2012 Stories of Australian Science

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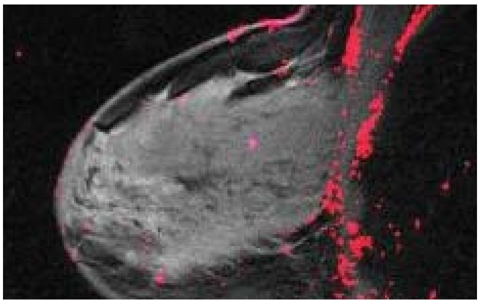

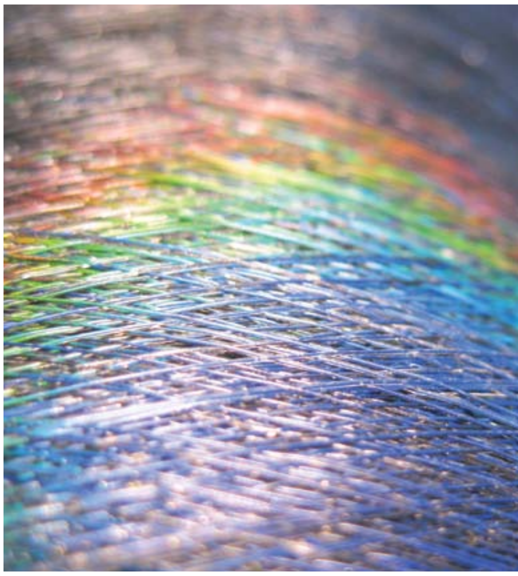

Welcome to Stories of Australian Science 2012

We've put together this collection of Australian science stories to give journalists and others around the world a taste of the breadth and depth of research activity in Australia.

You'll read about uniquely Australian work: a new form of chlorophyll found at Western Australia's Shark Bay; the immune tricks of wallabies; protecting lives and buildings from bushfires; and the role of synchrotron light in making great Australian wines.

This year, as we reviewed the collection, we realised that there was a strong physical sciences theme. That wasn't deliberate. But it's been a good time for the physical sciences in Australia. The nation will share constructing the world's largest radio telescope with South Africa. A precursor, the SKA Pathfinder telescope, is already booked out for the next five years. And Australia's high energy physicists shared in the announcement of the Higgs boson in July this year.

The renaissance in the physical sciences in Australia also reflects the growing convergence of the physical and life sciences.

The Australian Synchrotron, for example, has been a boon for life scientists. They've been queuing up for access to its powerful beams. And a dedicated life sciences supercomputer has been contributing to cancer genetics. These are just two of a series of substantial infrastructure investments that have underpinned Australian science recently.

Billions of dollars have been invested by the Federal government over the past decade. Now those investments are bearing fruit. In these pages you'll read how non-scientists are turning their ideas into reality thanks to a national fabrication facility; and how shared data is fast-tracking discoveries in astronomy, and giving the public access to 18 million observations of Australia's flora and fauna.

We also present the winners of some of Australia's leading science prizes.

This is our fourth collection of Australian science stories. The first was put together in 2007 when journalists met in Melbourne for the 5th World Conference of Science Journalists.

We look forward to catching up with friends and colleagues at the AAAS in Boston in February 2013 and in July 2013 in Helsinki at the 8th World Conference of Science Journalists.

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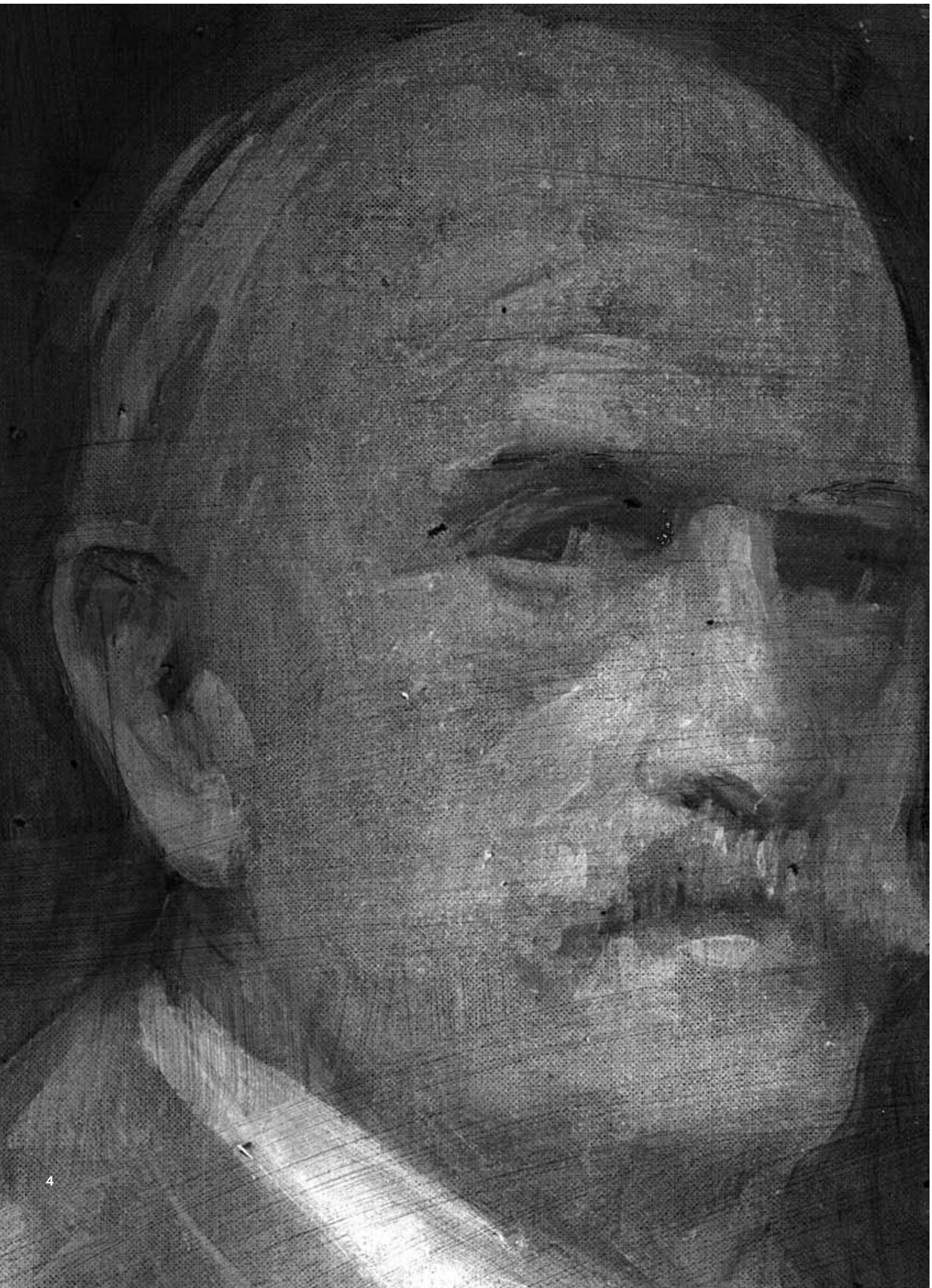
PHOTOS, CENTRE TOP: CONTRAST-ENHANCED MRI OF A BREAST (SEE PAGE 25), CREDIT: YANIV GAL; CENTRE BOTTOM: STUART WYITHE IS LOOKING BACK TO THE BIRTH OF THE FIRST GALAXIES (SEE PAGE 7), CREDIT: NASA, ESA, CRAL, LAM, STSCI; RIGHT: THE SMART BANDAGE FIBRES CHANGE COLOUR WHEN EXPOSED TO HEAT (SEE PAGE 33), CREDIT: LOUISE VAN DER WERFF, CSIRO.

Stories of Australian Science



HERE WE SEE THE RESULTS OF SYNCHROTRON EXPLORATION OF A SELF-PORTRAIT BY ARTHUR STREETON WHERE THE UNDERLYING IMAGE WAS DETECTED WITH SYNCHROTRON ANALYSIS (SEE HIDDEN ART REVEALED, NEXT PAGE). PAGE 28 HAS MORE ON THE SYNCHROTRON PROJECTS.

Hidden art revealed

A glimpse of a rare self-portrait by one of Australia's most highly regarded artists has emerged from what appeared to be a blank canvas—thanks to researchers at the Australian Synchrotron.

Early in the 20th century, Sir Arthur Streeton, a renowned Australian landscape artist, painted over a self-portrait with a heavy layer of white lead paint in order to reuse his canvas.

The paint makes it impossible to see underneath, even with modern X-ray techniques. So there the painting sat for years, at the National Gallery of Victoria (NGV).

Enter Dr Daryl Howard, his team at the Australian Synchrotron, and his colleagues from CSIRO and NGV, who used X-ray fluorescence spectroscopy to analyse the painting, revealing the precise location of the metal atoms in a 25-megapixel image.

Using this map of metal atoms, the scientists were able to establish where on the canvas certain paint pigments were concentrated.

For example, the element zinc is the main ingredient of a pigment used in oil painting called Zinc White.

"By tracing a map of the concentrations of zinc in the painting, we can start to see the white of Sir Streeton's collar and the fairness of his face," Daryl says.

"Anywhere else in the world, it would have taken a year to scan this painting—here it takes a day, because of a special detector called Maia, developed at the Synchrotron with CSIRO and Brookhaven National Laboratory in the US."

Daryl is now working with a computer programmer to come up with a better model to match patterns of atoms with actual pigments.

"We're working towards using a 'Photoshop on steroids' that will be able to fully reproduce these hidden artworks."

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Higgs boson: the Australian connection

In 2012, scientists celebrated at the announcement of the discovery of a Higgs boson-like particle, a subatomic particle that completes our model of how the Universe works.

The announcement was made simultaneously at CERN in Geneva, and to hundreds of physicists gathered in Melbourne for the International Conference on High Energy Physics.

"As scientific discoveries go, this is up there with finding a way to split the atom," says Prof Geoff Taylor, director of the ARC Centre of Excellence for Particle Physics at the Terascale (CoEPP).

"Australian groups have been part of this from the beginning—so, for the best part of 25 years," he says.

Australians contributed directly to the development of the ATLAS detector, one of two experiments looking for the Higgs boson at the Large Hadron Collider (LHC), and about 30 Australians contribute to the ATLAS research effort through the ARC Centre.

A bank of computers at the University of Melbourne also forms part of the network that processes the 25 million gigabytes of data generated by the LHC each year. The Australian facility is also being used to test new technology for this network, called the Worldwide LHC Computing Grid.

The Centre currently has $25 million in Australian Research Council funding over seven years, which supports the work of more than 20 senior investigators and 60 students or postdoctoral researchers.

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Frog peptides versus superbugs

Neutrons and native frogs are an unlikely but dynamic duo in the battle against antibiotic-resistant bacteria, commonly known as superbugs, recent research has shown.

The skin secretions of the Australian green-eyed tree and growling grass frogs contain peptides (small proteins) that help frogs fight infection. Researchers hope these peptides will offer a new line of defence against a range of human bacterial pathogens, including methicillin-resistant *Staphylococcus aureus* (MRSA).

New research conducted by the University of Melbourne together with the Australian Nuclear Science and Technology Organisation (ANSTO) is revealing how and why these peptides kill bacterial cells while leaving animal cells—frog or human—untouched.

ANSTO biophysicist Dr Anton Le Brun studies synthetic versions of these peptides at the molecular level using the "Platypus" neutron reflectometer. Neutron reflectivity analysis provides a picture of the structure and function of the peptides.

"We're getting an insight into how a particular peptide is interacting with the bacterium membrane and ultimately resulting in its death," says Anton. "We can locate where the peptide is in the membrane and look at the structural changes."

Unlike current antibiotics, which typically interrupt bacterial function, these frog peptides kill bacteria by attacking the lipid components of the cell membrane, punching holes in it or breaking it down. Because these peptides damage structure, rather than function, the development of resistance to antibiotics based on these peptides is reduced.

Anton and his colleagues hope this knowledge will lead to the design of powerful antibiotics that are less prone to bacterial resistance—a new phase in the battle against superbugs.

