, which is the base material currently used to build computers. Not only is it inexpensive and abundant, but there is already a trillion-dollar global industry geared to handling and manipulating silicon.

There is already a trillion-dollar global industry geared to handling and manipulating silicon

Quantum computers will use the spin, or magnetic orientation, of individual electrons or atomic nuclei to represent data in their calculations.

Two of the papers demonstrate that either phosphorus donor atoms or quantum dots within silicon can hold and process quantum information with more than 99 per cent accuracy.

Another paper shows that the phosphorus donor atoms within silicon have the capacity to link up and pass spin-encoded information between them. And the fourth paper outlines a method that can be used to determine where best to place the donor atoms within silicon crystals for maximum data processing efficiency.

Previously physicists from the same groups have shown it is possible to place individual atoms in silicon and to change the spin state of an individual phosphorus donor atom in a silicon crystal and to measure that change—in other words to write and read information in a quantum state, respectively.

Pony Express for quantum messages

Quantum memory has been extended to six hours in an advance that brings the spirit of the Pony Express to quantum communications, raising the prospect of physical transport of 'read once' quantum 'memory sticks'.

Researchers at the ARC Centre of Excellence for Quantum Computing and Communications Technology have also shown that quantum physics promises uncrackable communication, as any attempt to read the message will be immediately detectable.

"This new, very stable memory is also incredibly steady for the hundred or so milliseconds required to transmit a signal around the globe. It's the first valid candidate for quantum repeater stations supporting a global network," says the Centre's Matt Sellars.

Quantum information can be carried along optical fibres only a couple of hundred kilometres before too much of the signal is lost. A proposed solution is regular 'repeater' stations to maintain the signal—similar to Pony Express way stations providing riders with fresh horses every 10 miles.

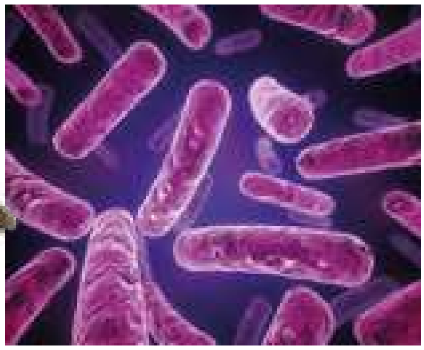
But quantum states are extremely fragile—any interaction with the outside world causes them to collapse, usually within a few milliseconds. To date, even the best quantum memories have not shown the resilience needed by repeater stations in a global quantum network.

The ARC Centre's researchers have extended quantum memory operating time by a factor of 100 times, achieving memory lifetimes of up to six hours. The scientists coded quantum information onto atoms of europium, then isolated the atoms from any external interaction via precisely aligned magnetic fields, preserving the fragile quantum information. The memory time raises the potential of physical, quantum 'memory sticks' that could be used to courier information, and the fragility of quantum-encrypted information means any attempt to read it in transit would be immediately obvious. "It's a 'read once' device," says Matt.

Couriers could carry such secure memory devices from city to city; modern Pony Express riders with quantum-encrypted communications in their saddlebags.

Photos: Howard Wiseman, credit: Trine Barfod Jensen; L-R: Sven Rogge, Andrea Morello, Michelle Simmons, Andrew Dzurak, credit: UNSW

For more information: ARC Centre of Excellence for Quantum Computation and Communication Technology, University of New South Wales, Tony Raeside, admin-cqc2t@unsw.edu.au, www.cqc2t.org



Pain relief from tarantulas

Relief isn't a term commonly associated with spiders, but Glenn King has found promising molecules in tarantula venom that he hopes will bring respite to the one in five Australian adults suffering from chronic pain.

He and his team at The University of Queensland's Institute for Molecular Bioscience have found a molecule in tarantula venom that stops the pain signal travelling to the brain.

The team is also studying the venom of other mini-beasts including scorpions, centipedes, ants and assassin bugs.

We have nine sodium channels involved in nerve impulses, named NaV1.1 through to NaV1.9. The tarantula venom molecule targets NaV1.7, which is located in our pain-sensing nerves and is the 'amplifier' of pain signals to the brain.

"The cool thing about spiders is that they developed molecules that target the 'switch' on the side of these sodium channels, which turns them on or off, and these switches are all quite different," Glenn says.

Tarantula venom could tackle chronic pain

Many of the drugs currently on the market target the 'hole' in these channels, which are all similar, making it difficult to selectively target just one channel. No-one has developed a drug that exclusively targets NaV1.7.

"Our premise was that spider venoms have lots of different molecules that target these channels. So we took 205 venoms from spiders all around the world, screened their venoms against this human channel and, amazingly, 40 per cent of the venoms completely block that channel. So we had a huge pool of molecules to choose from," Glenn says.

The next step will be to test the molecules in rodents, which have similar channels to humans, with the hope of isolating a lead molecule within three years to take to clinical trials.

Could your lab have the next antibiotic?

Could your newly synthesised molecule kill a superbug? Matt Cooper can tell you.

His team is offering a free screening service for the world's chemists to test their compounds against antibiotic-resistant bacteria, helping them to potentially find a new antibiotic that will fight the rise of these 'superbugs'.

"We're helping the community unlock the hidden value of these chemicals," says Matt, whose team is from the Community for Open Antimicrobial Drug Discovery (CO-ADD), a not-for-profit, global initiative of The University of Queensland's Institute for Molecular Bioscience. The screening began in February 2015, and Matt has already received thousands of samples from locations including India, Singapore, New Zealand, France, Israel, UK and the USA.

A free screening service will test your compounds for their potential to kill drug-resistant bacteria

He says he plans to help the global chemistry community assess the potential of a vast range of compounds that have never been screened for antibiotic properties. His work includes testing each chemical against five key superbug bacteria, two types of fungi, and human cells, to ensure the compounds are effective and safe for humans.

In pharmaceutical libraries, most molecules come from the same small number of sources and have already been screened by multiple pharmaceutical companies.

Matt's group has invested more than $5 million in setting up the team, assays and equipment, in one of the few open-access labs around the world equipped for this work. The project is also one of only two outside the UK to be supported by a Wellcome Trust Strategic Award.

Matt's research was inspired by his travels around South East Asia, India, Nepal and Pakistan more than 20 years ago, where he was moved by the number of people dying from easily preventable infections.

He also saw the burden wasn't limited to developing countries. In Australia, 170 people die every week from infections.

Insulin in a plant seed

An edible plant seed could deliver your insulin or cancer drugs if David Craik's research progresses as hoped. His team's work at The University of Queensland's Institute for Molecular Bioscience centres on cyclotides, which are a family of exceptionally stable circular proteins that occur naturally in many plants, such as violets and petunia.

Inspired by the stability and diversity of natural cyclotides, David's team has developed a way to join the two ends of a linear protein, allowing them to create 'designer' cyclotides that can be incorporated into crop plants, turning them into production factories for therapeutic drugs and insecticides.

"Essentially, we're recreating the structure of natural circular molecules and replacing part of their sequence to give them a pharmaceutical or agricultural activity," David says. "We can then incorporate the corresponding new gene, with its improved benefits, into plants which can naturally reproduce it."

One pharmaceutical application would be to simply harvest the plant, purifying the drug to produce a tablet. Or, by producing these molecules in edible plants or seeds, they could make the drugs easily and cheaply available, particularly for people in developing countries—though the work needs to be scaled up to get higher yields.

In agriculture, designer cyclotides with an insecticidal activity could be incorporated into crops such as cotton to give them a built-in pest protection.

Using plants to make and deliver drugs

So far they have had success with the re-engineered cyclotides for treating pain and obesity in animal and test tube models, although the research is yet to reach clinical trials. In future, the strength and stability of cyclotides may also be exploited for drugs, such as insulin, which currently have to be injected.

David received the 2014 Ramaciotti Medal for Excellence in Biomedical Research and the 34th GlaxoSmithKline Award for Research Excellence.

Photos: This tarantula's venom could help chronic pain (*Selenocosmia crassipes*, a resident of Queensland's east coast), credit: The University of Queensland; Could your chemical kill these antibiotic-resistant golden staph colonies? credit: The University of Queensland

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The University of Queensland Australia IMB Institute for Molecular Bioscience

Liver testing without a biopsy

A West Australian invention has become the gold standard in liver testing around the world.

It replaces painful and invasive liver biopsies with magnetic resonance imaging, using existing MRI scanners to detect and monitor iron levels in human livers. It's a concept scientists at The University of Western Australia are now looking to apply to other diseases.

Tim St Pierre and his team created the company Resonance Health to commercialise the technology, called FerriScan, which allows medical practitioners to easily monitor patients' liver iron regularly. It is now being used in more than 30 countries throughout the world.

Monitoring iron deposits in the liver is vitally important in patients with diseases such as thalassaemia, where the long-term build-up of iron in their body puts them at risk of developing cardiac disease.

The gold standard for liver testing

The team is now exploring the possibility of using their techniques to examine iron levels in the livers of children with cancer. Cancer patients often require a high number of blood transfusions during treatment, which can cause an overload of iron in the body.

The team hopes to find out how these iron levels affect children, as they know it has the potential to cause liver damage and heart problems later in life.

Tim's most recent invention, HepaFat-Scan, uses MRI scanners to more accurately measure liver fat concentrations and earned him the 2014 WA Innovator of the Year Award for Resonance Health.

This is an important step to diagnosing and treating fatty liver disease, a condition affecting 20 to 30 per cent of people in the Western world.

Is the speed of light really constant?

Two Western Australian scientists are moving fundamental physics questions from theory to lab with the help of high-precision, low-energy detectors.

Eugene Ivanov and Michael Tobar, of The University of Western Australia (UWA), have developed ultra-sensitive detectors to search for fundamental particles and other phenomena at low temperatures, allowing them to test previously theoretical questions such as the existence of dark matter and the measurement of gravitational waves.

"The next step in physics needs to be experimental," says Michael.

"And where some people are looking to particle accelerators and other large infrastructure for answers, we're implementing extremely high-precision, low-energy experiments in the lab."

The team used sapphire, quartz and other crystals to develop this range of ultra-sensitive detectors.

"To get measurements at the kind of high-energy scales we're looking at, you would need a particle accelerator about the size of our galaxy," says Michael.

"Or you can use our crystals."

The key to the detectors' high sensitivity is a low-noise technology developed over 20 years by Michael and Eugene.

The technology is already used as a frequency generator, where its pure signals make it an ideal timekeeper: making our most precise clocks more accurate, driving super computers and improving the performance of GPS.

Use a particle accelerator the size of the galaxy, or one of their crystals

It also reduces the noise that limits the resolution of radars, helping pilots see clean air turbulence and stealth bombers.

The invention has been one of UWA's biggest commercial successes, generating more than $30 million in sales under licence, before being sold to Raytheon in 2012.

Michael and Eugene were also awarded the 2012 Australian Institute of Physics Alan Walsh medal and the 2014 Clunies Ross medal for their work.

Photos: Monitoring iron in the liver made easier thanks to the FerriScan technology, credit: stock photo, Dollar Photo Club; Eugene Ivanov and Michael Tobar collaborated for more than 20 years on the technology, credit: The University of Western Australia

For more information: The University of Western Australia, Michelle Emmett, michelle.emmett@uwa.edu.au, units.physics.uwa.edu.au/magnetics/biomagnetics; Michael Tobar, michael.tobar@uwa.edu.au, www.physics.uwa.edu.au/research/frequency-quantum-metrology

An auto-correct system in plants could fix human gene faults

An auto-correct system for genetic errors in plants is helping plant breeders grow robust hybrid crops more efficiently. It also offers new tools for modifying human and animal proteins without modifying their genomes.

It's a discovery that has come from years of research by University of Western Australia scientists into how plants capture, store and use energy.

Ian Small and his team have found that plants cope with the accumulation of genetic errors in mitochondrial DNA by using a particular family of proteins, the pentatricopeptide repeat (PPR) family, to search for and replace mistakes in RNA sequences, which serve as working copies of the DNA code.

Errors in our DNA are removed from the gene pool over generations through breeding and the recombination of genes. But the system is different for mitochondria, the power packs of animal and plant cells.

The DNA in mitochondria is passed down as a clone from the mother, meaning any random genetic errors that arise accumulate with each generation, often resulting in faulty genes.

Now that Ian and his team have discovered how the proteins recognise the RNA errors, they are helping plant breeders improve methods for breeding hybrid varieties of wheat, which is challenging and very inefficient.

A better method of developing more energy-efficient wheat

"This will provide a better method of developing more energy-efficient wheat, resulting in higher yields and plants that are more resistant to droughts and pathogens, which farmers will hopefully be growing in the next 10 years," says Ian.

Further down the track, Ian hopes his research will help design custom-built proteins that can be sent into the human body to bind to a desired stretch of RNA, and could be used for a range of purposes from blocking RNA viruses to turning gene expression on or off.

For a careers-worth of genetic code-cracking, Ian was awarded the 2014 WA Scientist of the Year.

A microscope in a needle

A microscope that fits inside a hypodermic needle is the latest surgical tool in the fight against cancer.

Developed by a team of researchers at The University of Western Australia, the technology will help surgeons remove all traces of cancer during breast surgery and help avoid damage to blood vessels during brain surgery.

"Our microscope-in-a-needle will transfer microscopic imaging from the lab into the human body," says David Sampson, Director of the Optical+Biomedical Engineering Laboratory.

We are taking the microscope out of the lab and in to the body

Robert McLaughlin, who leads the research team, explains that "by working closely with surgeons and sitting in on operations, we've heard firsthand accounts of what surgeons find difficult, and what doesn't quite work well enough".

The team combined this feedback with their knowledge as medical engineers to make improvements to the technology.

Surgeons will hopefully use the microscope-in-a-needle as part of in vivo research trials within the next two years, with wide use in hospitals around five years away.

Twenty-five per cent of breast cancer sufferers require further treatment after having their lump removed, as cancer cells are sometimes left behind.

The microscope will allow surgeons to undertake a much more detailed search for any missed cancer cells, and to remove them immediately. This will reduce the need for more invasive follow-up surgery or further treatment.

In brain surgery, it will be used to check for nearby blood vessels before taking a biopsy, a procedure that until now has risked causing a bleed on the brain.

The microscope-in-a-needle team was a winner of the 2014 WA Innovator of the Year Award.

Photos: Ian Small's gene repair tools could change plant and animal breeding, credit: ARC CoE in Plant Energy Biology; This microscope-in-a-needle could help surgeons find every cancer cell. Robert McLaughlin and David Sampson are putting a microscope in a needle, credit: The Scene Team

For more information: The University of Western Australia/ARC Centre of Excellence in Plant Energy Biology, Ian Small, ian.small@uwa.edu.au, www.uwa.edu.au/person/ian.small; David Sampson, david.sampson@uwa.edu.au, Robert McLaughlin, robert.mclaughlin@uwa.edu.au, obel.ee.uwa.edu.au

THE UNIVERSITY OF WESTERN AUSTRALIA

Protection works for coral trout and fishers

Coral trout in protected zones are not only bigger and more abundant than those in fished zones of the Great Barrier Reef Marine Park, they are also better able to cope with cyclone damage.

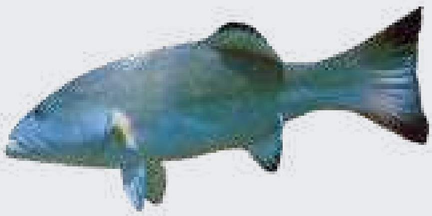
A joint study between the Australian Institute of Marine Science (AIMS) and the Australian Research Council Centre of Excellence for Coral Reef Studies at James Cook University combined a vast amount of information from underwater surveys from 1983 to 2012, on reefs spread across approximately 150,000 km^2 (more than 40 per cent) of the Marine Park.

Coral trout bounced back from cyclones

Biomass of coral trout—the main target of both commercial and recreational fishers—has more than doubled since the 1980s in the protected zones, with most of the growth occurring since a 2004 rezoning. And reefs in protected zones supported higher numbers of large, reproductively mature coral trout, even after being damaged by cyclones.

“Australia’s Great Barrier Reef Marine Park is looked upon as a global benchmark for large-scale reserve networks. Unlike many places where coral reefs are found, Australia is a developed country where fishing is fairly light and well regulated. Yet even here we see clear effects of fishing,” says co-author Hugh Sweatman, of AIMS.

“Our findings suggest that effectively protected networks of no-take reserves will help reef fishes cope with some present and future stresses, and help maintain coral reef fish populations as we know them.”



Using neutrons to show weak spots in turbines, railway lines and pipes

From pipes to power station turbines and railway lines, ensuring that engineering components perform under pressure can save lives.

By scattering neutrons from the OPAL research reactor across an object—such as a complex power station turbine—the Australian Nuclear Science and Technology Organisation (ANSTO) can test the integrity and safety of metal components.

This proactive approach to maintenance is helping to safeguard the power industry from millions of dollars in damage and potential loss of life or injury. For example, ANSTO is helping Hardchrome Engineering test their refurbished turbines and provide a subatomic ‘seal of approval’ for the safety of repairs undertaken.

Hardchrome Engineering has developed an innovative process for repairing instead of replacing components; significantly reducing operational costs and wastage. Comprehensive stress testing is crucial as turbine failure could be catastrophic.

“Neutron scattering can be used to analyse and refine production techniques to improve efficiency and ensure accidents don’t happen,” says Industrial Liaison Manager Anna Paradowska, a senior research scientist at ANSTO.

Neutron scattering techniques can be used to ensure accidents don’t happen

The railway industry has also used neutron scattering research techniques to look into the problem of weak spots on rails.

By analysing rails provided by the Australian Track and Rail Corporation and Queensland Rail, ANSTO was able to determine how the rails were damaged and advise on ways to manage rail fatigue.

The Jemena and Zinfra Group are also using neutron scattering to test pipes and pipelines across Australia to ensure seals are working as they should.

This proactive approach to maintenance is helping to safeguard the power industry from millions of dollars in damage and potential loss of life or injury

Photos: Coral trout biomass in the protected zones has more than doubled since the 1980s, credit: LTMP, Australian Instituite of Marine Science; Anna Paradowska with Mehdi Soodi (Laser Manager from Hardchrome Engineering) setting up the turbine blade for neutron measurements, credit: Australian Nuclear Science and Technology Organisation

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Bypassing genetic 'spelling errors' in muscular dystrophy

A promising treatment for Duchenne muscular dystrophy (DMD) could open the way to therapies for cystic fibrosis, spinal muscular atrophy and other disorders.

The drug eteplirsen, now in phase three clinical trials, is performing "exceedingly well" and slowing the progress of DMD, says Steve Wilton of the Centre for Comparative Genomics at Murdoch University.

Steve and his colleague Sue Fletcher have worked with their team on the treatment over the last decade, and now with the help of almost $800,000 from the National Health and Medical Research Council, they will see if the technology can be applied to other diseases.

Steve says there is potential for a huge range of applications.

Most forms of muscular dystrophy are caused by 'spelling mistakes' in genes. In DMD, these prevent the production of the protein dystrophin. Without this cellular shock absorber, muscle fibres are more fragile and prone to rupture.

DMD affects approximately one in 5000 males born worldwide; those affected usually need a wheelchair by age 12.

Eteplirsen works by removing the disease-causing part of the dystrophin gene message in boys with the most common type of genetic fault, allowing a working version of the protein to be made.

Steve and Sue received the NSW Health Jamie Callachor Eureka Prize for Medical Research Translation in 2013 for their research.

Further studies have begun using additional drugs for different mutations in other parts of the dystrophin gene, and treating both younger boys and those who are no longer able to walk.

Slowing the progress of genetic disorders

Rare genetic disorders affect more than 400,000 Australians, and treatment options are limited for most of them. Because the diseases are individually uncommon, it is often difficult to secure funding to perform research on these conditions.

Better tasting bread for China

Murdoch University researchers have discovered how to produce better tasting and higher quality Australian bread using new genome data for wheat.

Rudi Appels, the co-director of the International Wheat Genome Sequencing Consortium and the head of the Australia–China Centre for Wheat Improvement at Murdoch University, contributed to a detailed draft sequence of the bread wheat genome published in *Science*.

How wheat can survive in ice and desert

This sequence identified the chromosome parts that control the quality, quantity, disease resistance and climate adaptation of the bread wheat grain.

"We found new parts of chromosome 7A that control grain quality and yield, and others that control resistance of the wheat to powdery mildew, a fungal disease which stunts the growth of the plant," says Rudi.

"Another part helps the wheat adapt to different climates. It's the reason wheat can survive both in the middle of a desert and in the icy climate of Norway."

Rudi's colleagues, together with the Chinese Academy of Agricultural Sciences in Beijing, have defined new proteins contributing to grain quality.

Using the new genome data they have produced a wheat line with more high-quality proteins and fewer low-quality proteins.

"It will produce better tasting bread and increase the attractiveness of Australian wheat to overseas markets," says Murdoch University's Wujun Ma.

Proteins in wheat control traits such as bread taste and structure, which determine the overall quality of the plant. But Australia's hot, dry climate changes the levels of proteins in our wheat, making it lower in quality and less appealing to overseas markets, particularly China.

This work was supported by the Grains Research and Development Corporation and the Asian Century program.

Photos: Steve Wilton and Sue Fletcher have worked with their team on a Duchenne muscular dystrophy treatment for the last decade, credit: Murdoch University

For more information: Centre for Comparative Genomics, Murdoch University, Steve Wilton, swilton@ccg.murdoch.edu.au, Sue Fletcher, sfletcher@ccg.murdoch.edu.au, Rudi Appels, r.appels@murdoch.edu.au, Wujun Ma, w.ma@murdoch.edu.au, www.murdoch.edu.au

The genetics of epilepsy: bringing hope to families

Sam Berkovic and Ingrid Scheffer have changed the way the world thinks about epilepsy, a debilitating condition that affects about 50 million people.

Twenty years ago doctors tended to regard most forms of epilepsy as acquired rather than inherited. In other words, they believed epilepsy was mostly due to injury: the result of things like a crack on the head in a car accident, a bad fall in the playground, a tumour, or something having gone wrong in labour. Parents felt responsible and the resulting guilt was enormous.

The two clinician-researchers from The University of Melbourne have led the way in finding a genetic basis for many epilepsies, building on their discovery of the first ever link between a specific gene and a form of epilepsy. Finding that answer has been of profound importance for families.

Along the way, Sam and Ingrid discovered that a particularly severe form of epilepsy, thought to result from vaccination, was actually caused by a gene mutation. This finding dispelled significant concerns about immunisation.

Their discoveries of the connections between epilepsy and genes have opened the way to better targeted research, diagnosis and treatment for epilepsy. With collaborators, they have shown that genes can lead to seizures in different ways in different forms of epilepsy. An important cause, for instance, is interference with the movement of nutrients across nerve cell membranes. In one of these cases, treatment using a diet that avoids glucose is effective.

For their contribution to the study of epilepsy, its diagnosis, management and treatment, Sam Berkovic of The University of Melbourne and Austin Health and Ingrid Scheffer of The University of Melbourne and the Florey Institute of Neuroscience and Mental Health and Austin Health received the 2014 Prime Minister's Prize for Science.

Australian crystals clean gas, food, air...

Forty per cent of the energy consumed by industry is used to separate things—in natural gas production, mineral processing, food production, pollution control. The list goes on.