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PHOTOS: THE STREETON PAINTING OVERPAINTED (RIGHT TOP), THE ZINC CONTENT IMAGE (RIGHT BOTTOM) AND CORRECTED ZINC IMAGE (LEFT), CREDIT: DARYL HOWARD; THIS PAGE: THE GROWLING GRASS FROG'S SKIN SECRETIONS INCLUDE DISEASE-FIGHTING PEPTIDES, CREDIT: CRAIG CLEELAND; GEOFF TAYLOR (RIGHT) CELEBRATES THE HIGGS BOSON-LIKE PARTICLE ANNOUNCEMENT AT THE MELBOURNE CONVENTION CENTRE WITH PAULINE GAGNON OF CERN, CREDIT: LAURA VANAGS/ARC CENTRE OF EXCELLENCE FOR PARTICLE PHYSICS AT THE TERASCALE; SCREEN SHOT OF THE AGE FRONT PAGE, THURSDAY 5 JULY 2012.

Prime Minister's Prizes for Science

Since 2000 the prizes have recognised leaders in Australian science. In 2011 the Prime Minister awarded her prize to two chemists—neither were household names, but their discoveries are changing how plastics and other polymers are made. They were joined by the discoverer of a new form of chlorophyll; a young physicist casting light on our Universe's "dark age"; and two remarkable science teachers.

For more information on the prizes visit Prime Minister's Prizes for Science

www.innovation.gov.au/PMSP

Changing the world one molecule at a time

Many plastics and polymers—including paints, glues and lubricants—will be transformed in the coming years by the work of Australian chemists, Professors David Solomon and Ezio Rizzardo.

Their work is integral to more than 500 patents and their techniques are used in the labs and factories of DuPont, L'Oréal, IBM, 3M, Dulux and more than 60 other companies.

Polymers are chemical structures built of repeating units of molecules joined together like beads on a string.

David and Ezio found ways to provide unprecedented control over the structure, composition and properties of these polymers, which are now used in almost every facet of our lives.

"The raw materials don't really change, it's how you put them together that counts," says David.

This polymer revolution is largely thanks to this pioneering pair: David, who taught himself about polymers while working for Dulux as a teenager; and Ezio, who came to Australia as a young Italian migrant without a word of English.

For their work, David and Ezio jointly received the 2011 Prime Minister's Prize for Science.

With the world's biggest chemical companies using their process to build ever more sophisticated polymers, David and Ezio are developing new polymer applications.

David is developing a one-molecule-thick polymer film that will prevent evaporation from reservoirs and water storages, while Ezio is developing "smart" biomaterials to carry drugs which can be targeted precisely at specific tissues.

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New chlorophyll a gateway to better crops

A chance finding has led to the first new chlorophyll discovered in 67 years, opening up possibilities for biofuel and food crops to use sunlight more efficiently.

Chlorophyll is a key molecule in photosynthesis—the process by which plants harness sunlight—providing our food, our fossil fuels and the oxygen we breathe.

This new variant, chlorophyll *f*, was found during a study of single-celled cyanobacteria, formerly known as blue-green algae, which live in the ancient rock-like accumulations called stromatolites in Shark Bay, Western Australia.

For her contribution to our knowledge of chlorophyll and cyanobacteria, University of Sydney A/Prof Min Chen received the Science Minister's Prize for Life Scientist of the Year in 2011.

This discovery is particularly significant for our sustainable future because chlorophyll *f* harvests far-red light, which is lower on the energy spectrum than visible light.

This potentially broadens the range of light that can be used for photosynthesis. Introducing chlorophyll *f* into crop plants would open the way to more efficient collection of energy from the sun. It could also allow biofuel and food crops to be planted closer together, increasing overall yields.

"Finding the new chlorophyll was totally unexpected—it was one of those serendipitous moments of scientific discovery. I was actually looking for chlorophyll *d*, which we knew could be found in cyanobacteria living in low light conditions. I thought that stromatolites would be a good place to look, since the bacteria in the middle of the structures don't get as much light as those on the edge," Min says.

Min's group is now culturing the cyanobacteria in the lab, in the hope of sequencing its genome and isolating the gene or genes responsible for chlorophyll *f*—which may lead the way for crop plants to one day take advantage of its benefits.

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Birth of our hot Universe

An Australian physicist is unravelling the mystery of how the hot, brilliant stars we see today emerged from our Universe's "dark age".

Theoretical physicist Prof Stuart Wyithe is one of the world's leading thinkers on the Universe as it was 13 billion years ago, when there were no stars or galaxies, just cold gas.

In the next few years astronomers will learn much more as powerful new telescopes come online.

"These new telescopes will be looking at radiation coming from hydrogen atoms 13 billion years in the past—a time only 800,000 years after the Big Bang," says Stuart, who is based at the University of Melbourne.

Piecing together when the first galaxies were born and how big they were—these are just some of the things possible with the Square Kilometre Array (shared between southern Africa and Australasia) and the Murchison Widefield Array (MWA) in Western Australia.

"It's exciting that in a few short years we will have a better understanding of this 'dark age' of the Universe," he says.

"This 'epoch of reionisation' (the transition from a cold Universe to a hot one) is the last non-understood event in the history of the Universe.

"Astronomy is all about trying to understand how the Universe came to look the way it does, as well as how it works."

For his work on the physics of the formation of the hot Universe, Stuart received the 2011 Malcolm McIntosh Prize for Physical Scientist of the Year.

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Camping and puppets top science teaching prizes

Brooke Topelberg's students are so keen on science that her lunch-time science club has a waiting list. And Jane Wright has been taking high school girls to explore science in the bush for over 25 years.

Both of these passionate professionals have been awarded a Prime Minister's Prize for Excellence in Science Teaching.

Brooke was only three years out from an education degree when she was appointed science coordinator of her primary school in Westminster—a suburb in Perth, Western Australia, that is home to many immigrant families.

As she set about making science a priority in the school, she was introduced to the concept of using puppets as a non-threatening, inclusive way to teach science and other difficult topics.

"I immediately recognised that these teaching methods would work wonders in the classroom."

Within five years, due largely to Brooke's drive and leadership, not only is her lunch-time science club booked out, but also Westminster Primary School was named Western Australia's Science School of the Year.

Dr Jane Wright entered her profession to gain teaching experience after doing postdoctoral studies—ever since, she's been inspiring generations of young women at Adelaide's Loreto College.

In 2011, Jane coordinated her 26th week-long, annual camp in the Flinders Ranges for 90 Year 11 girls and 13 staff—the girls leave their mobile phones at home and instead take water samples, examine rock formations and learn about biodiversity.

In 2012, Jane will hold teacher workshops on applying for teaching awards, especially the Prime Minister's Science Prizes.

"It's important that teachers have the confidence to apply for prizes that recognise their achievements."

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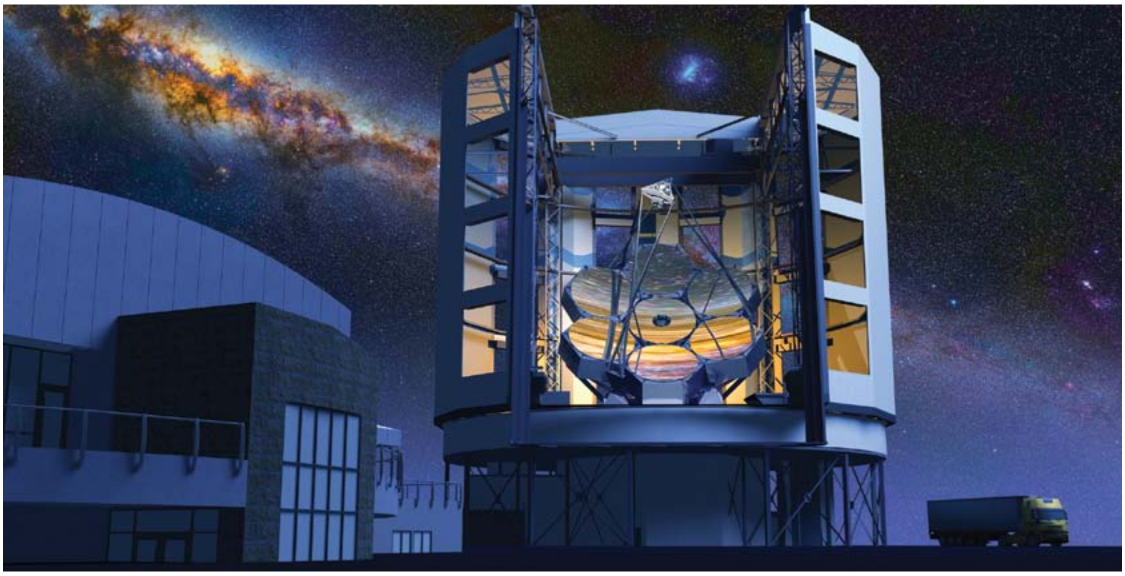
PHOTOS: PRIME MINISTER'S PRIZE FOR SCIENCE WINNERS, DAVID SOLOMON (LEFT) AND EZIO RIZZARDO (RIGHT) WITH PRIME MINISTER JULIA GILLARD, CREDIT: PRIME MINISTER'S SCIENCE PRIZES/IRENE DOWDY; 2011 PRIME MINISTER'S PRIZE FOR EXCELLENCE IN SCIENCE TEACHING IN PRIMARY SCHOOLS WINNER, BROOKE TOPELBERG, WITH STUDENTS, CREDIT: PRIME MINISTER'S SCIENCE PRIZES/BEARCAGE; THIS PAGE: LEFT: 2011 LIFE SCIENTIST OF THE YEAR MIN CHEN, CREDIT: PRIME MINISTER'S SCIENCE PRIZES/BEARCAGE; MIDDLE TOP: DAVID SOLOMON AND EZIO RIZZARDO'S WORK HAS TRANSFORMED PAINTS, CREDIT: ISTOCKPHOTO; MIDDLE BOTTOM: STUART WYITHE IS LOOKING BACK TO THE BIRTH OF THE FIRST GALAXIES, CREDIT: NASA, ESA, CRAL, LAM, STSCI; RIGHT: STUART WYITHE'S MODELS OF AN EARLY UNIVERSE WILL BE EXPLORED BY THE NEXT GENERATION OF TELESCOPE, CREDIT: PRIME MINISTER'S SCIENCE PRIZES/BEARCAGE.



Birds, bees, robots and flying

He isn't a pilot, but few people would know more about ways of navigating while flying than Prof Mandyam Srinivasan (Srini) of the Queensland Brain Institute. And he's steadily finding out more.

Initially known for his work in bees, since receiving the Prime Minister's Prize for Science in 2006, Srini has shown that birds and insects use a similar system of visual guidance to prevent themselves from crashing into trees when flying through dense forest.

At the heart of this system is the ability to sense how quickly images travel across the eye. The closer objects are, the shorter the time they remain in view.

Although simple in concept, this way of measuring distance and speed can be harnessed to achieve sophisticated navigation tasks of collision avoidance, landing and tracking moving targets.

It also explains how animals with minute brains can perform aeronautical feats difficult for human pilots with expensive equipment.

Srini's research is a rare blend of pure and applied science.

His findings are already being put into practice in designing visual navigation systems for robots and developing autopilots for drones or unmanned aerial vehicles (UAVs).

"We've come a long way in the past five years," Srini says.

It's not surprising that his work is supported by a diverse string of sponsors including private companies like Fujitsu, the Queensland and Australian Governments, and the US Air Force.

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Prized astronomer continues to contribute

He received the first ever Malcolm McIntosh Prize for Physical Scientist of the Year in 2000, then the Shaw Prize in Astronomy in 2006, the Gruber Cosmology Prize in 2007 and the Nobel Prize for Physics in 2011—it's been a satisfying progression for Brian Schmidt, professor of astronomy at the Australian National University, and for Australian science. Schmidt led one of two research teams that determined that the expansion of the Universe is accelerating.

But winning awards does not mean he's resting on his laurels. Apart from countless invitations to speak, Brian has his hands full with commissioning SkyMapper, a new optical telescope equipped with Australia's largest digital camera at 268 megapixels.