Each offers an application for Matthew Hill's crystals. He has demonstrated that the space inside metal–organic frameworks (MOFs)—the world's most porous materials—can be used as efficient and long-lasting filters.

By choosing different combinations of metals and plastics, Matthew's CSIRO team can make a wide range of customised crystals. Then, using antimatter and synchrotron light, they map the internal pores, determine what each crystal can do and explore potential applications.

First cab off the rank is natural gas separation. His team has developed a membrane embedded with crystals that efficiently separates natural gas from contaminants and lasts much longer than traditional membranes. He's working with gas companies to develop the patented technology that could replace the multistorey processing plants found on gas fields with smaller truck-sized systems.

Patented applications for the food industry are also in the works. And further down the track are carbon dioxide scrubbers; safe compact storage systems for gas and hydrogen; and even crystals that could deliver drugs on demand.

The space inside metal–organic frameworks can be used as efficient and long-lasting filters

For his work on the development of metal–organic frameworks for practical industrial application, Matthew Hill, Australian Research Council Future Fellow and leader of the Integrated Nanoporous Materials team at CSIRO, was awarded the 2014 Malcolm McIntosh Prize for Physical Scientist of the Year.

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

Photos: The Hon Tony Abbott, PM, with recipients of the 2014 Prizes, credit: Prime Minister's Prizes for Science; Ingrid Scheffer and Sam Berkovic revealed the underlying genetic element of many epilepsies, credit: Prime Minister's Prizes for Science/WildBear; Matthew Hill's crystals will save energy across industry, credit: Prime Minister's Prizes for Science/WildBear

Why are cells different?

Genes are not enough to explain the difference between a skin cell and a stem cell, a leaf cell and a root cell, or the complexity of the human brain. Genes don't explain the subtle ways in which your parents' environment before you were conceived might affect your offspring.

Another layer of complexity—the epigenome—is at work determining when and where genes are turned on and off.

Ryan Lister is unravelling this complexity. He's created ways of mapping the millions of molecular markers of where genes have been switched on or off, has made the first maps of these markers in plants and humans, and has revealed key differences between the markers in cells with different fates.

The map that guides the fate of cells

He's created maps of the epigenome in plants, which could enable plant breeders to modify crops to increase yields without changing the underlying DNA.

He's explained a challenge for stem cell medicine—showing how, when we persuade, for example, skin cells to turn into stem cells, these cells retain a memory of their past. Their epigenome is different to that of natural embryonic stem cells.

He has also recently explored the most complex system we know—the human brain—discovering that its epigenome is extensively reconfigured in childhood during critical stages.

For his broad contributions to life science Ryan Lister of the Australian Research Council Centre of Excellence in Plant Energy Biology at The University of Western Australia received the 2014 Frank Fenner Prize for Life Scientist of the Year.

Using Japanese to inspire students

Many teachers struggle to make science fun for their students. For a Canberra teacher, this means creating an environment where every student can see the impact of science in daily life. And an Adelaide teacher is keeping kids engaged by teaching science in Japanese.

Geoff McNamara from Melrose High School in Canberra has created a hothouse of science learning—complete with a seismometer, GPS antenna and weather station, each transmitting real-time data straight into the classroom.

"We all need science literacy to navigate the complexity of the modern world," says Geoff. So he reaches out to each student's interests—from genetics to driving to cosmology—to demonstrate the inevitable relevance of science.

For higher achieving students Geoff developed Academic Curriculum Extension (ACE) Science, connecting students with working scientists and engaging them in a wide range of real-world science investigations.

At Seacliff Primary School in Adelaide's south, Brian Schiller's students are describing states of matter, mixing of materials, and products of chemical reactions—in Japanese.

"Science can be a basis for teaching many different subjects, such as language, music, numeracy, reading and writing," he says. "Students can play and create, and relate their learning to the world around them."

Science can be a basis for teaching language, music, numeracy…

Brian nurtures creativity through student-initiated investigations, where the students bring the questions and Brian guides them in setting up investigations to get the answers.

But it's not just the answers that Brian wants his students to get: it's the ability to use their imaginations to ask 'what if…?' or 'why does…?' and find their own way to an answer using 'fair testing' and experimental controls.

For their contributions to teaching science, Geoff McNamara and Brian Schiller have each received a 2014 Prime Minister's Prize for Excellence in Science Teaching.

Photos: Ryan Lister's work transcends plants, animals and humans, credit: The University of Western Australia; Brian Schiller says "students can play and create, and relate their learning to the world around them", credit: Prime Minister's Prizes for Science/WildBear; Geoff McNamara reaches out to each student's interests to demonstrate the inevitable relevance of science, credit: Prime Minister's Prizes for Science/WildBear

Ocker cells shake up skeletal science

A population of versatile stem cells that snap into action after injury may also be the key to preventing and treating certain cancers.

Found in mouse bone marrow, OCRs—pronounced 'ockers', and short for osteochondroreticular stem cells—come alive to create bone and cartilage after a fracture. They are a completely different population from the mesenchymal stem cells originally believed to be the origin of all bone, cartilage and fat in the body.

"Until this research, we thought we knew all about bone stem cells," says Daniel Worthley, who performed the work with collaborators at Irving Cancer Research Center, Columbia University, USA.

"But we found a new target cell to study and potentially use in regenerative medicine for skeletal disease."

The researchers expect to find that an equivalent population is responsible for human tumours. And the stakes are high: osteosarcoma and chondrosarcoma are cancers found in bones and cartilage, and can be hard to treat. The tumours often affect relatively young patients.

But the implications may be even broader. OCRS are classified as connective tissue stem cells, and the research also identified a similar population of cells in the intestine.

"Like scar tissue, connective tissue surrounds many solid organ cancers, and is believed to be important in supporting cancer growth and spread," says Daniel.

OCRs are opening up a whole new avenue for understanding cancer origins and growth.

Daniel is now looking further at the importance of connective tissue stem cells as head of the Gastrointestinal Cancer Biology Group at the South Australian Health and Medical Research Centre.

We thought we knew bone stem cells—but these are completely new

Reprogrammed stem cells 'remember' past life

Stem cells generated from adult cells still retain a memory of their past despite being reprogrammed, Australian scientists have found. Now scientists think they can teach the cells to forget their past.

Induced pluripotent stem (iPS) cells have huge potential in stem cell medicine. A skin cell, a heart cell, almost any cell can be persuaded to turn back into a stem cell and then turn into new tissues. But all's not perfect.

Jose Polo from the Australian Regenerative Medicine Institute in Melbourne and Ryan Lister from The University of Western Australia independently observed how, during cell development, changes are imprinted on the genes of the cell. Some of these epigenetic modifications remain when the cell is reprogrammed back into an iPS cell: it retains an epigenetic memory of what it was meant to be.

Stem cells remember their predestination

"This limits what the iPS cell can develop into and the uses to which it can be put," Jose says. "But we might be able to take advantage of this bias to produce regenerative cells for a particular purpose."

The two researchers made their discoveries overseas—Jose in Boston, and Ryan in San Jose. Then in Australia they started collaborating across the Nullarbor Plain on ways to reprogram the epigenetic memory, to persuade the cells to forget what they were destined to be.

Jose Polo was one of the two inaugural recipients of the National Stem Cell Foundation of Australia's Metcalf Prizes for Stem Cell Research in 2014. Jose received $50,000 and mentoring from pioneering scientist Don Metcalf as part of his prize.

In 2014 Ryan Lister received the Prime Minister's Prize for Life Scientist of the Year (see page 11) and in 2015 he won the Metcalf Prize. Both are recipients of Viertel Fellowships.

Photos: Daniel Worthley (R) and colleagues Francis Lee (L) and Siddhartha Mukherjee from Columbia University Medical Center, credit: Daniel Worthley;
OCR stem cells (red) in the head of a femur, credit: Mike Barnett for Columbia University Medical Center; Jose Polo with the late Don Metcalf, credit: Mark Coulson/NSCFA

For more information: Gastrointestinal Cancer Biology Group, South Australian Health and Medical Research Centre, Daniel Worthley, Dan.worthley@sahmri.com, www.sahmri.com/our-research/themes/cancer/theme/theme-overview, National Stem Cell Foundation of Australia, Julia Mason, CEO, jmason@stemcellfoundation.net.au, www.stemcellfoundation.net.au

Unwrapping brain development

Not satisfied with transforming plant biology and stem cell science, The University of Western Australia's Ryan Lister is also tacking the human brain.

How our brains develop is still largely a mystery. Ryan thinks part of the answer is in the DNA packaging.

He is deciphering the customisable, rich layer of extra information—the epigenome—that acts like chemical signposts to tell cells how to read DNA. He's found there are huge changes in the patterns of these signposts during brain development of mice and humans. Now he's focusing on how this influences brain development and function, for better or worse.

"We've found that one form of these signposts, called DNA methylation, changes in the brain during the period of childhood when all the neurons are connecting," Ryan says.

As they open their eyes the epigenome changes

In mice, Ryan's team saw that at two weeks old—right around the time they begin opening their eyes, and a time of high sensory input—a different type of methylation suddenly begins appearing.

"It appears to be part of normal brain development in both mice and humans, even though we're separated by tens of millions of years of evolution," Ryan says.

This is a very different picture to our understanding of eight years ago. Improvements in technology have reduced the cost of DNA sequencing 10,000-fold and allowed Ryan to sequence the epigenome and map the precise location of these chemical signposts.

He plans to investigate their involvement in learning and memory, as well as various disorders and diseases including autism spectrum disorders, Alzheimer's, and schizophrenia.

Your memories in DNA?

A Queensland researcher thinks that long-term memory could be stored in DNA. It's a radical concept that he's going to test over the next year.

Geoff Faulkner already has evidence that there are lots of bits of mobile DNA in memory cells. One piece, known as L1, can insert itself into the genome of individual brain cells. His work may have consequences for how memories form, for brain disorders such as schizophrenia, and even spill over into diseases such as haemophilia, muscular dystrophy and some forms of cancer.

Long-term memory could be stored in DNA

Changes in the epigenome may also play a role—and he and Ryan Lister are collaborating on how Geoff's mobile DNA interacts with the epigenome. Geoff received the 2014 Centenary Institute Lawrence Creative prize for his big idea.

Repairing the brain with its own stem cells

Kaylene Young believes she can persuade lazy stem cells in our brain to repair brain injuries and even treat diseases such as multiple sclerosis and Alzheimer's.

She and her colleagues at the Menzies Research Institute Tasmania have found neural stem cells and related progenitor cells—which feed, protect and assist nerve cells—in the outer part of the brain most prone to damage, known as the cortex.

By understanding the behaviour and function of these cells, they one day hope to use them for treating nervous and brain disorders or damage.

"Our ultimate goal is to harness the regenerative capacity of these cells for the treatment of neurodegenerative diseases, mental health disorders and traumatic brain injury," says Kaylene.

Neural stem cells to treat brain damage

She says the progenitor cells are the only cells, apart from other neurons, with which nerve cells communicate electrically. That means there may be an electrical means of controlling them or modifying their behaviour to induce regeneration.

Kaylene Young was one of two recipients of the inaugural Metcalf Prizes for Stem Cell Research, awarded by the National Stem Cell Foundation of Australia in 2014.

Photos: Ryan Lister plans to apply the brain development research to see if it can be used to screen for diseases, credit: Prime Minister's Prizes for Science/WildBear; Geoff Faulkner's work may have consequences for how memories form, and brain disorders, credit: Centenary Institute; Kaylene Young is helping repair the brain with its own stem cells, credit: Mark Coulson/NSCFA

For more information: University of Western Australia, Ryan Lister, ryan.lister@uwa.edu.au, listerlab.org; Centenary Institute, www.centenary.org.au/about/lawrencecreative; National Stem Cell Foundation of Australia, Julia Mason, CEO, jmason@stemcellfoundation.net.au, www.stemcellfoundation.net.au

Securing Australia's offshore oil and gas industry, literally

How do you secure a ship 500 metres long and six times heavier than an aircraft carrier to the seafloor for 25 years?