And he's also involved in two significant new facilities pioneering technology to be used in the Square Kilometre Array (SKA), the world's largest radio telescope: the Murchison Widefield Array and the Australian SKA Pathfinder. In his spare time, he's working on one of the next generation of optical telescopes, the Giant Magellan Telescope.

After it smooths out teething problems with vibrations, the fully-automated SkyMapper at Siding Spring Observatory in central northern New South Wales will begin a survey of the southern sky measuring the shape, brightness and spectral type of more than a billion stars and galaxies, down to a million times fainter than the eye can see. This information will give Australian astronomers an edge when bidding for observing time on the world's most important telescopes.

Brian is grateful for the acknowledgement that his work he has received in Australia. "The Malcolm McIntosh Prize was the first award I received for my work on the accelerating Universe," he says. "It is a sign of the nation's confidence—and important to me—that my home country was able to recognise my part in this discovery first."

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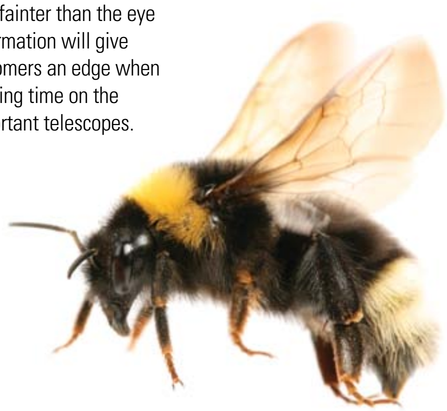

PHOTOS: BRIAN SCHMIDT, THE MALCOLM MCINTOSH PHYSICAL SCIENTIST OF THE YEAR 2000 AND 2011 PHYSICS NOBEL LAUREATE, CREDIT: ANU; BRIAN SCHMIDT WORKS ON MANY OF THE WORLD'S LARGEST TELESCOPES, INCLUDING THE GIANT MAGELLAN TELESCOPE, UNDER CONSTRUCTION IN CHILE, CREDIT: GIANT MAGELLAN TELESCOPE—GMTO CORPORATION.

Neutrons revealing new battery technology and stopping train derailments

Australian Nuclear Science and Technology Organisation

www.ansto.gov.au

Tracking lithium for better batteries

Imagine a mobile phone, gaming gadget or laptop with a battery that never needs replacing, or electric cars powered by batteries that are as fast to recharge as it is to refill your car with petrol. Researchers at the Australian Nuclear Science and Technology Organisation (ANSTO) are unlocking the secret inner workings of lithium ion (Li-ion) batteries to develop better, safer portable power.

Li-ion batteries are becoming increasingly popular. They have higher energy densities (more power) and better cycle-ability (less power loss with each use and recharging) than other battery systems on the market.

However, there is much scope to improve their performance and safety. For example, widely used liquid electrolytes can be flammable and toxic, and solid electrolytes, while safer, are currently less efficient.

Researcher Dr Neeraj Sharma says an understanding of the electrochemistry of lithium within a battery and the mechanism of charge-transfer is fundamental to improving Li-ion batteries.

Neutron diffraction shows researchers what is happening at a molecular level inside the batteries in real time, tracking the movement of lithium ions during battery use (discharging) and recharging. This technique gleans information about the structure of a material by studying the way it scatters a beam of neutrons.

"The key thing in these batteries is what happens to the lithium. We have the sensitivity to see what happens and potentially improve the way these batteries work at an atomic level," says Neeraj.

The ANSTO battery research is probing the factors that improve shelf life and safety, the speed of charging and discharging, and the optimal use of electrolytes. It's a bright future for this versatile power source.

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Could a neutron beam help stop train derailments?

Scientists are using neutron radiation to look inside solid steel and analyse the stresses within rail tracks. This research will ultimately improve the safety and operational and repair efficiency of heavy-haul railways.

The wheels of heavily laden trains place considerable rolling-contact loading on rail tracks. The heavy loads can change the material properties near the running surface and within the railhead—causing "fatigue". A number of serious incidents, including derailments, have been attributed to rail failures resulting from rolling-contact fatigue and accumulated residual stress.

Bragg Institute instrument scientist Dr Vladimir Luzin is looking at fatigue in insulated rail joints (IRJs) within a research project initiated by the Cooperative Research Centre for Rail Innovation. IRJs are an integral part of rail track systems, but they are also weak points, and their replacement is the single largest track maintenance cost in New South Wales, apart from ballast work.

"When a rail comes out of a factory it has already some residual stress," explains Vladimir. "Now we are looking at the atomic level to see how these stresses develop through the life of the rail joints."

Vladimir uses neutron diffraction to see how residual stresses evolve through different production steps and during service. The beauty of neutrons is that they can penetrate steel—unlike X-rays—and they can be used to map the stresses inside the rail components non-destructively.

Manufacturers and operators want to control and minimise these stresses. This research, backed by modellers and metallurgists, will help industry partners cut costs, modify production methods and develop rails of a quality and strength that can handle increasing loads.

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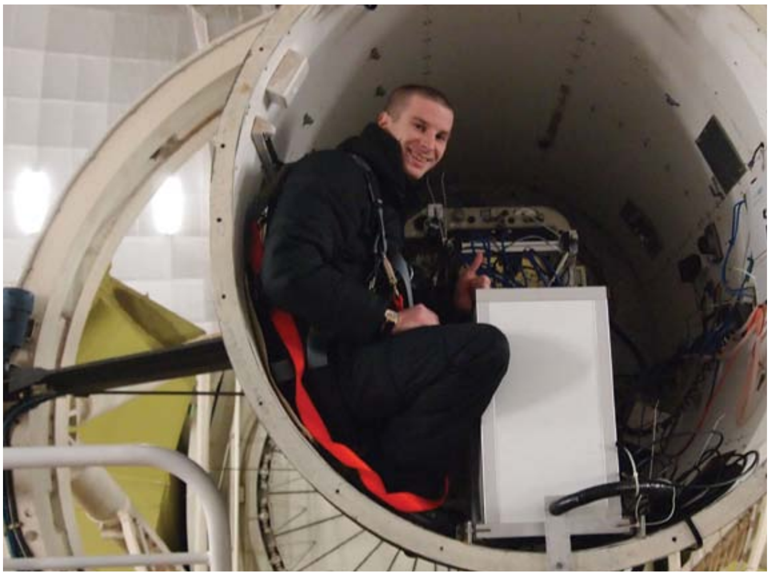
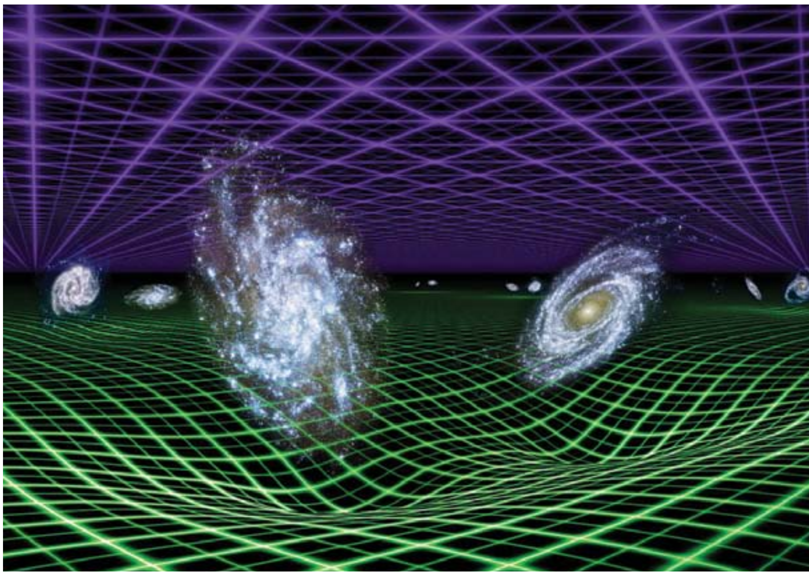
PHOTO: NEERAJ SHARMA PREPARES A SAMPLE BATTERY IN THE GLOVE BOX, CREDIT: ANSTO.

A new era for Australian astronomy

In May 2012 the Square Kilometre Array Organisation announced that the giant radio telescope will be built jointly in southern Africa and Australia-New Zealand. Australia's precursor (ASKAP) is already booked out for its first five years. But radio astronomy isn't the only game in town. The Australian Astronomical Observatory is developing new instruments and contributing technologies to the Giant Magellan Telescope under construction in Chile.

MORE ASTRONOMY STORIES ON PAGES 7, 8 AND 31 AND AT WWW.SCIENCEINPUBLIC.COM.AU/STORIES/ASTRONOMY





Massive galaxy survey confirms accelerating Universe

The Universe is definitely getting bigger, faster—and astronomers using the Anglo-Australian Telescope in NSW have confirmed it.

The results are now in for WiggleZ, a survey of the night sky, spanning 200,000 galaxies and billions of years of cosmic history.

"This puts a nail in it. Clearly the universe is accelerating, and clearly there is something like dark energy," says Prof Matthew Colless, director of the Australian Astronomical Observatory and a member of the WiggleZ team.

By detecting the patterns in the way galaxies are distributed in time and space, WiggleZ was able to confirm claims that there must be an unseen force in addition to gravity.

Without this force, which physicists call dark energy, the distribution of galaxies in the universe would be quite different.

This independently verifies the discovery of the accelerating expansion of the Universe that won Australian astronomer Prof Brian Schmidt the 2011 Nobel Prize.

"We found exactly what we set out to look for. That's a bit boring in one way, but really it's a beautiful confirmation of our best theory so far for how the Universe is put together," says Matthew.

In 2012, astronomers announced that the Square Kilometre Array radio telescope will be shared between southern Africa and Australia-New Zealand. One of the tasks of the Australian component, building on the Australian Square Kilometre Array Pathfinder (ASKAP), will be to conduct another galactic survey.

This new survey, called WALLABY, will look for the signature of dark energy in both the distribution of galaxies and their motions by surveying half a million galaxies across three-quarters of the sky.

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Galactic shutterbug

A new instrument at the Australian Astronomical Observatory (AAO) can sample the light coming from hundreds of galaxies per night—which can tell us new things about the Universe.

Sydney-AAO Multi-object Integral field spectrograph (SAMI) can look at up to 100 galaxies in a night, because it can look at 60 different regions in each of 13 different galaxies, all at once.

But most observatories around the world can only do one galaxy at a time.

"From a single sampling, you can't tell if, or how, a galaxy is moving," AAO astronomer Dr Jon Lawrence says. "With SAMI, we can."

SAMI can achieve these feats thanks to two smart features.

First, arrays of close-packed optical fibres called hexabundles allow the sampling of light from many regions of a galaxy at once.

Second, instead of just one hexabundle interpreting this light, there are multiple units—SAMI has 13 bundles of optical fibres taking the feed of spatial information.

The speed of galactic winds and the conditions that give birth to stars are part of what Jon and his team hope to glean from SAMI, which started its official scientific data collection in August 2012.

SAMI was developed by the Astrophotonics Group at the University of Sydney, and the AAO. Australia is now ramping up its capacity to manufacture the hexabundles as well.

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Wide open skies for Australian astronomy

CSIRO's Australian Square Kilometre Array Pathfinder (ASKAP) telescope is already booked out for much of its first five years of data gathering, even before it formally begins early operations in 2013.

More than 400 astronomers from over a dozen nations have already signed up to look for pulsars, measure cosmic magnetic fields, and study millions of galaxies.

ASKAP was built at the specifically radio-quiet Murchison Radio-astronomy Observatory (MRO) in Western Australia as a technology demonstrator for the $2 billion Square Kilometre Array (SKA) radio telescope.

Not only that, the newly completed 36-dish ASKAP is a fully functioning instrument in its own right featuring new "radio camera" technology that gives a huge 30° field of view.

"Instead of concentrating on one small patch of space, we can cover the whole sky in a fairly short space of time with great sensitivity," says CSIRO's ASKAP project director Antony Schinckel.

"We can then zoom in and do research on the interesting objects that are found in the initial survey, using some of CSIRO's other instruments such as the Australia Telescope Compact Array at Narrabri, the 'The Dish' at Parkes, or a range of other facilities around the world."

Antony also says some of the future capacity of ASKAP is being kept free so time can be allocated for other scientific proposals and to explore unexpected discoveries.