This is the challenge facing the multibillion-dollar Prelude Floating Liquefied Natural Gas (LNG) plant, which is to be to be secured in 250 metres of water off Australia's north-west coast.

But it's also the sort of question that will become increasingly common as we look to deeper and deeper water for our energy resources.

Stopping billion-dollar gas plants moving in cyclones

"As the industry attempts to push the floating LNG concept into areas more than a kilometre deep, they'll be looking for new types of anchors, and that's what we're working on now," says Australian Research Council Laureate Fellow Mark Cassidy from The University of Western Australia.

A geotechnical engineer by trade, Mark's work underpins the engineering design of the anchors securing our offshore platforms, floating gas processing plants, pipelines, and wind and wave energy generators.

His team conducts model tests on soils they collect from around the world, determining how various anchors will perform in different locations.

What he wants to know is: when you pull on one of these anchors, how much load will it take before it breaks free?

"We need to ensure that, even in a large cyclonic event, the offshore platforms remain securely attached to the seabed," says Mark.

As a result of their work the team have now developed software to assist engineers to design the right anchors for their site, and their work has been written into the international engineering standards.

'Golden staph' three species, not one

Golden staph (*Staphylococcus aureus*) was thought to be a single, well-defined species—until a recent Darwin discovery showing that bacteria with golden staph characteristics are actually three distinct species.

Several years ago Menzies School of Health Research scientists began to notice a genetically unusual golden staph causing skin infections in Aboriginal children.

That led to two new species of the staphylococcus bacteria being described and accepted as valid. One of these is a silvery, un-pigmented strain, *S. argenteus*.

This 'silver staph' has now been found in human infections around the world. So far the other species, *S. schweitzeri*, has only been found in bats and non-human primates in Africa.

The discovery was made by Phil Giffard, Steven Tong and Deborah Holt of the Menzies School of Health Research, working with the UK Sanger Institute and Germany's University Hospital Münster.

"This work has completely changed the understanding of the diversity and natural history of one of the most important pathogens of humans," Phil says.

"It has clear potential in contributing to the development of new therapeutic agents and managing antibiotic resistance."

Phil and his team have found the newly discovered strains can become resistant to certain antibiotics by swapping genes with golden staph.

They are now conducting large-scale genetic comparisons of the three species to understand the links between genetic make-up and the potential to cause disease and acquire antibiotic resistance.

Several years ago Menzies School of Health Research scientists began to notice a genetically unusual golden staph causing skin infections in Aboriginal children.

Photos: Torpedo anchors in the Centre's geotechnical centrifuge at UWA, credit: Joan Costa; Golden and silver staph are recognised as distinct species thanks to Menzies School of Health Research scientists, credit: Phil Giffard

For more information: UWA Centre for Offshore Foundation Systems/ ARC Centre of Excellence for Geotechnical Science and Engineering, Mark Cassidy, mark.cassidy@uwa.edu.au, www.cgse.edu.au; Menzies School of Health Research, Darwin, Northern Territory, Phil Giffard, Phil.giffard@menzies.edu.au, www.menzies.edu.au/page/Menzies_30th/Stories/Silver_lining_to_staph_discovery

Mutations may fingerprint deadly cancers

Which prostate cancers can be left alone?

Only 10 per cent of prostate cancers are lethal, but which ones? Australian researchers have tracked the mutations that drive the cancer to spread through the body, and eventually become lethal.

The research shows they can be detected in the original tumour and even in blood samples. Testing the DNA of prostate cancer cells may help clinicians in the future identify which cancers need to be urgently removed and which ones might simply be monitored.

"Some advanced cancer cells evolve the ability to break away from their original location, travel through the bloodstream and create secondary tumours in another part of the body," explains Clare Sloggett, Bioinformatician and Research Fellow at the Victorian Life Sciences Computation Initiative (VLSCI). "Cells in this state of metastasis are the most deadly."

A critical part of this discovery was Clare's analysis of DNA information from biopsies from patients diagnosed with lethal prostate cancer.

The search for those mutations that can cause some cancer cells to become more deadly than others requires the super speed and unique expertise available at computing facilities such as the VLSCI.

"Such detailed analysis of a single biopsy generates about 400GB of raw data. This could easily double, once that analysis has been compiled," says Clare.

The study was led by The University of Melbourne and the Epworth Prostate Centre, and is part of a global project that includes the Peter MacCallum Cancer Centre, Garvan Institute, Cambridge Research Institute, and the USA's Memorial Sloan Kettering Cancer Center, among many others.

The study also uncovered information about how cells responded to different treatments, which could lead to the development of more sophisticated clinical approaches.

Chocolate and iron for speedy drug delivery

Natural phenols, such as those found in chocolate, and minerals such as iron are being used to develop fast, economical drug-delivery capsules.

Frank Caruso and his team at The University of Melbourne are making nano-sized capsules that will encase vaccines and protect them from being broken down when entering the body. They believe that this delivery system will be biologically friendly and overcome a major challenge for medical materials: their compatibility with living systems.

One of the challenges of treating diseases such as cancer and HIV is delivering treatment with minimal damage to healthy areas.

Fast-tracked drug delivery

Frank's nanotechnology expertise allows him to carefully control the size and shape of the tiny particles, enabling more precise delivery to specific cells. And because the materials are already FDA-approved, Frank expects to be able to fast-track the drug development process.

Frank and his team are applying their work to a range of diseases and collaborations. These include:

- delivering targeted HIV vaccines, working with physician/scientist Stephen Kent
- investigating cardiovascular disease with the Baker IDI Heart and Diabetes Institute
- delivering neurotrophins, which assist neuron survival, to hair cells in the inner ear with Rob Shepherd of the Bionics Institute
- investigating the delivery of cancer drugs and their efficacy at killing specific cancer cells.

The research is being conducted under the Australian Research Council Centre of Excellence in Convergent Bio-Nano Science and Technology, of which Frank is Deputy Director.

He is also an ARC Australian laureate fellow.

Photos: DNA tests may identify lethal prostate cancers, credit: stock photo, iStockphoto; Bioinformaticians can use Circos plots to visualise how cancer genomes differ from healthy ones, credit: Peter Casamento; Frank Caruso is creating nano-packages for drug delivery, credit: Richard Timbury, Casamento Photography

For more information: Victorian Life Sciences Computation Initiative, Clare Sloggett, sloc@unimelb.edu.au, www.vlsci.org.au; The University of Melbourne, Frank Caruso, fcaruso@unimelb.edu.au, www.findanexpert.unimelb.edu.au/display/person16579

Who cares about the blobfish?

Hugh Possingham and his team are making conservation more efficient. They're helping to save less fashionable threatened species by getting more bang for the bucks donated to cute and cuddly species.

The team of ecologists and mathematicians in the Australian Research Council Centre of Excellence in Environmental Decisions (CEED) worked with the New Zealand government to assess how to better spend money that is donated to conservation. They've shown that by protecting habitats shared by several different species, the money donated to charismatic ones can be stretched further to save other species as well.

"The way we currently attempt to save species is inefficient, choosing species that are popular or charismatic, like koalas and tigers, over those that are less well known or even ugly, like the blobfish," says Hugh, ARC Laureate Fellow and Director of CEED.

We also give money to threatened species without taking into account how useful that species is in their ecosystem, or how genetically distinct they are.

But these donations could now work in favour of the less popular species.

"Keeping the spotlight on the charismatic species means we can attract more conservation funding," explains Hugh. "We can then focus on promoting conservation activities that tackle a threat, like land clearing, which endangers several other species as well as the cuddly ones, giving more species a better chance of survival."

"This keeps private donors happy, because they see the outcomes they invested in, and it keeps us happy knowing that we're conserving even more species."

The way we currently attempt to save species is inefficient

Could this cute koala help save less cute plants and animals?

Western Australia hit by prehistoric tsunamis

The 2004 Boxing Day tsunami devastated coastal communities around the Indian Ocean and left people asking what are the risks of future tsunamis and super storms? The answers can be found, at least in part, in the prehistory of coastlines.

Anja Scheffers' research had already revealed that at least two tsunamis have hit the west coast of Australia in the last 7,000 years.

Then, with the support of an Australian Research Council Future Fellowship, she went on to unravel Western Australia's stormy past by creating a precisely dated sediment record of prehistoric cyclones over the past 7,000 years.

Her reading of the coastal landscape is based on analysing beach ridge sequences, coastal boulder deposits, rock layers and sediments. It's complex, painstaking and imperfect, but Anja believes that her combination of technologies can be used to create long local histories of storms.

She hopes that her work, at Southern Cross University, will help coastal communities around the world to identify tsunamis and cyclones that occurred in the past 7,000 years and to predict the future risk.

It's impossible to predict major tsunamis and super storms based on historical human experience

"One thing is for sure," she says, "Western Australia has to be prepared for strong and even super cyclones in the future."

With Anja's insights on Western Australia's stormy past, coastal communities and companies in the state may be able to better prepare for the unexpected.

Photos: Who cares about the blobfish? Credit: Kerryn Parkinson © NORFANZ Founding Parties; Koala, credit: Liana Joseph; Hugh Possingham, credit: ARC Centre of Excellence for Environmental Decisions; Anja analysed sediment from the Western Australia coastline to create a local history of storms, credit: M. May, M. Engel and A. Scheffers

For more information: ARC Centre of Excellence in Environmental Decisions, Hugh Possingham, h.possingham@uq.edu.au, ceed.edu.au; Southern Cross University, Anja Scheffers, anja.scheffers@scu.edu.au, scu.edu.au/geoscience/index.php/61

From little things, big things grow

Michelle Simmons' work building silicon atomic-scale devices is paving the way towards a quantum computer with the capacity to process information exponentially faster than current computers.

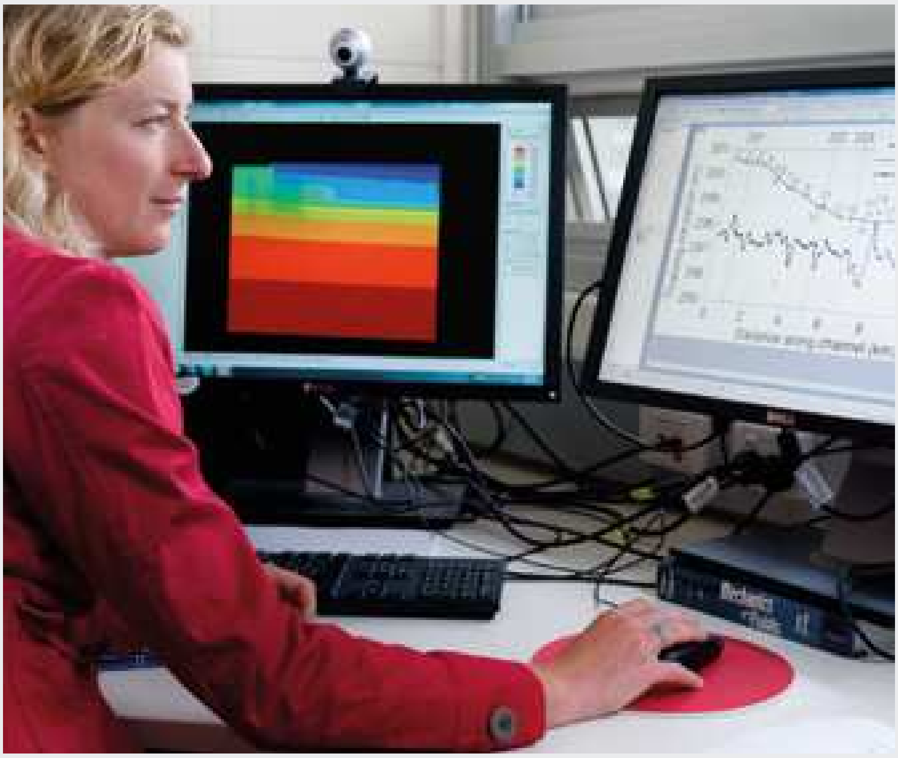
She is also Director of the Australian Research Council Centre of Excellence for Quantum Computation and Communication Technology, acknowledged to be a world-leader in the field of quantum computing—which uses the spin, or magnetic orientation, of individual electrons or atomic nuclei to represent data.

In the past five years, Michelle's research group and collaborators have made a number of notable advances. They have fabricated the world's first single-atom transistor in single-crystal silicon, and the world's narrowest conducting wires, also in silicon, just four atoms wide and one atom tall with the current-carrying capacity of copper.

Michelle Simmons is a member of the American Academy of Arts and Sciences

These results form the components of the first quantum-integrated circuit and have been produced in silicon, the widespread and inexpensive material that already has a trillion-dollar industry devoted to handling it.

This past year, Michelle and her group have shown they can couple donor atoms and transport spin-encoded information between them. For her efforts, among several other honours and awards, Michelle—who is a laureate fellow and Scientia Professor of Physics at the University of New South Wales—has become one of only 11 Australians to be elected a member of the American Academy of Arts and Sciences, a prestigious body that contains more than 200 Nobel Prize winners in its ranks.



Turning groundwater into wine

An investigation into groundwater underneath South Australia's McLaren Vale wine region will help to ensure the local hydrologic cycle and world-famous wines keep flowing freely, and contribute to better groundwater management across Australia. About a third of Australia's water comes from underground sources.

In September, Margaret Shanafield will begin investigating the groundwater in Willunga Basin—responsible for irrigating South Australia's iconic McLaren Vale vineyards.

Groundwater in the Willunga region has shown a gradual long-term decline and many wine producers already rely on a privately funded reclaimed water scheme to satisfy their requirements.

About one third of Australia's water comes from underground sources

Willunga is one of six long-term monitoring sites set up in 2009, by the National Collaborative Research Infrastructure Strategy and the National Centre for Groundwater Research and Training, to reveal the secrets of Australia's subterranean water supplies.

The site has a wealth of existing data and the facilities Margaret needs to develop tools to help water managers in the basin and experts in her field to preserve naturally occurring water sources.

She's also trying to uncover new information about the relationship between groundwater and surface water to enable more accurate predictions of water availability in the future.

"Until 2009, Australia didn't have sufficient infrastructure to fully investigate how those reserves are restocked," says Margaret, who is an Australian Research Council Discovery Early Career Researcher Award (DECRA) fellow.

McLaren Vale – perfect for grapes but needs reliable water

Groundwater flows at a much slower rate than surface water, but Margaret believes the two are inextricably linked.

"We talk about groundwater and surface water as though they're separate things because we look at them on different timescales. I'm hoping to change that," Margaret explains.

Photos: Michelle Simmons is one of only 11 Australians elected as a member of the American Academy of Arts and Sciences, credit: UNSW; Margaret Shanafield is tracking McLaren Vale's declining groundwater, credit: National Centre for Groundwater Research and Training; McLaren Vale, credit: National Centre for Groundwater Research and Training

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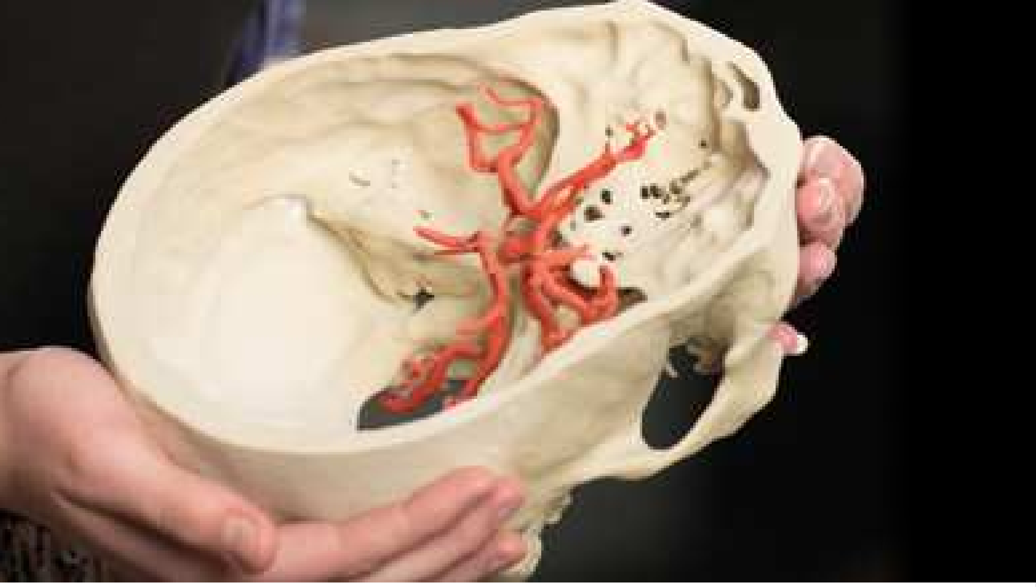
Australian Government
Australian Research Council



Press print for more body parts

"You can't teach anatomy without bodies. Or at least you couldn't until now," says Monash University's Paul McMenamin.

Immune trick revealed by 21st Century microscope

The molecular process behind a killer hole-punch has been revealed through a unique combination of technology—which Monash University call their '21st Century microscope'.

Michelle Dunstone and her colleagues have spent years studying the pore-forming proteins that our immune cells use to punch holes into and destroy damaged cells and invading bacteria. They've used a vast range of complementary techniques from protein crystallography to electron microscopy and computational biology.

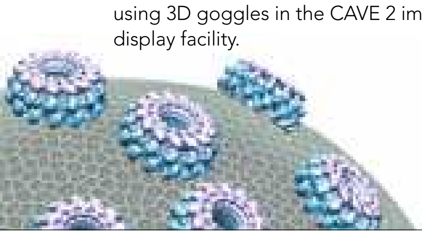
> **I never believed I'd see these hole-punching proteins at work**

Recently for the first time she was able to see these hole-punching proteins at work thanks to a Monash project that takes data captured by the synchrotron and cryo-electron microscopy, crunches it with the MASSIVE super computer, and then visualises it in 3D in real time.
Then she can explore each atom in the protein using 3D goggles in the CAVE 2 immersive display facility.

"This combination of technologies is analogous to the light source, focusing knobs and eyepiece of a conventional microscope, but it lets scientists see a lot more," says Ian Smith, Monash's Vice-Provost of Research and Research Infrastructure.

Scientists using the 'microscope' are:

- looking for signs of Huntington's disease in the brain's wiring, which takes two hours instead of two months when the data are visualised in the CAVE 2
- mapping the architecture of our kidneys—developing 3D models of a kidney's vascular system in just three to four minutes with the real-time feedback between MASSIVE and the imaging and medical beamline at the Australian Synchrotron
- working with Jansen to find new drugs for lupus—looking for relationships in their data using visual displays.



He and his colleagues are printing 3D plastic body parts of unprecedented detail and accuracy that have the potential to revolutionise anatomy teaching.

Anatomy students need a high degree of familiarity with the intricate details of the human body. That ideally comes with repeated handling and hands-on study. But students are often reluctant to touch a cadaver any more than necessary.

Removing the emotional, ethical and physical restrictions to close handling and repeated study improves the students' familiarity with the human body. Another advantage of the printing is the expertly applied false colouring picking out intricate nerves, veins, arteries and ligaments that are much harder to identify in preserved cadavers.

> **Creating copies of human body parts—simply a matter of pressing print**

As a robust, nonbiodegradable product, they're also a big cost saver.

"Storage and transport of real human bodies is extremely expensive," says Paul, who is Director of Monash's Centre for Human Anatomy Education. "And in many countries, cultural or economic barriers mean human bodies aren't available at all."

The detail in the printed body parts is uncanny, taking many medical educators and researchers by surprise. In comparison, previous, simplified plastic body parts look like a child's toys.

Replacement of broken or worn printed body parts is also straightforward, Paul explains.

"It's a huge amount of work to create the original part—scanning the body parts, combining thousands of images and applying the colours. But once it's done, it's done. Creating copies is just a matter of pressing 'print'."

3D-printed human foot, showing ligaments, muscle, nerve and bone

Photos: The printed parts will hold up to repeated handling and close study, credit: Centre for Human Anatomy Education; The combination of technologies is analogous to the light source, focusing knobs and eyepiece of a conventional microscope, credit: Monash University; Pore-forming protein, credit: Monash University; 3D-printed human foot, showing ligaments, muscle, nerve and bone, credit: Centre for Human Anatomy Education

MONASH University

For more information: Centre for Human Anatomy Education, Monash University, Paul McMenamin, paul.mcmenamin@monash.edu, www.med.monash.edu.au/anatomy/facilities/3d-printer.html; Monash University, Ian Smith, Ian.Smith@monash.edu, www.monash.edu/research/infrastructure

Shared data reveals radio bursts, and a lunch break

In May 2014, a team led by PhD candidate Emily Petroff from Swinburne University was the first to see ‘fast radio bursts’ (FRBs) live, using the Parkes radio telescope in central New South Wales. The search was triggered by signals found in recycled data. They also discovered that someone was opening the kitchen microwave.

Lasting only milliseconds, fast radio bursts were first discovered in 2007 by American astronomers combing archival data from Parkes. They are thought to have been generated by extreme events billions of light-years from Earth. But they’d never been seen live until Emily’s coordinated stake-out. And no-one would know about them without access to radio data accumulated by Parkes.

Recycled data doubled the productivity of Hubble

This is just one example of the benefits of documenting, storing, and making data accessible to others.

Open Research Data, a 2015 study commissioned by the Australian National Data Service, found that the value of unrealised data sharing was an estimated $1.4 to $4.9 billion.

The report parallels the experience of NASA. They found that $75 million spent on sharing Hubble Space Telescope data led to a doubling in the science output.

And the lunchbreak? Emily and her colleagues found other unexplained radio bursts in the data they analysed and named them perytons. These turned out to occur only during lunch breaks and were tracked down to someone opening a microwave oven.

Where did the antimatter go?

Antimatter has been disappearing and Melbourne researcher Phillip Urquijo wants to know why.

He’s hoping that the Belle II experiment, commencing in Japan in 2017, will give him an answer—and if he’s lucky it will answer many other questions about the beginning of the Universe too.

“What I hope we’ll discover is clear evidence of new quarks, leptons or other force-carrying particles,” says Phillip. “And I’d be really excited if we found a new kind of Higgs particle using this indirect approach.”

Belle II will use the SuperKEKB particle accelerator, near Tokyo, smashing positrons into electrons to recreate the reactions that occurred early in the formation of our Universe.

They’ll then use precision measurements to study how the particles they create interact, hunting for signs of new particles of nature.

Where the Large Hadron Collider hopes to measure these types of fundamental particles directly, the complementary and powerful Belle II will be looking for the signs they exist.

The big question Belle II aims to answer is: what happened to all the antimatter that existed at the big bang, but has since disappeared?

“We’re some of the way to understanding antimatter decay—but we don’t yet understand enough about what is happening to explain what we see cosmologically,” says Phillip.

Phillip is the physics coordinator for Belle II, which has more than 600 collaborators from 23 nations. He’s based at the Australian Research Council Centre of Excellence for Particle Physics at the Terascale in Melbourne, where he’s also building some of the components for the SuperKEKB.