Over the coming years, existing ASKAP infrastructure will be built up to create an array of around 100 dishes, creating part of the first phase of the SKA, a giant radio-telescope project being constructed in both southern Africa and Australia-New Zealand.

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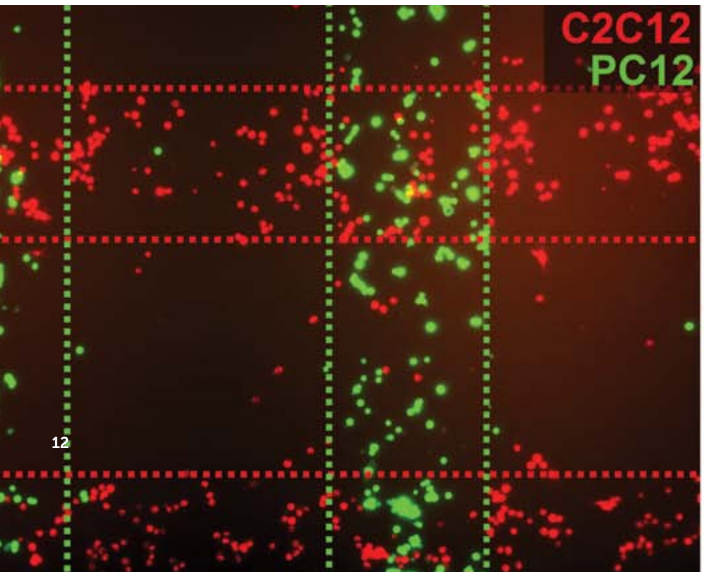
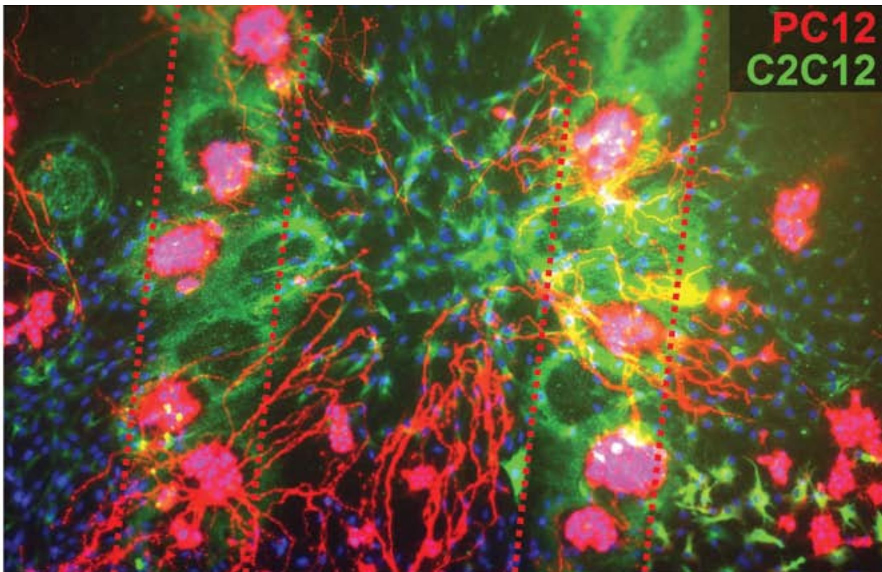
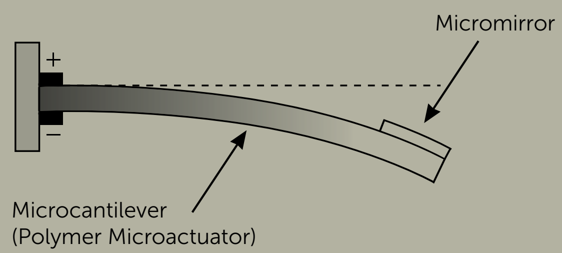
PHOTOS, LEFT: ONE OF CSIRO'S ASKAP ANTENNAS AT THE MRO, CREDIT: BARRY TURNER, CSIRO; RIGHT TOP: THE FIRST AUSTRALIAN SQUARE KILOMETRE ARRAY PATHFINDER ANTENNA, CREDIT: PHOTOGRAPHY BY PAUL BOURKE AND JONATHAN KNISPEL. SUPPORTED BY WASP (UWA), IVEC, ICRAR, AND CSIRO; RIGHT BOTTOM: THE PINWHEEL GALAXY, FROM WHICH SAMI CAN SAMPLE LIGHT FROM MORE THAN 60 DIFFERENT REGIONS AT ONCE, CREDIT: EUROPEAN SPACE AGENCY & NASA. PHOTOS, THIS PAGE: ASTRONOMER SAM RICHARDS SITTING IN THE PRIME FOCUS CAGE AT THE ANGLO-AUSTRALIAN TELESCOPE, WHERE THE SAMI INSTRUMENT USUALLY SITS, CREDIT: JON LAWRENCE; THE WIGGLEZ SURVEY LOOKED AT OVER 200,000 VISIBLE GALAXIES (CENTRE), BUT ALSO GAVE INSIGHTS INTO DARK MATTER (THE GREEN GRID THAT DEFORMS THE GRAVITY FIELD) AND DARK ENERGY (THE PURPLE GRID), CREDIT: NASA/JPL-CALTECH.

The smallest devices transform science and art

Across Australia researchers are developing ideas for minute devices that will transform health, energy, environmental and defence research. The Australian National Fabrication Facility is helping them turn those ideas into reality.







Australian National Fabrication Facility—providing micro and nano fabrication facilities to Australian researchers.

Bringing together over 500 state-of-the-art fabrication tools and experts from 21 institutions, the Australian National Fabrication Facility (ANFF) supports researchers at each stage of the discovery process—from fundamental research to manufacturing at the micro or nano scale.

ANFF's capabilities, grouped into eight nodes across Australia, support processing of hard materials (metals, semiconductors and ceramics) and biological or soft materials (such as polymers); and their transformation into functional devices such as sensors, medical devices, nanophotonics and nanoelectronics. Applications range from next-generation computing to new ways of testing and treating disease, and we present six case studies here.

The ANFF is supported by the Australian Government under the National Collaborative Research Infrastructure Strategy (NCRIS).

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Micro sensors for extreme conditions

New miniaturised sensors, made from a combination of silicon carbide (SiC) and the single-layer lattice of carbon atoms known as graphene, are being designed to operate under the harshest of conditions.

"We see applications in accelerometers and gyroscopes for aerospace and automotive uses, as well as in the harsh environments of mining and deep sea exploration," says Dr Francesca Iacopi of the Queensland Micro and Nanotechnology Facility (QMF) at Griffith University. "There's also potential for high-sensitivity biological sensors; for instance, blood monitoring and pressure sensing."

Research, led by the Australian National Fabrication Facility's (ANFF) Queensland node at Griffith University, promises a new generation of tiny microelectromechanical system (MEMS) sensors that are sensitive to very low forces, can work at high frequencies and in extreme conditions—above 1,000°C or under an acceleration of several times g—and are resistant to chemical attack.

The idea for the new graphene-SiC technology came out of an ANFF meeting with US Air Force scientists, and is founded on the "outstanding mechanical properties of graphene, the fact that graphene can be synthesised on SiC, and our capability of easily making microbeams and membranes with our silicon carbide-on-silicon technology, which is a core QMF capability," says Francesca.

"The research is still in its early stages. If successful, however, it may get to market quite rapidly… five years as a rough estimate," says Francesca.

ANFF has been instrumental in bringing together and leveraging the expertise, technologies and needs of Griffith University, QMF, the Queensland State Government and the US Air Force laboratories.

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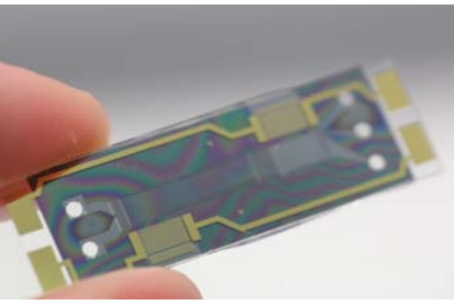
bit.ly/UNJxiw

Micro muscles bend to the task

A breakthrough in the polymers used to make electrically controlled artificial "muscles" could be important for future drug delivery in the body, as well as a having a host of other applications.

The new research, conducted at the Australian National Fabrication Facility's (ANFF) materials node at the University of Wollongong (UOW) in NSW, has produced materials which, unlike earlier versions, do not need to be immersed in an electrolyte solution. They are self-sufficient and can even work in air.

PHOTOS: PAULA DAWSON'S WORK MAY HELP TO DELIVER HOLOGRAPHIC TV AND 3D DISPLAY TECHNOLOGIES—REPRESENTED HERE WITH AN ARTIST'S IMPRESSION (SEE PAGE 15), CREDIT: PAUL HENDERSON-KELLY; MUSCLE (C2C12) AND NERVE (PC12) CELLS PRINTED ONTO COLLAGEN 'BIO-PAPER'(SEE PAGE 14), CREDIT: IPRI; THIS PAGE: NEW MICROELECTROMECHANICAL SENSORS WILL BE USED IN EVERYTHING FROM ROCKET MOTORS TO BLOOD-MONITORING DEVICES, CREDIT: NASA; ONE APPLICATION IS WITHIN MICRO OPTICAL DEVICES, WHERE THE "MUSCLE" COULD ACT AS A CANTILEVER TO MOVE A MIRROR, CREDIT: G. ALICI ET AL.



The tiny "muscles" are comparable in size to human hair, between 20 and 150 microns in diameter. The ANFF's OptoFab node at Macquarie University played a vital collaborative role, using its technological know-how to cut the materials down to the necessary micro dimensions. "This is the first time anyone has scaled them down to this size, as far as I know," says Prof Gursel Alici, head of the Intelligent Nano-Tera Systems Research Group at UOW.

The polymer actuator is sandwiched between two active polymer layers. When an electrical potential difference is applied between the active layers, this multi-layer structure bends and will retain its position for hours or maybe even days. Applying a reverse potential will bend it back through its original position to the other side.

"Devices made using these smart materials will act in a fashion similar to real muscles, but unlike other micro-devices will use less power, and will be biocompatible, compliant and non-toxic," says Gursel.

The muscles could be incorporated in micro-optoelectromechanical systems, with potential applications that include micropumps, microswitches, microgrippers and microcantilevers, which could be used for moving, positioning or holding micro devices and objects. One big possibility is for drug delivery inside the body, in which microcantilevers could be used to release controlled amounts of drugs from tiny reservoirs.

This project has been undertaken within the scope of an Australian Research Council Discovery Project DP0878931.

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Small devices to fight a big disease

Detection of dangerous water-borne pathogens will soon be much easier, thanks to advances using microfluidic systems developed at the Melbourne Centre for Nanofabrication (MCN), the Victorian node of the Australian National Fabrication Facility (ANFF).

MCN has designed a microchip that takes a stream of water and separates out cell-sized impurities, such as *Cryptosporidium*—the bug responsible for the 1998 Sydney water contamination scare.

"The motivation was to simplify the laborious task of testing for pathogens in natural water systems," says Dr Sean Langelier of MCN. "The hope was to develop a platform technology that could be extended for use in detection of a broad collection of different bugs."

The work began in early 2011 in partnership with CSIRO, Monash University and the University of New South Wales, as part of a cluster collaboration dedicated to water quality and sensing in Australia. ANFF's involvement has been instrumental and nearly all of the fabrication and development work has taken place at the MCN.

Microfluidics deals with the control and manipulation of fluids in tiny, constrained volumes, in order to perform scientific tasks. The advantages in such systems centre around the cost and effort savings associated with miniaturisation and automation. Additionally microfluidics systems afford interesting opportunities in terms parallelisation—multiple iterations of a process performed in concert for the purposes of high throughput.

"This microfluidic technique will replace laborious bench-scale detection of pathogens by eye, which can take hours, even days," says Sean. "Other big advantages are that detection can be done in a continuous fashion and the method is scalable for handling larger sample volumes; something that is difficult to achieve using traditional batch filtration methods."

The device will be part of an integrated system which, in addition to filtration, will possess dedicated operations for detection and quantification of any pathogens present.

"Development of a commercial technology from this work is on the horizon. We need just a bit more time and resources," says Sean.

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Made to order: printing of live cells

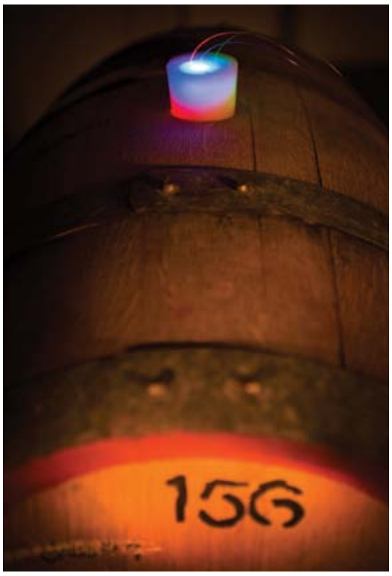
Surgeons may soon be able to regrow patients' nerves, such as those in damaged spinal cords, using technology adapted from the type of inkjet printer most of us have connected to our computer at home.

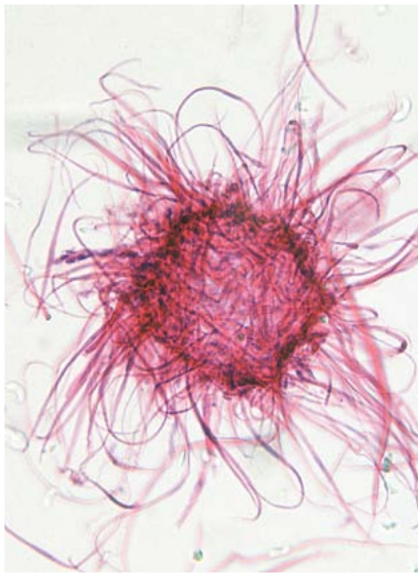
Researchers at the ARC Centre of Excellence for Electromaterials Science (ACES), University of Wollongong (UOW) node in NSW, have spent the past three years developing the technology to print living human cells—nerve cells and muscle cells onto tiny biodegradable polymer scaffolds. They've also developed a special "ink" that carries the cells.

The ink has to keep the cells in suspension, as well as having the right chemical compostion to keep them alive. It also protects them as they are shot out of the printer at amazing speeds.

The scaffolds act as the base upon which the cells thrive, and contain substances such as growth factor molecules and electrical conduits to enable stimulation to promote cell growth. The aim is to produce structures up to 4 cm long, which can be "patched" into broken or damaged nerves or muscles.

"There's great interest from the medical world, and we are working closely with clinicians at St Vincent's Hospital in Melbourne," says Prof Gordon Wallace, director of the Materials node of ANFF and ACES. "They're very interested in the possibilities it raises, and the collaboration is resulting in new ideas almost every week."





"The support from ANFF and the collaborative, interdisciplinary approach that our facilities bring has attracted the best people in the world to join our teams," he adds.

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electromaterials.edu.au

A new art form from nanotech

Science and art have combined to bring hand-drawn content for holographic TV and other 3D display technologies a step closer, thanks to research at the Australian National Fabrication Facility's NSW node (ANFF-NSW) at the University of New South Wales (UNSW).

Unlike the traditional method of making a hologram—which involves reflecting a laser off a real object—the new technique simulates objects within computer software. In a recent test, a virtual, digital hologram file was produced and etched as a 3 mm-wide nanoscale pattern onto a glass plate using ANFF-NSW's Electron Beam Lithography facility. When laser light was shone through the glass, a 3D hologram sprang into life.

"A beam of electrons is used to write a pattern made up of millions of tiny pixels, each one being one-hundredth the width of a human hair. When reconstructed using laser light the fuzzy pattern produces a sharp 3D image," says Prof Andrew Dzurak, director of the ANFF-NSW node.

The work is also a milestone for Holoshop, an Australian Research Council Discovery Project for the design and evaluation of rapid 3D drawing technology to allow content creation in holograms and other 3D displays. Holoshop is led by A/Prof Paula Dawson, an internationally renowned holographic artist at the UNSW College of Fine Arts (COFA).

"I'm excited by the potential for this technology to make real-time production of 3D digital content suitable for holograms and 3D display systems," Paula says, "particularly the potential for the hand-drawing of subjects and designs using a haptic interface system to encode the gestural data."

"At ANFF we've really enjoyed working with a talented and innovative artist like Paula Dawson to bring art and technology together in this new form," Andrew adds.

The work is a collaboration between COFA, UNSW School of Electrical Engineering and VisLab at the University of Sydney. The bit map etched onto the wafer was produced by Nihon University in Japan.

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www.anff.org.au/new-south-wales-node.html

Light work makes for better wine

New Australian technology will enable real-time monitoring of wine throughout its fermentation and maturation process, reducing spoilage and improving quality.

The "Smart Bung" technology has been pioneered at the University of Adelaide by the Institute for Photonics & Advanced Sensing (IPAS) and the School of Agriculture, Food and Wine (SAFW). The work is led by Prof Tanya Monro, director of IPAS.

An optical fibre sensor incorporated into the bung of a wine cask can detect substances that might cause the wine to spoil. The optical fibres have tiny holes that take up minute samples of the wine. The sensor shines light through the fibres to determine the concentration of certain important chemicals, such as hydrogen peroxide and sulphur dioxide—all without having to open the cask. The system will enable continuous, real-time cask-by-cask monitoring and an immediate response if problems are detected.

As Australia is the world's fourth-largest wine exporter, Smart Bungs promise to improve the profitability of the industry greatly. Work began on the technology about two years ago, and it is now funded by a Linkage grant from the Australian Research Council.

"The Australian National Fabrication Facility's (ANFF) Optofab node provided the special optical glass fibre and surface functionalisation required to make the sensors," says Piers Lincoln, IPAS manager. "ANFF has been critical in ensuring facilities are available to produce the sensors."

Smart Bungs will also help the environment by reducing transport requirements because samples can be measured on-site, dramatically decreasing the use of chemicals for analyses, increasing agricultural yield, and lowering wastage.

"It'll take another five years and around $2 to $3 million in R&D funding before the technology gets to market—but when it does, we believe it will replace standard laboratory-based analyses," Piers says.

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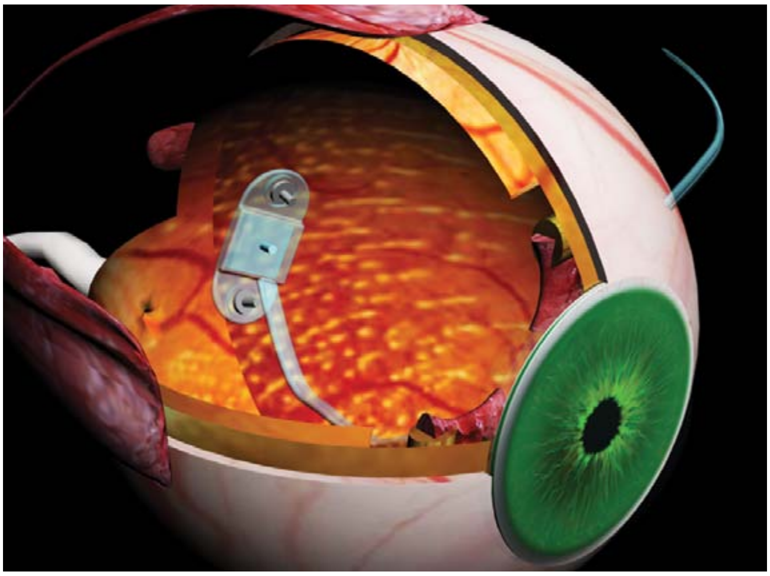
PHOTOS: A MICROFLUIDIC WAFER, CREDIT: MCN; GORDON WALLACE IS DEVELOPING THE TECHNOLOGY TO PRINT LIVING HUMAN CELLS, CREDIT: IPRI; THIS PAGE: SMART BUNGS PROMISE TO IMPROVE THE WINE INDUSTRY'S PROFITABILITY, CREDIT: ISTOCKPHOTO; SMART BUNGS USE SENSORS BASED ON OPTICAL FIBRES TO CONTINUOUSLY MONITOR THE HEALTH OF WINE DURING THE FERMENTATION AND MATURATION PROCESS, CREDIT: IPAS/JENNIE GROOM PHOTOGRAPHY; MUSCLE CELLS CAN BE PRINTED ONTO TINY BIODEGRADABLE POLYMER SCAFFOLDS, CREDIT: ISTOCKPHOTO.

Bionics: from hearing to sight to calming an epileptic storm

Australia's bionic ear has brought hearing to deaf children around the world.
Now its inventor is working on a better ear, while others turn his legacy into the gift of sight.

In August this year, Bionic Vision Australia researchers successfully implanted an early prototype bionic eye into a recipient, Dianne Ashworth, who lost her sight over 20 years ago.



Bionic eye researchers take a shine to diamond

Electrodes made of diamond are helping Melbourne researchers build a better bionic eye.

Some types of blindness are caused by diseases where the light-sensing part of the retina is damaged, but the nerves that communicate with the brain are still healthy—for example, retinitis pigmentosa and age-related macular degeneration.

Dr David Garrett and his colleagues at the Melbourne Materials Institute at the University of Melbourne are using diamond to build electrodes that can replace the light-sensing function of the retina: they deliver an electrical signal to the eye via a light-sensing camera.

These electrical impulses would cause the healthy neurons in the retina to fire and send visual information to the brain—restoring a sense of sight.

But the functionality of the first bionic eye implants will be limited. Patients will need to learn and adjust to this new sense of vision to tell the difference between light and dark and recognise basic shapes.

"Like with the bionic ear, software may be able to greatly improve on the original hardware," David says. "Because of Melbourne's history with the cochlear implant and the infrastructure here, we're making progress quite quickly."

Diamond suits the bionic eye project for two reasons: lacing diamond with nitrogen makes it conduct electricity, enabling electrodes to link up with the existing nervous system; and diamond is not prone to corrosion, infection or breaking down in the body, even after many years.

"You want these devices to last as long as possible—and for that you can't beat diamond," David says.

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Bionic pioneer explores how we're wired for sound

Prof Graeme Clark changed the way we thought about hearing when he gave Rod Saunders the first cochlear implant in 1978—now he might just do it again.

Back then, Graeme brought together a team of engineers and medical personnel; now he's trying to reveal exactly how the brain is wired for sound—by bringing together software specialists and experts on materials that can interface with the brain.

"We're aiming to get closer to 'high fidelity' hearing for those with a cochlear implant," says Graeme, now distinguished researcher at NICTA (National ICT Australia) and laureate professor emeritus at the University of Melbourne. "This would mean they could enjoy the subtlety of music or the quiet hum of a dinner party."

With this goal, Graeme is working with Rod's hearing system one last time—even though Rod passed away in 2007.

Rod, who lost his hearing at 46 in a car accident, left his body to science, so Graeme is examining very finely cut sections of Rod's brain, which for the better part of four decades was interfaced with the electrodes of a cochlear implant.

To translate this work into better outcomes for patients, and better knowledge of how the brain can interface with bionics, Graeme collaborates with NICTA, La Trobe University, the University of Wollongong and the Department of Otolaryngology (ear, nose and throat) at the University of Melbourne.

For his significant achievements in advancing our knowledge of human health, Graeme was awarded the 2011 $50,000 CSL-Florey Medal—which is part of CSL Limited's program of fostering the next generation of medical researchers and recognising excellence in biomedical research.

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www.csl.com.au/about/community/fostering-science.htm

On-demand epilepsy drug

A new brain implant could deliver anti-epilepsy drugs straight to where they're needed and, in future, on demand. This will be particularly helpful for the 30 per cent of epilepsy patients who suffer severe side-effects, such as nausea, rashes, weight change and dizziness, from their medication, leaving them unable to be treated.

The implant is a biodegradable polymer that ARC Centre of Excellence for Electromaterials Science associate Bionics program leader A/Prof Simon Moulton compares to the types of polymers used in dissolvable stitches.

"We're now at a stage where we can get really nice long-term release over three months," Simon says. "The holy grail of the project is to develop an implant that delivers drugs for a very long time, reducing the need for repeated invasive brain operations."