We’re looking for new quarks and leptons

Photos: Stock photo, iStockphoto; Phillip Urquijo—looking for missing antimatter, credit: Casamento photography; Japan’s SuperKEK facility being upgraded for the Belle II experiment, credit: KEK

For more information: Australian National Data Service, ands.org.au/resource/open-research-data.html; ARC Centre of Excellence for Particle Physics at the Terascale, Phillip Urquijo, phillip.urquijo@unimelb.edu.au, www.coepp.org.au

You can read more about these and other Australia–Japan collaborations online at www.scienceinpublic.com.au/stories/japan

Changing lives: Australia–Japan science links

Japanese science changing Australia

The impact of Japanese technological prowess on Australian society is obvious for all to see. How we listened to music was transformed by audio recording technologies: from the Walkman to the CD.

Home entertainment was changed by video tapes, DVDs, and game consoles. We rely on Japanese innovation in transport—reliable car engineering, the lean manufacturing techniques that made them affordable and, more recently, hybrid cars.

Fundamental science discoveries are now bringing a new era of transformation. Japanese researchers were honoured last year with the Nobel Prize for their invention of the blue LED. They succeeded where for 30 years everyone else had failed. Incandescent light bulbs lit the 20th century; the 21st century will be lit by LED lamps—lasting a lifetime and using a fraction of the energy.

In 2006 Shinya Yamanaka discovered how intact mature cells in mice could be reprogrammed to become immature stem cells. By introducing only a few genes, he could reprogram mature cells to become pluripotent stem cells, that is, immature cells that are able to develop into all types of cells in the body. His work is transforming stem cell medicine and many Australian researchers are now using his induced pluripotent stem cells to develop stem cell medicine.

Australian science changing Japan

It's not a one way trade. Japanese lives are being improved by Australian inventions such as the bionic ear, gum that repairs tooth decay, sleep disorder treatments, lithium to treat bipolar disorder, aircraft black boxes, and anti-flu drugs, which are all in daily use in Japan.

And when you connect to a fast and reliable wi-fi network you can thank Australian astronomers who were searching for black holes and created tools for cleaning up radio waves.

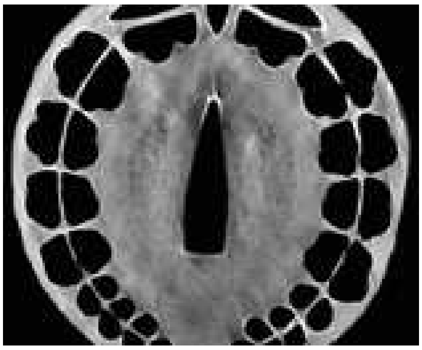
Collaborating for the future

Today there are hundreds of thriving Australia–Japan research collaborations, many of which will have a profound impact on our lives in the years ahead.

Over the past five years, Japan has consistently placed within the 10 countries that have the highest number of collaborations with Australian researchers on Australian Research Council–funded projects. The ARC reports that the most popular disciplines for collaboration with Japan are: material engineering; biochemistry and cell biology; atomic, molecular, nuclear, particle and plasma physics; astronomical and space sciences and plant biology.

In this feature we highlight some of the collaborations.

Photos: Screening for new malaria drugs, credit Griffith University; Nobel Laureate Shinya Yamanaka changed stem cell science, credit: Gladstone Institutes/Chris Goodfellow



Sharing light and neutrons

Japanese researchers are coming to Australia for our neutron beams. It's helping them to continue their research following the shutdown off all Japanese research reactors in the aftermath of the Great East Japan Earthquake. And it cements a friendship in beamline science that kickstarted Australian access to synchrotron light.

Japan has a rich history in nuclear research and has fourteen research reactors, ranging from very small teaching reactors to the 140MW JOYO prototype fast breeder reactor. But following the Great East Japan Earthquake and the Fukushima accident all Japanese research reactors were shut down and are awaiting regulatory and government approvals before they can start up again.

Neutron beams were among the products of the research reactors. Beams from the reactors are diverted through a beamline where they can perform a wide range of useful tasks: testing turbines, train wheels and tracks, and similar metal objects; investigating the structure of starch and other biological molecules; developing new battery technologies; and many other material science applications.

So the Australian Nuclear Science and Technology Organisation (ANSTO) offered time on its neutron beamlines at OPAL, Australia's research reactor, located on the southern edge of Sydney. Now Japanese scientists are the second largest international user community at OPAL.

From 1992 to 2008 thousands of Australian scientists ventured north to Japan's Photon Factory in Tsukuba, west of Tokyo, where the Australian government established the Australian National Beamline Facility. The facility was used for a vast range of applications, from developing anti-flu drugs to creating new wool fibres and assessing jet engine wear. "It trained a whole generation of Australian scientists and laid the groundwork for the construction of Australia's own synchrotron," says ANSTO's Richard Garrett.

"Australian science owes an enormous debt of gratitude to Japan and the Photon Factory for their generous support over all these years," he says.

Elephant seals discover bottom water

Japanese and Australian researchers deployed elephant seals to solve a Southern Ocean mystery in 2013.

Southern elephant seals fitted with satellite tags foraged on the continental shelf down to 1,800 metres and revealed a layer of dense cold water—so called Antarctic bottom water—flowing out into the deep ocean.

Reaching places that we just can't get to

"These seals are fantastic oceanographers," says Tim Moltmann, Director of Australia's Integrated Marine Observing System. "They dive and explore under the Antarctic ice sheets reaching places that we just can't get to."

The discovery filled an important gap in our understanding of how the Southern Ocean affects global climate.

Finding new drugs for malaria

Malaria affects hundreds of millions of people worldwide. For many it's a direct cause of poverty. New drugs may be on the way thanks to an Australian team working with a remarkable new Japanese organisation to find new drugs.

The Global Health Innovative Technology Fund (GHIT) is investing one hundred million dollars in creating new products to improve global health. High on their priorities is malaria, and they've turned to a team at Griffith University on Australia's Gold Coast to help them find new malaria drugs.

There Vicky Avery and her colleagues have a unique technology platform that they've already used to screen millions of prospects. Several are showing promise.

"Most of the current drugs tackle the malaria parasite in its asexual stage, when it's growing rapidly in blood cells and causing visible symptoms," says Vicky. "We decided to see if we could also break the reproductive cycle—when male and female gametocytes form and are taken up by a mosquito biting you. If we are ever going to totally eradicate malaria we'll need to break this transmission cycle." The team already has some promising lead compounds.

Other collaborations

Read more about these collaborations and more at www.scienceinpublic.com.au/stories/japan

Seeing every cell in a whole adult brain

Scientists from RIKEN, the University of Tokyo, JAST, and the Queensland University of Technology have developed CUBIC—a technique for rapidly imaging the brain. They believe it will be scalable to whole bodies.

Biomedical applications for 'magic crystals'

CSIRO and Osaka Prefecture University are developing biomedical applications for the massively absorbent metal–organic framework crystals developed by CSIRO. (See also Matthew Hill on page 10.)

How our phones track us

Billions of us now have phones that tell us and others where we are and what's around us. A team from RMIT, Intel, Fudan University and Keio University is exploring the cross-cultural and intergenerational study of this phenomenon, and the implications for privacy, in three key sites: Tokyo, Shanghai and Melbourne.

Photos: A *tsuba* (hand guard) from a samurai sword imaged using neutrons from OPAL, credit: Floriana Salvemini, ANSTO; Elephant seal solves an ocean mystery, credit: Chris Oosthuizen

Smartphones into $2 science labs, first vaccine for Hendra virus and floaties for choppers

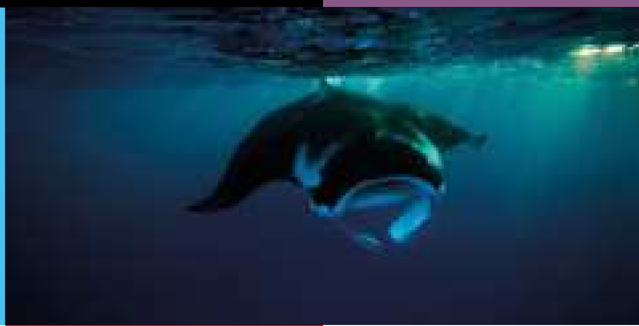
2014 EUREKA PRIZE WINNERS

Floaties for choppers

Helicopters sink. Quickly. Not any more.

West Australian inventor and ex-Navy diver Tim Lyons has created a helicopter buoyancy device that inflates within a second, and is built to a lightweight, bolt-on/ bolt-off design.

Fighting substance abuse



Thousands of young Australians suffer substance abuse and mental health issues on their own—afraid to reach out for help, or even admit the problem.

Maree Teesson's team at the National Drug and Alcohol Research Centre connects those young Australians with the information they seek and the help they need.

200 divers changing marine science

The Reef Life Survey team has harnessed the efforts of 200 divers around the planet to create a unique global dataset that's generating significant scientific findings.

Their data has shown, for example, that nutrients leaking from fish farms often extend hundreds of metres from the farm, rather than tens of metres as assumed in regulations. And they've shown that marine protected areas can take decades to recover from fishing.

Changing the way we talk about the science of climate change

Lesley Hughes thinks she can change sceptical minds about climate change.

Over 20 years of researching and communicating the science of climate change, Lesley Hughes of Macquarie University has learned some valuable lessons. That catastrophising is counterproductive, for example. Focusing on catastrophic risks can switch people off and entrench contrary views even deeper.

(Not) curing cancer only part of the story

Terry Speed accepts he's never going to see the headline 'statistician cures cancer'.

However, it's a sure bet that every significant triumph we see in the long fight against the 'big C' has been won on the back of some serious, high-quality number crunching. And there's a good chance Melburnian Terry Speed helped.

These are just some of the winners of the 2014 Australian Museum Eureka Prize.

Full press kit at australianmuseum.net.au/ 2014-winners-eureka-prizes

Photos: Alfred manta feeding, credit: Gary Cranitch; Basket star, credit: Charles Tambiah

Image finalists in the 2014 New Scientist Eureka Prize for Science Photography

First vaccine and treatment against Hendra virus

With a human death rate over 50 per cent and an ability to cross species, the Hendra virus that emerged in 1994 had frightening potential.

CSIRO quickly identified the new virus, but a vaccine proved harder. Now, thanks to the work of CSIRO's Hendra Virus Research Team in Geelong, we have the first vaccine and effective human treatment against the virus, and skills and resources that are being applied against Ebola.

Crystals, flies and rare diseases

2014 L'ORÉAL AUSTRALIA FELLOWS

How flies can help us predict the future

Our planet's climate is changing. How will bees cope—will they still be able to pollinate our crops? Will dengue and malaria–carrying mosquitoes spread south?

Vanessa Kellermann is looking for the answers—working with native fruit flies found from Tasmania to tropical Queensland to find out. She has already demonstrated that tropical flies don't have the genetic capacity to evolve quickly.

Photos: L'Oréal Australia

Clean water with crystals

Cara Doherty has a vision for a new manufacturing industry for Australia. She works with crystals that are packed with … nothing.

They're highly porous sponges—down to a molecular level—and can be customised to absorb almost any molecule. Her crystals could transform water filters, batteries and medical sensors, and clean up carbon emissions. (See also the work of her colleague Matt Hill on page 10)

Solving rare disease mysteries

Elena Tucker has brought peace of mind to families affected by rare energy disorders. She's found genes responsible for some of these diseases.

Now she will look at hundreds of individual genomes to determine the causes of sex-determination disorders.

Videos and profiles at www.scienceinpublic.com.au/loreal

Making plastics, mining, and engineering

2014 ATSE CLUNIES ROSS MEDALS

John Nutt helped design and analyse the sails of the iconic Sydney Opera House early in a career that saw him pioneer the use of computers in engineering, and contribute to the first fire code for buildings.