Results from animal trials performed by collaborators at St Vincent's Hospital in Melbourne are promising—the implant can reduce the number of seizures and their duration. "That gives us confidence that our approach is working," Simon says. Human trials, though, are still a long way off.

Simon's team is also seeking ways to treat epilepsy with the minimum possible drug dose and thus to minimise side-effects. "We're trying to deliver small amounts of drugs in the brain in a way that suits all the people with epilepsy, including that 30 per cent," he says.

To achieve this, Simon and his colleagues are also developing an implant that will only release the drug when it's needed—using conducting polymers that would respond to electrical signals in the brain prior to a seizure.

"We want to combine all those properties together and provide on-demand drug delivery in such a way that the patient never experiences a seizure."

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PHOTOS: GRAEME CLARKE WITH A YOUNG COCHLEAR EAR RECIPIENT, CREDIT: COCHLEAR; NEURONS CAN TRANSMIT ELECTRICAL SIGNALS FROM A CAMERA TO THE BRAIN, CREDIT: ISTOCKPHOTO; THIS PAGE: LEFT: DAVID GARRETT'S MELBOURNE TEAM IS DESIGNING DIAMOND ELECTRODES TO REPLACE LIGHT-SENSING PARTS OF THE RETINA, CREDIT: DAVID J. GARRETT; MIDDLE TOP: CSL FLOREY MEDAL, CREDIT: CSL LIMITED; MIDDLE BOTTOM: SIMON MOULTON IS DELIVERING ANTI-EPILEPSY DRUGS DIRECTLY TO THE BRAIN, CREDIT: ISTOCKPHOTO.

Bushfire shelters, an anti-bingle radar, and printable solar cells

These are just some of the projects supported by the State of Victoria's Science Agenda Investment Fund. The grants support market-focussed projects that are turning research into tangible outcomes.

Next generation packaging

Melbourne-based manufacturing company RMAX is working with CSIRO to make a sustainable, and biodegradable, version of a product involved in the life-cycle of many of the things we buy.

They hope to cut the environmental impact of the nine thousand tonnes of expanded polystyrene (EPS) that ends up in Australian landfill every year.

"When you get your computer or washing machine home from the department store it comes packaged with moulded EPS," says RMAX general manager Graham Attwood.

"EPS not only provides great impact protection but also thermal protection as in the case of the fresh food industry—the boxes that keep sensitive food stuffs, such as fruit and vegetables, cool.

"What we're trying to do with this project is to provide a viable alternative to EPS that is biodegradable, and made from a renewable non-oil-based raw material."

The key to the project is developing a new formulation that can be used in existing EPS-moulding machinery.

A "prototype box" was formed using a biodegradable polymer tweaked by CSIRO scientists, though its properties are not yet a close match for EPS.

It was also not yet sufficiently cost effective to produce, Graham says, though the cost dynamics would shift as the oil price and landfill charges increased and the project had a promising future.

"Ultimately we'll get to a point where we'll have a fit-for-purpose solution," Graham says.

"There will also come a point where it will become very commercially attractive to make the switch to a greener technology."

The initiative is being supported with a $720,000 collaborative science and innovation grant from the Victorian Government.

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Building better bushfire protection

The bushfires that raged across Victoria in February 2009, claiming 173 lives, did not leave only destruction and sadness in their wake.

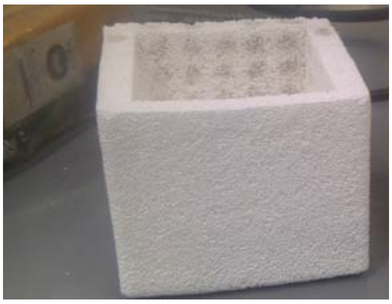
Green shoots of innovation have emerged, and flourished in the form of three new devices to combat the ravaging force of radiant heat.

"Many houses that catch fire in a bushfire burn from the inside out … this wasn't fully understood until relatively recently," says Sam Davis, project manager at the Victorian Centre for Advanced Materials Manufacturing (VCAMM).

"Radiant heat causes the windows to break and the wind then blows burning debris into the house.

"That's where we came up with the idea of shields, like a curtain."

The Advanced Bushfire Materials Consortium—headed by VCAMM and including industry partners Frankston Concrete and Diver Industries—has developed a prototype fire and heat-proof curtain to cover the outside of a house window during a bushfire.



The consortium has also reached the production phase on a similar shield for inside the cabin of a fire truck, for emergency use should a vehicle get trapped.

Testing is also underway on a walk-in concrete shelter, which is designed to fit five people and withstand the most extreme of bushfires.

"It's been tested at 1000 degrees [Celsius] on the outside, for over an hour, and the temperature inside the shelter did not exceed 40 degrees," Sam says.

"It came through with flying colours … in reality we know a bushfire usually passes in 10–15 minutes."

The shelter, which is modular and scalable, should be commercially available by 2013.

The VCAMM's Bushfire Shelter Project received a $400,000 collaborative science and innovation grant from the Victorian Government.

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Live streaming for healthy waterways

Water sampling devices are keeping watch around the clock for toxic discharges into Melbourne's creeks and stormwater drains, thanks to Victorian researchers at the Centre for Aquatic Pollution Identification and Management (CAPIM), based at the University of Melbourne.

And, they are also developing a new range of aquatic critter-containing sensors.

The Autonomous Live Animal Response Monitors (ALARM) will house live molluscs, insects or shrimps and transmit images and data to scientists via the web, in the ultimate test of a creek's health.

"These will be real-time sensors which we deploy out in the stream and we'll be able to download their activity and look for signs of stress in the animals," says CAPIM chief executive Dr Vincent Pettigrove.

"We'll be able to sit in the office and look at how a shrimp in a stream 500 km away has been faring overnight."

The technology is under development in aquarium-based trials.

Meanwhile, CAPIM's pollutant samplers are already in place in targeted waterways and drains to watch for toxic discharges.

In cases where the pollution is traced to its source, their data is handed over to environmental authorities.

CAPIM was established to identify and manage pollution in waterways with a three-year, $2.98 million collaborative science and innovation grant from the Victorian Government.

"The funding we were awarded was a real fillip because it gave us a chance to develop new technologies … the samplers are a key part of why we're able to identify point-source pollution," says Vincent.

For more information:

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Granular plant protection

A farmer whose onion paddock is hit by the fungal disease "white rot" faces the loss not only of that crop but of productive use of the field for several years.

Relief could be at hand, however, thanks to a novel granulated fungicide now being tested in the field in Victoria.

"In the case of white rot, there is no existing commercially acceptable treatment and if a farmer has an infestation in their field they can't use it for onions or similar crops for up to 15 years," says Anthony Flynn, managing director of the agricultural chemical research company Eureka! AgResearch. "They've just had to move the crop on to the next paddock."

The new granulated fungicide targets the soil-borne fungus *Sclerotium cepivorum*.

The granules are designed to be spread directly onto an affected paddock, and they are activated the next time it rains. By being able to deliver the fungicide closer to the roots of the plants, and then release it slowly, the granules more efficiently target the disease than current alternatives that require spraying.

It is one of a range of innovative granulated products being developed by Eureka! AgResearch, and supported by a $1.15 million collaborative science and innovation grant from the Victorian Government.

Granulated pesticides and fungicides can be packaged cheaply in cardboard, which costs farmers less to transport than the liquid forms which dominate the global market.

"There are also application advantages—if you need to apply pesticides or fungicides from the air, granules will go through the canopy of a tree much easier," Anthony says.

"It's also safer—if there's a chemical spill it is easier to clean up the granules. It's giving farmers a cheaper option and better disease control."

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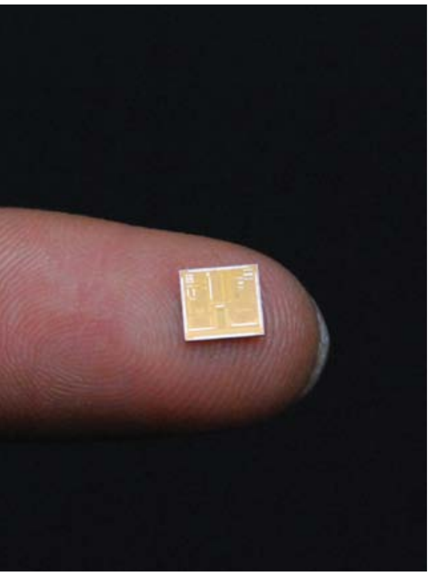
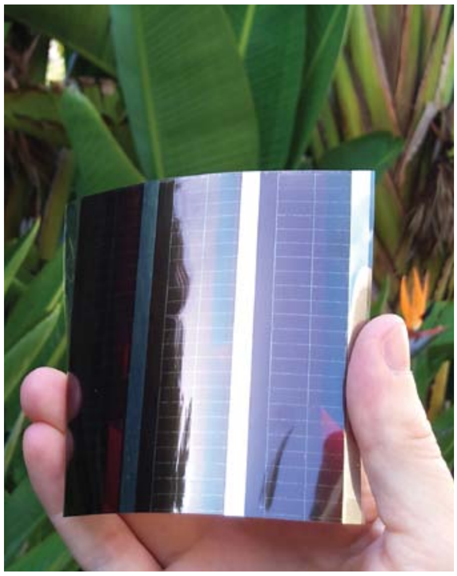
State Government Victoria

PHOTOS: MANY HOUSES THAT CATCH FIRE IN A BUSHFIRE BURN FROM THE INSIDE OUT, CREDIT: ISTOCKPHOTO; A PROTOTYPE OF THE WALK-IN CONCRETE SHELTER, UNDER DEVELOPMENT BY VCAMM, WHICH IS DESIGNED TO PROVIDE A SAFE REFUGE AMID THE MOST EXTREME OF BUSHFIRES, CREDIT: VCAMM; THIS PAGE: LEFT: VICTORIAN RESEARCHERS ARE DEVELOPING REAL-TIME SENSORS OF WATER QUALITY, CREDIT: ISTOCKPHOTO; MIDDLE: THE PROTOTYPE BIODEGRADABLE POLYMER BOX (ABOVE) ALONGSIDE A STANDARD EXPANDED POLYSTYRENE BOX (BELOW), CREDIT: GARY TOIKKA, CSIRO; A NEW GRANULATED FUNGICIDE WILL HELP ONION FARMERS TREAT WHITE ROT, CREDIT: ISTOCKPHOTO.





Avoiding bingles with a cheap small radar

Car manufacturers are queuing up to meet the Melbourne makers of the world's smallest and cheapest automotive radar system.

The Radar on a Chip (ROACH) detects and tracks objects around the car. It's part of an active safety system that can warn drivers about possible collisions and, if necessary, integrate with braking, steering, seatbelt and airbag systems to avoid, or minimise the consequences of, an accident.

ROACH project manager Dr Mandy Li says the University of Melbourne/ NICTA Victoria Research Lab team impressed car makers with their innovative solution at an automotive conference in Sweden in May 2012.

Luxury cars already have radar fitted to detect approaching objects, but existing systems cost about $1,000. ROACH's advanced technology brings the cost down to less than $50, suitable for the mass market.

The other key advantage of ROACH is that it's small—the size of a postage stamp and only 1 cm thick—while other radar systems are about the size of your palm.

It's a headache for car designers to integrate a larger system into the bumper of the car. "If we can make it cheaper and smaller, car makers can put more radar units around the car to create a 360 degree protection zone," Mandy says.

After the success of this first working prototype, the team hopes to have a second prototype late in 2012.

This project is supported by a $1.77 million collaborative science and innovation grant from the Victorian Government.

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Laser therapy to fight early signs of eye disease

Around fifteen per cent of people aged in their fifties who think their eyes are fine will show the early signs of age-related macular degeneration (AMD) if tested.

It is Australia's leading cause of blindness and there is no way to stop it progressing even when detected in its earliest phase.

"There have been advances in treatment but that's at the end stage," says Prof Robyn Guymer, who heads the Macular Research Unit at the Centre for Eye Research Australia.

"In the early stage there is no specific treatment, other than a healthy lifestyle and perhaps the use of supplements."

This could be about to change. Robyn is studying the effects of retinal rejuvenation therapy (2RT), which uses an experimental nanosecond laser a thousand times less powerful than those commonly used to treat eye disease.

How it works is not yet clear, although it appears to stimulate a natural, biological healing process. Treating one eye also prompts improvement in the other, hinting at the possibility of a beneficial systemic effect.

A pilot study, funded via a $540,000 collaborative science and innovation grant from the Victorian Government, showed positive results, and recruitment is now underway for a four -year randomised trial involving 200 patients with early-stage AMD.

"We need to prove beyond a doubt that if you have the new laser treatment in the early stages of AMD you are less likely to become blind over time," Robyn says.

"The aim is to prevent people from getting to the end stage of AMD, where in some cases there is no treatment currently available and in other cases there is a need for long term, regular, treatment to reduce the vision loss from AMD."

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Victoria in race to print solar cells

In the future, the entire roof of your house could be a solar panel, and you could harness the power of the sun while on a remote bushwalk, thanks to cheap, printable solar cells.

Work is underway to perfect the "printing" of a film-like layer of solar cells that can be applied cheaply to hard or flexible surfaces to generate electricity from sunlight.

"One of our major industrial supporters is Bluescope Steel and they want to be able to print or coat solar cells directly on to their roofing material, so when you're putting up your roof you'll be putting up a solar array," says Dr David Jones from University of Melbourne's Bio21 Institute.

"We're now at a point where we can print these solar cells reliably, and we're going to the next step of using bigger and faster printers and a more automated printing process."

David is project coordinator for the Victorian Organic Solar Cell Consortium (VICOSC, also see next story), which has a mid-2013 deadline to hand over a prototype solar cell printer to its industry partners.

The VICOSC is receiving a $5 million collaborative science and innovation grant from the Victorian Government.

David says companies are in a global race to bring products with "integrated" solar generation capabilities to market and ultimately this would re-shape the economics of solar power.

"In the roll-out, you're likely to see the first use of solar cells for temporary purposes: shade cloth for caravans and in tenting materials for example," David says.

"You'll be putting up your tent and powering up your holiday."

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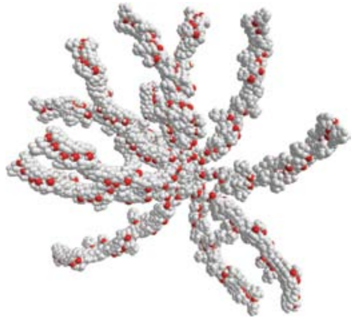
State Government Victoria

PHOTOS: THE CMOS CHIP AT THE HEART OF ROACH, CREDIT: LUAN ISMAHIL, NICTA; ROBYN GUYMER (LEFT) IS TRIALLING AN EXPERIMENTAL LASER-BASED THERAPY WHICH AIMS TO STOP AGE-RELATED MACULAR DEGENERATION FROM PROGRESSING BEYOND ITS EARLIEST PHASE, CREDIT: CERA; IN THE FUTURE, THE ENTIRE ROOF OF YOUR HOUSE COULD BE TILED WITH PRINTED SOLAR CELLS LIKE THIS ONE, CREDIT: DJ JONES, UNIVERSITY OF MELBOURNE.

New materials for clean energy, more efficient oils, and more



Spray-on solar cells

Imagine a power station that's literally sprayed onto your roof—and could match the colour of your tiles.

Thin film solar cells are thinner, cheaper and more versatile than the traditional silicon solar panels. They're already being printed (see previous story), soon they could be spray painted.

"These cells can be made with semiconductor dye materials, so you can match them to any colour or pattern you like—they'll just convert that part of the solar spectrum into electricity. In the future we could have billboards that act as solar panels," says Dr Gerry Wilson of CSIRO's flexible electronics team.

Organic photovoltaic (OPV) cells are made from organic (carbon-containing) materials instead of silicon, making them lighter and less expensive than conventional silicon solar panels.

Gerry is part of the Victorian Organic Solar Cell Consortium, whose printable thin film solar has brought affordable lighting and power available to developing countries. Spray-on solar takes this to a new level.

"To print OPVs, you have to make concentrated solutions to produce a strongly absorbing but thin film. Unfortunately, many of these materials are sparingly soluble, so we use [toxic] organic solvents, like dichlorobenzene," Gerry says, "With spray-on solar you just spray longer with a normal solvent.

"Plus, the spraying process allows you to build in a charge gradient—to make a more efficient cell."

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Star-shaped polymers boost engine performance

New lubricants containing star-shaped polymers have hit the market, thanks to Australian polymer technology. Lubrizol Corporation has launched the first commercial products developed using CSIRO's Reversible Addition Fragmentation chain Transfer (RAFT) polymer synthesis process.

CSIRO chemist Dr Ezio Rizzardo says the RAFT process allows much greater flexibility and potential for polymer synthesis, compared with conventional methods. "Conventional polymerisation is a relatively simple process with two ingredients: large amounts of monomer and a small amount of an initiating agent. You apply heat; a chain reaction starts and runs to completion, making polymer chains that can have widely varying lengths."

RAFT technology revolutionises polymer synthesis through the addition of a third ingredient—a "RAFT Agent"—that transforms the synthesis into a more controlled step-wise process.

"The RAFT Agent dictates the size of the chains and all the chains produced are a similar size. This gives the product unique properties," says Ezio, who was joint winner of the 2011 Prime Minister's Prize for Science for this research.

The RAFT process has been nicknamed "living polymerisation" because it can be stopped and restarted, and chains can be continued with different monomers, giving unprecedented control over the composition and structure of new polymers.

Star-shaped polymers—with arms that roll up at low temperatures and extend when warmed—improve the viscosity of Lubrizol's lubricants, giving the vehicles that use them better performance and mileage.

Lubricants are just the beginning. RAFT technology is leading to a new generation of polymers in drug delivery systems, cosmetics, agrichemicals, solar cells and industrial chemicals.

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Fibre optics: from cables to constipation

A new fibre optic medical tool is revolutionising our understanding of constipation, diarrhoea and irritable bowel syndrome and other serious digestive illnesses. Medical scientists can see for the first time the coordinated, fine and complex muscular activity of the human digestive system in action.

CSIRO optical physicist Dr John Arkwright, together with Dr Philip Dinning, of Flinders University, collected a 2011 Eureka Prize for their creation of the fibre optic catheter, which gleans information about digestive function by measuring pressure.

"Measuring pressure changes tells us about the patterns of muscle contraction that are happening, both in a healthy gut and when something goes wrong," says John.

Conventional catheters record pressures deep within the colon, with sensors placed every 10 cm. While they can sense large sweeping muscular contractions through the bowel, they don't have the spatial resolution to detect finer movements.

In contrast, the fibre optic catheter has up to 144 sensors spaced 10 mm apart. These sensors are designed to reflect back specific colours of light to indicate pressure changes. The resulting spectrum provides an unprecedented level of detailed information about the muscular activity of the bowel.

"The great advantage of optical fibres is their ability to carry enormous amounts of information in a thin and highly flexible fibre," John says. "As you can imagine, it's much more comfortable for patients."

"I'm originally a telecommunications engineer with no medical background. It's exciting to see the same technology I've used in submarine cables being used in a completely different way in human health."

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CSIRO

PHOTOS: TOP: FIBRE OPTIC TECHNNOLOGY IS HELPING JOHN ARKWRIGHT UNDERSTAND OUR DIGESTIVE FUNTION, CREDIT: ISTOCKPHOTO; BOTTOM LEFT: GERRY WILSON IS DEVELOPING SPRAY-ON SOLAR CELLS, CREDIT: ISTOCKPHOTO; BOTTOM RIGHT: ASTERIC™ VISCOSITY MODIFIERS ARE TAILOR-MADE STAR-SHAPED POLYMERS MADE POSSIBLE BY RAFT, CREDIT: LUBRIZOL.

Something borrowed, something new

Don't give away your old glasses

It's much better to give new glasses than recycled glasses if you want to help one of the 640 million people who are vision-impaired or blind simply for the lack of an eye examination and appropriate glasses.

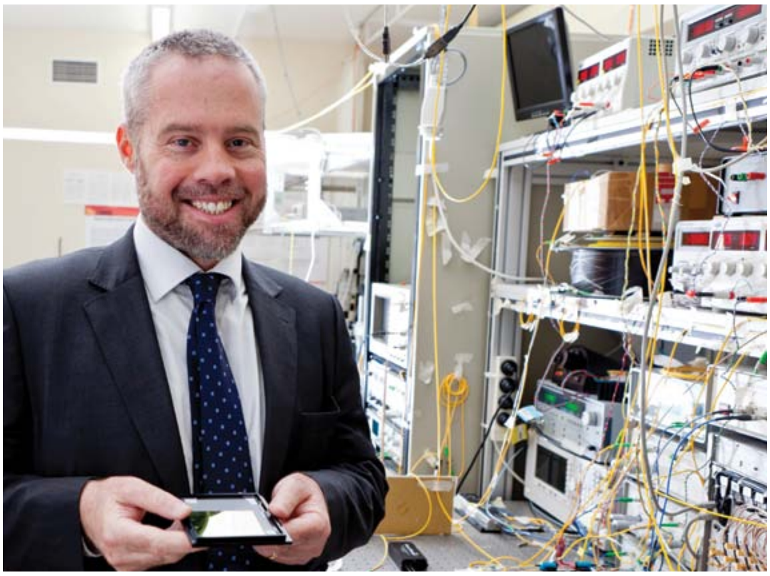
This is according to a new international study led by Australian researchers.

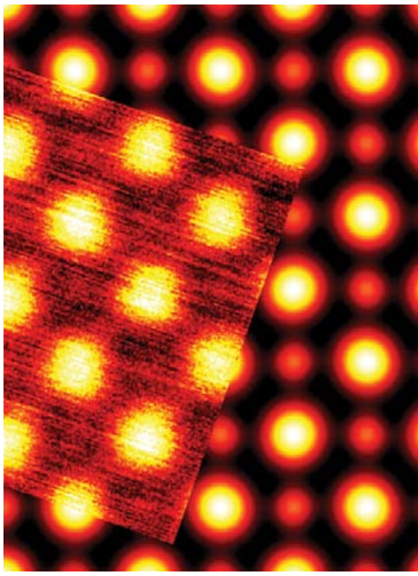
Dr David Wilson, research manager in the Asia-Pacific for International Centre for Eyecare Education and head author of a major paper on the topic, says although you might feel good sending your old reading glasses to a developing country, it is far better to give $10 for an eye examination and a new pair of glasses—and that's more likely to strengthen the ability of these communities to help themselves.

"We'd heard anecdotal evidence that only something like 5 per cent of recycled glasses were being used effectively—the rest were discarded," David says.

David and his international collaborators found that only 7 per cent of 275 recycled pairs of glasses tested were suitable for use.

"The relatively small proportion of usable glasses contributed to the high societal cost of delivering recycled glasses, which was found to be US$20.49 per pair, close to twice that of supplying ready-made glasses," David says.





"We can buy ready-mades by the boxload—already sorted into power levels, straight off the boat—for about a $1.90 a pair."

This is much more efficient than recycling glasses.

"In recycling, it takes a trained optometrist in Sydney, for example, several minutes per pair to use an instrument to sort the lenses by power and then clean and refurbish the glasses themselves, let alone the logistics and costs of getting those glasses to those who need them."

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Light-powered chip smashing records

A new computer chip, which uses light instead of electronic signals to process information, could lead to high security, energy-efficient internet links more than 1,000 times faster than today's networks.

This "photonic chip" uses special glass, photonic crystals, to bend light and slow it down. The slower the light travels, the more efficiently the chip can operate—and the smaller and more energy efficient the resulting devices can be.

Developed by Prof Ben Eggleton and his team at the Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS) at the University of Sydney, the same technology could be used to build quantum computers.

"If you can generate individual photons of light, you can use these quantum states to build completely quantum-secure communications networks, fundamentally secure to eavesdropping," Ben says.

There are already companies in Australia commercialising quantum security, coding sensitive information defence and banking based on his work.

Ben reckons the chip could be used in high speed communications in three to five years. The chip also has applications in astronomy, where Ben's science career began, and could be used in the Square Kilometre Array to filter microwave signals from space.