Kevin Galvin's invention of the Reflux Classifier has generated hundreds of millions of dollars in benefits to the Australian economy, and revolutionised mineral processing around the world. It maximises mineral recovery by improving the recovery of fine, but still valuable, particles.

Ezio Rizzardo, **Graeme Moad**, and **San Thang** invented a new way of making plastics called RAFT. Their techniques are being used by DuPont, L'Oréal, IBM, 3M, Dulux and many other companies. Their work has been cited more than 12,000 times in the scientific literature and is integral to more than 500 patents.

There's still room for innovation in railways as **Ravi Ravitharan**, **Peter Mutton**, and **Graham Tew** have shown through 40 years of work at the Institute of Railway Technology at BHP then Monash University. Operators of heavy-haul and metro railway systems around the world rely on them to solve issues from track wear and design to maintenance and safety.

Eugene Ivanov and **Michael Tobar** have created the world's lowest-noise oscillators, now used in radar, astronomy and industry. Read more on their work on page 6.

More at www.atse.org.au/atse/about/clunies-ross-award/content/about/previous-recipients.aspx

Predicting change, brains, trains and mental health

STATE AWARDS

"Trait-based ecology" enables Macquarie University's **Mark Westoby** to explain patterns of species occurrence and abundance and to understand the impacts of climate change and changing patterns of land use. He received the $55,000 NSW Scientist of the Year. www.chiefscientist.nsw.gov.au/awards/nsw-science-and-engineering-awards-2014

Nanocapsules for drugs delivery: **Frank Caruso** is making miniature capsules that could better deliver drugs for cancer, AIDS and cardiovascular diseases. He won one of the 2014 Victoria Prizes for Science & Innovation worth $50,000. Read more about Frank on page 15.

Metals and Alzheimer's: **Ashley Bush** is working out how the interaction of certain proteins and metals in the brain contribute to the development of diseases such as Alzheimer's, Parkinson's and Huntington's. For his work at the Mental Health Research Institute he received a Victoria Prize for Science & Innovation. www.veski.org.au/Professor-Ashley-Bush

From the subatomic to finance markets: **Anthony Thomas** is at the forefront of subatomic physics. He is unravelling the rich and complex structure of subatomic matter with implications for our understanding of the Universe, and of the financial markets and climate change. The University of Adelaide researcher won the South Australian Scientist of the Year. www.statedevelopment.sa.gov.au/science/science-excellence-awards-sa/2014-winners

Plant energy: Western Australia's Scientist of the Year, **Ian Small**, has pioneered research into how plants capture, store and release energy. Read more about his work at The University of Western Australia on page 6.

Understanding autoimmunity: **Carola Vinuesa's** work has led to the discovery of genes important for immune regulation and is paving the way for the development of new drugs to fight autoimmune diseases such as lupus, juvenile diabetes and certain cancers. She received the inaugural CSL Young Florey Medal for her research at the Australian National University into how the immune system produces antibodies to fight disease. www.aips.net.au/aipstv/2014-csl-young-florey-medallist-prof-carola-vinuesa/

Australian Academy of Science medals

Harry Messel has been a powerful force in science education—from the Physics Foundation to textbooks and his establishment of International Science Schools. He was awarded the Academy Medal.

Simon McKeon is a prominent business leader and philanthropist who has made extensive contributions to Australian science and innovation including chairing the CSIRO Board and the agenda-setting McKeon report into medical research in Australia. He was awarded the Academy Medal.

The life and death of cells: **Jerry Adams** has advanced understanding of cancer development, particularly of genes activated by chromosome translocation in lymphomas. By clarifying how the Bcl-2 protein family controls the life and death of cells, he and his colleagues at the Walter and Eliza Hall Institute of Medical Research have galvanised the development of a promising new class of anti-cancer drugs. Jerry was awarded the 2014 Macfarlane Burnet Medal.

The secret life of reactions: Numerous chemical reactions take place via so-called reactive intermediates, short-lived molecules that are usually undetectable. But The University of Queensland's **Curt Wentrup** can see them using flash vacuum thermolysis with low temperature spectroscopy. His contribution to theoretical chemistry is also helping in the creation of new compounds. Curt was awarded the David Craig Medal.

Revealing the oldest vertebrate fossils: **Gavin Young** used the fossil record to date the Transantarctic Mountains and went on to map the Amadeus Basin in central Australia, resulting in the discovery of the oldest known vertebrate fossils on the planet. Gavin, from the Australian National University, was awarded the Mawson Medal.

Geoscience is central to the modern wealth of Australia: **Neil Williams**' career across academia, industry and government contributed to the exploitation of vast mineral deposits including oil and gas. His leadership of Geoscience Australia has made Australia a leader in the use and application of high quality science to manage natural resource issues. Neil was awarded the Haddon Forrester King Medal.

Green light: Swinburne University's **Min Gu** is developing the use of light through nanophotonic innovations which have significant benefits, including low energy consumption big data centres, early cancer detection and environmentally friendly solar cells. Min received the Ian William Wark Medal.

Early-career Awards

More on all the Academy medals at www.science.org.au/awardees-2014

Julie Arblaster's climate research is helping to explain the climate of the Australian region, particularly the ozone hole, El Niño, the monsoon, and Australian rainfall variability.

David Warton is driving data analysis in ecology, making it a more predictive science. His tools are influencing statistics across science and industry.

Christian Turney has pioneered new ways of combining climate models with records of past climate change spanning from hundreds to thousands of years.

Maria Seton has redefined the way we reconstruct the movement of continental plates and contributed to studies on the effect ocean basin changes have had on global long-term sea level and ocean chemistry.

Richard Payne has pioneered peptide chemistry and drug discovery for neglected diseases, advancing a number of lead compounds for the treatment of tuberculosis, malaria and cancer.

Geoff Pryde's research investigates the fundamental properties of the quantum world and how these can be harnessed for radical advances such as ultra-secure long-range communications.

Katherine Belov has overturned the paradigm that Australian mammals have primitive immune systems. Her work has implications for wildlife disease and future antimicrobials.

Ryan Lister studies the epigenome in both plants and animals. Read more of his work on pages 11 to 13.

Kieran Harvey is unravelling the signalling networks that control organ size. His work will provide fertile ground for therapeutic interventions for cancer and degenerative diseases.

Emma Johnston is revealing the causes and consequences of bio-invasion through her work combining traditional laboratory studies with novel field-based experiments in Antarctica, the Great Barrier Reef, and temperate Australian estuaries.

Worm spit that heals then kills

Cairns researchers have discovered a wound-healing and cancer-causing hormone in the spit of a liver worm that lives in over nine million people and infects adventurous Australian tourists.

The Southeast Asian liver fluke munches through the liver, repairing the damage as it goes. But after many years of infection it can cause liver cancer and kills 20,000 people each year in Thailand alone.

"The growth hormone makes cells multiply quickly and uncontrollably, which is a key stage at the start of many aggressive and deadly cancers," says Michael Smout from James Cook University.

"As it feeds on blood and tissue in the liver, the worm creates wounds, and then heals them, we suspect. This is good for the host in the short term, but repeated wounding and healing over decades combined with chronic inflammation can lead to this deadly form of cancer," Michael explains.

The researchers hope their study will lead to vaccines to prevent liver cancer in impoverished regions of Asia, and to new treatments for non-healing wounds, which are an increasing problem for the ageing population here in Australia.

Michael won the inaugural FameLab Australia competition in 2014 and represented Australia in the national finals at the Cheltenham Science Festival.

Future fuels will come in orange flavour

Queensland researchers are persuading baker's yeast to produce jet fuel from sugar.

Timothy Brennan and his colleagues at The University of Queensland have helped genetically engineered yeast evolve to make an oil called limonene, which is found naturally in lemons and oranges, and also happens to be an efficient jet fuel.

An efficient jet fuel—from oranges

While there are plenty of researchers already producing small amounts of yeast-derived biofuels around the world, one common limitation is that production volumes are limited by the toxicity of the fuel.

Tim and his colleagues redesigned a bioreactor, so fuel is removed immediately after it's produced by the yeast. This allows the yeast to tolerate up to 700 times more fuel than it would in a traditional bioreactor.

How do bees choose a new home?

Not all honeybee species think like the common western hive bee when it comes to deciding on a place to nest. Some are capable of making faster collective decisions, according to James Makinson and his University of Sydney and Thai university colleagues.

"When western hive bees want to find a new place to nest, the queen and a subset of the colony's workers set out as a swarm, which forms a temporary cluster close to their existing nest site. Scout bees then take off and search for a specific nest location," James says.

The scout bees will spend around 40 minutes evaluating a potential nest site before returning to the swarm.

Giant Asian bees make faster decisions

But James has found that two little-known species—the giant Asian honeybee and the tiny red dwarf honeybee—use a more rapid, collective decision-making process that enables them to choose a new home quickly. And they aren't as fussy when it comes to the quality of their new home.

With farmed bees under pressure worldwide James' work has implications for managing pollination services, ecological health and pest control.

Cannibalistic cancer eats itself to survive treatment

Stubborn cancer cells play a cunning trick when faced with treatments designed to kill them—they eat themselves to survive. But Lisa Schafranek has found a way to starve the cancer cells, making them more susceptible to cancer therapy.

Lisa and her team at the South Australian Health and Medical Research Institute have used a clinically available drug, originally developed as an antibiotic to treat lung infections, to stop leukaemia cells from eating themselves to survive cancer therapy.

Photos: The wound-healing worm munching through the liver, credit: Banchob Sripa; Tim Brennan, credit: Australian Institute for Bioengineering and Nanotechnology; James Makinson filming a giant Asian honey bee (*Apis dorsata*) cluster in Chiang Rai province, northern Thailand, credit: James Makinson; Lisa Schafranek, credit: OK-White Lane

Acid oceans and a symphony

The oceans around East Antarctica are becoming acidic at a faster rate than expected, and could become toxic to some forms of marine life in the next 15 years.

The findings are the result of research led by Nick Roden at the University of Tasmania and CSIRO, building on a 20-year program initiated by the Australian Antarctic Division.

The study, published in the *Journal of Marine Chemistry*, was the first to document these changes.

From Antarctic plankton to a symphony

A budding videographer, Nick took a video camera with him to Antarctica. Nick's footage and research inspired Tasmanian composer Matthew Dewey to write a symphony—ex Oceano—that promotes understanding of the role of the ocean in supporting life.

The 45-minute symphony was recorded in Prague by the Czech National Symphony Orchestra, and is available on iTunes. It was supported by Lynchpin's Ocean Project.

Jetlag skin patch may prevent brain damage in newborns

Melatonin patches could help improve the outcome for babies starved of oxygen at birth, says James Aridas from Monash University.

Melatonin helps neutralise free radicals—unstable molecules that are a natural waste by-product of the body. Free radicals can damage the fats that are an important part of cell walls and organs, and which are rich in newborn babies' brains.

The body can normally eliminate these destructive molecules. However, when a baby is starved of oxygen and then re-exposed to it, there is an overproduction of free radicals in the first hours after birth, which overwhelms the body's capacity to eliminate them.

The melatonin patches will be easy to use and can be stored without refrigeration.

Reducing permanent brain injury at birth

Boosting the libido of prostate cancer survivors

Perth researchers have shown that twice-weekly exercise can improve sexual function in prostate cancer patients by 50 per cent.

One in six Australian men will be diagnosed with prostate cancer, and 90 per cent of them will report some form of sexual dysfunction during or after their treatment.

Exercise and recover your libido

Prue Cormie, a senior research fellow, and her colleagues at the Edith Cowan University Health and Wellness Institute put a group of men with prostate cancer through a supervised exercise program involving twice-weekly group-based sessions of resistance exercise, such as weight lifting, and aerobic exercises including walking and cycling.

"After three months, the men involved in the exercise program had a 50 per cent greater level of sexual activity. Not only is exercise effective, but it is more patient-friendly and cost-effective treatment than the alternatives."

Carbon fibre that copes with bingles

Giving carbon fibre extra chemical arms means it could have the gripping power it needs to stand up to minor traffic accidents.

High-performance cars use carbon fibre, making them lighter and consequently faster and more fuel-efficient. But carbon fibre is prone to damage from sudden impact and can't be repaired, only replaced, making it costly to fix.

Deakin University's Linden Servinis has developed a treatment that makes carbon fibre 16 per cent stronger by forming extra chemical 'arms' that grip onto its surroundings.

"The carbon fibre composite materials we work with are made of black hair-like carbon fibres weaved together and coated in hard plastic," explains Linden.

"We've found a way to help the fibres hold together."

Photos: Pushing through Antarctic ice, credit Nick Roden; James Aridas, credit: OK-White Lane; Prue Cormie is helping prostate cancer survivors regain their libido, credit: Cohesion Magazine, ECU; Linden Servinis, credit: OK-White Lane

Pet abuse a warning for family abuse

Different forces on bones can tell a story—an animal's skeleton keeps a distinct record that indicates the force applied to bones from past injuries, breaks or fractures.

Broken bones can tell a story of abuse

University of Sydney vet Lydia Tong is using those differences to teach vets how to tell the difference between bone fractures caused by accidents and those caused by abuse. Her fracture identification tools are giving vets the added confidence to identify cases of violence against pets and could serve as a warning of domestic violence.

"Around 70 per cent of women escaping violent homes also report pet abuse," says Lydia. "So vets are often the first to see evidence of abuse in a family, when they treat injured pets."

A 'tango' between light and mirrors

Francis Torres from The University of Western Australia has developed the mirror device at the heart of a new amplifier technology, which uses an interaction between a high-powered laser and mirror motion to magnify subtle metal, temperature and biological vibrations so they are more easily detected.

"Our idea is to connect the sensors in existing space exploration tools to our amplifier so they can look deeper underground and find smaller and hard-to-find targets such as hidden mineral deposits, water or other bacterial life," says Francis.

The technology could also enhance the detection sensitivity of Earth-exploration tools and medical sensors.

Picture sound and light as dancing partners

Buddhist singing bowls inspire solar cell design

Buddhist singing bowls resonate with sound and have inspired a Canberra scientist to create nano-bowls that do the same with light. Using these bowls in solar cells will increase their ability to capture more light and convert it into electricity.

Light bouncing around nano-prayer bowls makes for more efficient solar panels

"Current standard solar panels lose a large amount of light energy as it hits the surface, making the panels inefficient," says the Australian National University's Niraj Lal. "But if the cells are singing bowl–shaped, then the light bounces around inside the cell for longer."

Niraj and his colleagues hope to apply his singing bowl concept to tandem solar cells, a technology that absorbs sunlight more effectively but has previously been limited to aerospace applications.

Are you in control?

Do you always feel in control? The effortless state of 'flow' reported by sportspeople—where they anticipate and quickly react to their opponent's moves—is a highly sought-after state.

But for those with mental illnesses such as schizophrenia, losing control can be distressing says Vince Polito, from Macquarie University.

The sense that we have control over our own actions is called our sense of agency. By looking at what triggers and blocks the state of flow experienced in elite sportspeople and musicians, Vince hopes to better understand the common causes of losing control.

Fresh Science pushes early-career scientists with a discovery into the media spotlight. Every year since 1998 we've trained and promoted some of the best up-and-coming scientists. In 2014 Fresh Science partnered with the British Council's FameLab competition and the overall winner competed at the Cheltenham Science Festival. Find out more at **www.freshscience.org.au**

Photos: Lydia Tong attending a puppy in Vanuatu, credit: Kris Radder; Francis Torres, credit: OK-White Lane; Niraj Lal with the Buddhist bowl that inspired his research into solar cells, credit: OK-White Lane; Vince Polito, credit: OK-White Lane

For more information: Fresh Science, freshscience.org.au

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- The University of Melbourne
- The University of Western Australia
- Victorian Life Sciences Computation Initiative

FRONT COVER (top): iStock bacteria illustration, credit: iStock, see P5; (second from top) Xinhua Wu led the project to print a jet engine, credit: Monash University, see P2; (clockwise from centre) Matthew Hill's crystals will save energy across industry, credit: Prime Minister's Prizes for Science/WildBear, see P10; This tarantula's venom could help chronic pain (*Selenocosmia crassipes*, a resident of Queensland's east coast), credit: The University of Queensland, see P5; Who cares about the blobfish? see P 16; Sven Rogge, Andrea Morello, Michelle Simmons, Andrew Dzurak, credit: UNSW, see P4.

INSIDE FRONT (clockwise from top left): Securing Australia's offshore oil and gas industry, literally, credit: iStock, see P14; Monitoring iron in the liver made easier thanks to the FerriScan technology, credit: stock photo, Dollar Photo Club, see P6; Coral trout biomass in the protected zones has more than doubled since the 1980s, credit: LTMP, Australian Institute of Marine Science, see P8; McLaren Vale, credit: National Centre for Groundwater Research and Training, see P17.

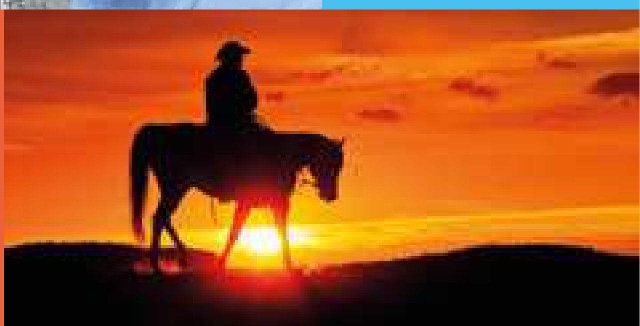
PAGE 1 (clockwise from top left): Bioinformaticians can use Circos plots to visualise how cancer genomes differ from healthy ones, credit: Peter Casamento, see P15; Perth's Fiona Bull says good city design can keep you fitter, credit: Matt Galligan, see P3; Michelle Simmons is one of only 11 Australians elected as a member of the American Academy of Arts and Sciences, credit: UNSW, see P17; Smarter, lighter water filters, credit: L'Oréal Australia, see P23; Phillip Urquijo—looking for missing antimatter, credit: Casamento photography, see P19.

INSIDE BACK (clockwise from top left): measurements made on a photon's wavefunction in one lab affected the photon's quantum state monitored in another lab, credit: Trine Barfod Jensen, see P4; Kaylene Young is helping repair the brain with its own stem cells, credit: Mark Coulson/NSCFA, see P13; Eugene Ivanov and Michael Tobar collaborated for more than 20 years on the technology, credit: The University of Western Australia, see P6; Japan's SuperKEK facility being upgraded for the Belle II experiment, credit: KEK, see P19; Pony Express for quantum messages, credit: iStock, see P4.

BACK COVER (clockwise from top): Reefs in protected zones supported higher numbers of large, reproductively-mature coral trout, credit: LTMP, Australian Intitiute of Marine Science, see P8; Glenn King with an Australian tarantula, credit: The University of Queensland, see P5; Lydia Tong attending a puppy in Vanuatu, credit: Kris Radder, see P28; Replacing invasive biopsies with MRI scanners to find iron in the liver, credit: stock photo, Dollar Photo Club, see P6; Tim Brennan and colleagues are making a jet fuel from oranges, credit: Australian Institute for Bioengineering and Nanotechnology, see P26; Use a particle accelerator the size of the galaxy, or one of their crystals, credit: The University of Western Australia, see P6; (centre) This microscope-in-a-needle could help surgeons find every cancer cell, credit: The Scene Team, see P7.

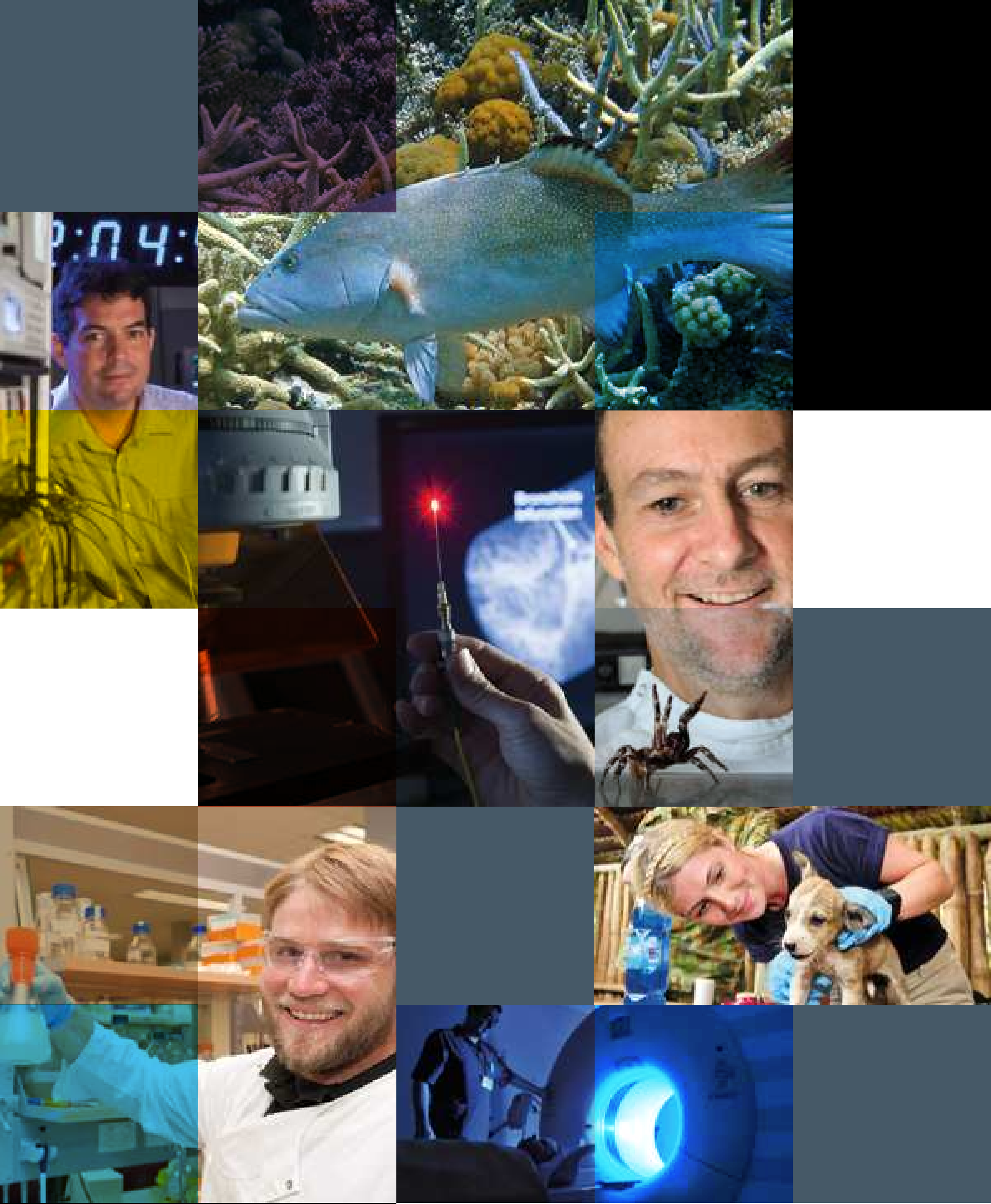
Spooky action one. Einstein nil.

Pony Express for quantum messages



Repairing the brain with its own stem cells

Is the speed of light really constant?



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