In 2010, Ben's team set world speed record for optical switching in what he calls a "hero experiment", designed to highlight the capabilities and feasibility of this new technology.

Working with teams at the Australian National University node of CUDOS and in Denmark, they constructed a terabit-per-second Ethernet link—that's 1,000 times faster than the National Broadband Network currently being constructed across Australia.

The basic science underpinning this technology has won Ben the 2011 Australian Institute of Physics Walter Boas Medal for research excellence.

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Revealing the structure of catalytic converters in cars

The first microscopes gave humans the ability peer deep into the microscopic world, allowing us to see cells and microbes in unprecedented detail. Using the latest electron microscopes we are now able to see detail down to single atoms.

In fact, materials scientists can detect impurities in their latest compounds, atom by atom, using powerful electron microscopes aided by sophisticated modelling of what happens when the electron beam hits the material.

Dr Adrian D'Alfonso and a team of theoretical physicists at the University of Melbourne have developed these models and they are already helping groups around the world look at and understand nanomaterials in a way they haven't been able to before.

"The biggest challenge facing electron microscopy has been in image interpretation—the image you record may not reflect the structure of the object that you are imaging," Adrian says. "But using our technique you can tell what kind of atom you're looking at and, most importantly, where it sits in relation to other atoms and what groups might be attached to it.

"And you can now tell apart a silicon atom and a phosphorous atom if they are next to each other in a material—something you couldn't do before."

For example, cerium-zirconium oxides are used in catalytic converters to convert toxic car exhausts into less lethal substances—but until recently the exact structure of these catalysts was disputed because the catalysts were too small to use crystallography or traditional electron microscopy.

"Working with Spanish colleagues from the University of Cadiz, we used our technique to determine the actual structure of the nanoparticle with the aim to better understand the particle's catalytic properties," says Adrian.

In 2011, his research won Adrian the Australian Institute of Physics Bragg Gold Medal for best PhD thesis.

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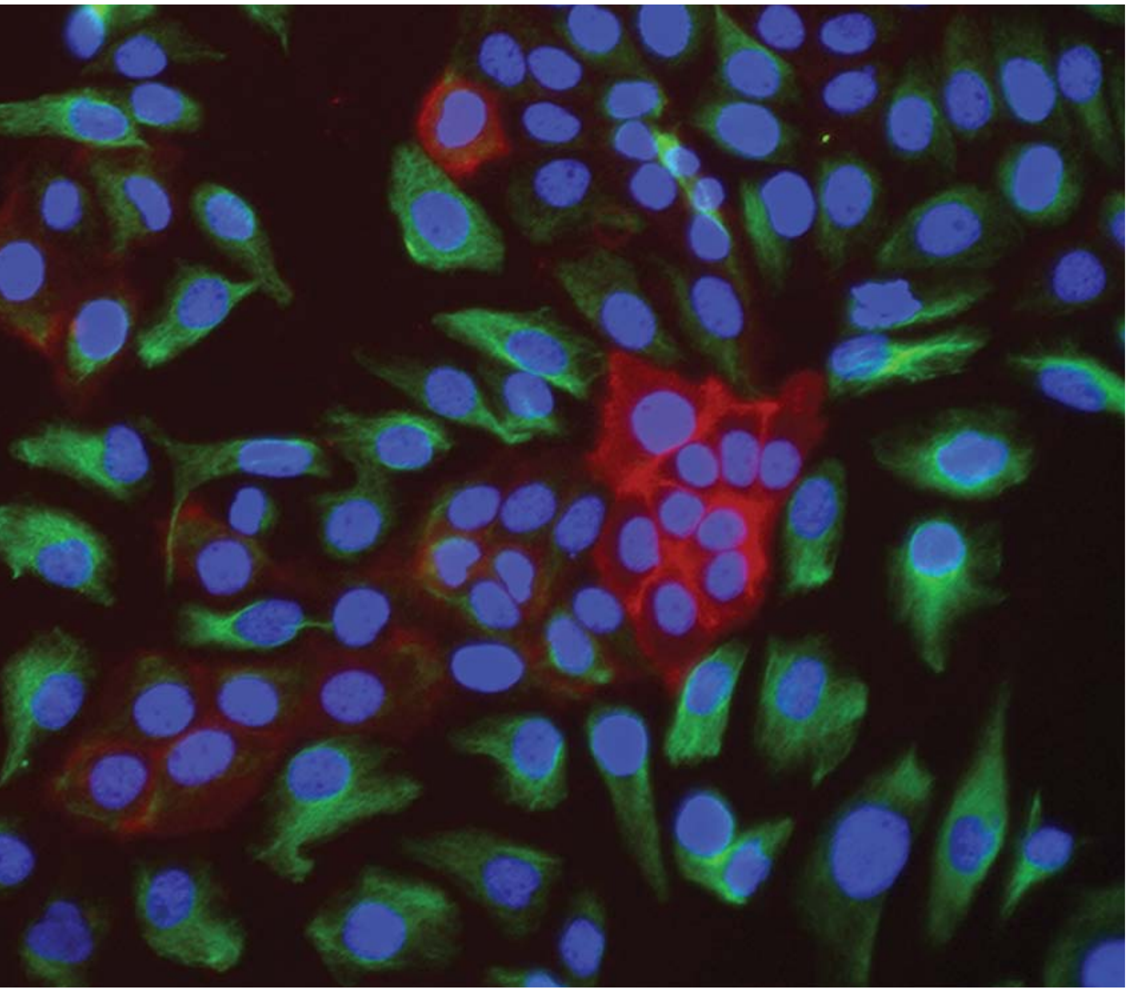
PHOTOS: THEMBANI WAITS FOR AN EYE EXAMINATION AT THE UMLAZI COMMUNITY HALL NEAR DURBAN, SOUTH AFRICA, CREDIT: DEAN SAFFRON/ICEE; THIS PAGE: LEFT: BEN EGGLETON WITH HIS PHOTONIC CHIP, WHICH COULD LEAD TO FASTER INTERNET, CREDIT: ARC CENTRE OF EXCELLENCE FOR ULTRAHIGH BANDWIDTH DEVICES FOR OPTICAL SYSTEMS (CUDOS); MIDDLE: BEN EGGLETON'S PHOTONIC CHIP COULD LEAD TO INTERNET SPEEDS 1,000 TIMES FASTER THAN THE NATIONAL BROADBAND NETWORK, CREDIT: ISTOCKPHOTO; RIGHT: ELECTRON MICROSCOPY IMAGES OF A $BISRMNO_3$ CRYSTAL MODELLED BY ADRIAN D'ALFONSO AND HIS TEAM, CREDIT: ADRIAN D'ALFONSO/MICHEL BOSMAN.

Looking into our cells

Why do some breast cancer cells spread and can we detect these cells before they metastasise? Can we give live blood cells a health check? The answer to both questions is yes for researchers using Victoria's life science supercomputers. Meanwhile in Queensland a new computer tool is improving MRI detection of breast cancer.



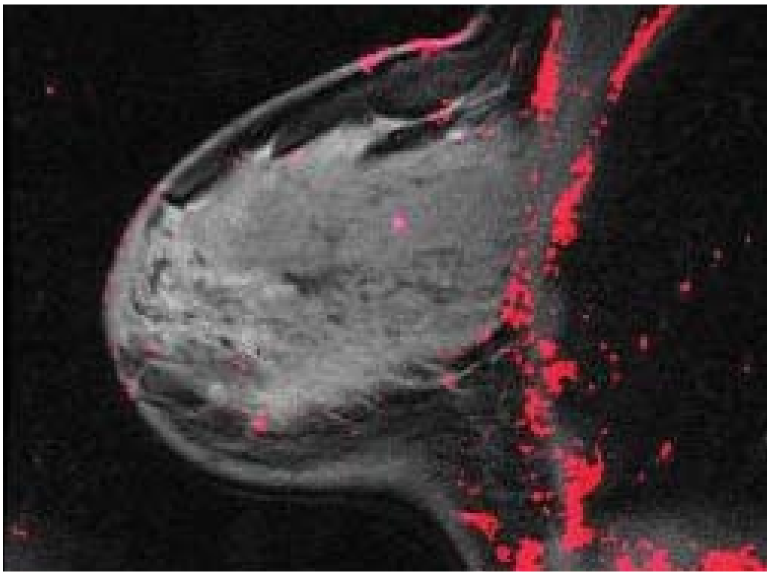
Spotting cancer cells before they spread

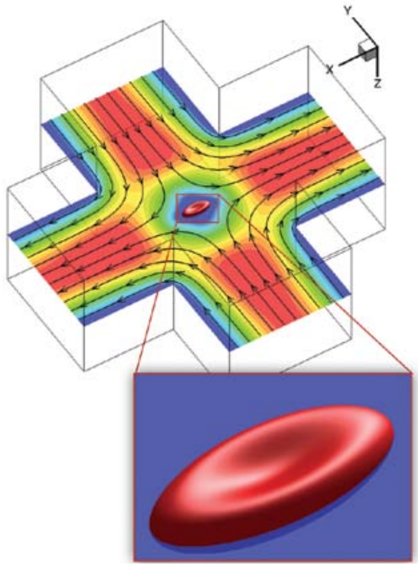
The long-term survival chances of patients with breast cancer plummet if the cancer recurs or spreads to other parts of the body in the process known as metastasis.

So the National Breast Cancer Foundation recently funded a five-year, $5 million National Collaborative Research Program to investigate metastasis and discover potential drugs to stop or slow it. The EMPathy Breast Cancer Network program was also charged with finding ways of diagnosing metastasis before it occurs. The research is highly dependent on the latest sequencing technology and demands the massive computer power and sophisticated data handling techniques of modern bioinformatics.

Much of the data generation involves high throughput, next generation DNA and RNA sequencing. Genetic material is replicated and chopped into millions of small pieces that are analysed in parallel. This results in massive sets of data to be sorted and fitted together into a coherent sequence—and that's a job for bioinformatics. So the researchers collaborate with scientists from the Victorian Life Sciences Computation Initiative.

The focus is on epithelial mesenchymal plasticity (EMP)—the capacity of cells to change from structured, stay-put, epithelial cells to mobile, less organised, mesenchymal cells and vice versa. EMP is an important underlying mechanism of foetal development. But in cancers it facilitates metastasis.





Led by Prof Erik (Rik) Thompson, of St Vincent's Institute of Medical Research and the University of Melbourne, the EMPathy program brings together an Australia-wide network of researchers and clinicians who'll be working almost simultaneously on seven different themes along the drug development pipeline, so what they find can be fast-tracked into the clinic.

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Health check for live cells

Unhealthy cells are less "squishy" than their healthy counterparts. That difference is used by a small device developed by engineers at Monash University to test living blood cells for diseases, such as malaria and diabetes. The device can then sort the cells for future culturing and experimentation without harming them.

The patented "lab-on-a-chip" and accompanying control system has attracted considerable interest from pharmaceutical companies, according to co-inventor Dr Greg Sheard of the Department of Mechanical and Aerospace Engineering.

"When blood cells become unhealthy, their mechanical properties alter," he says. "There's increasing evidence showing they lose their squishiness—their membrane stiffness, internal viscosity and deformability all change."

The new device, which is about the size of a microscope slide, can assess that. But its operation depends on an understanding of fluid flows and on simulations involving the complex equations of computational fluid dynamics. That's why its inventors needed access to the supercomputers at the Victorian Life Sciences Computation Initiative to design it.

The chip is marked with micro-channels about a tenth of a millimetre wide in the shape of a cross. At the end of the arms are portals through which fluid can be injected or withdrawn. By careful management and control of the fluid flows down each arm, individual blood cells, less than a hundredth of a millimetre in diameter, can be drawn into the centre of the cross.

At this point they are subjected to a fluid pulse, and their deformation assessed and recorded using high speed photography. On the basis of the result the blood cells can be sorted and ejected down one of two exit arms.

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New tool for better breast cancer detection

Queensland scientists are helping radiologists to spot the more subtle signs of breast cancer, using computer tools and magnetic resonance imaging (MRI).

Currently MRI allows radiologists to detect lumps or other growths by creating a 3D anatomical image of the breast.

Prof Stuart Crozier and his team at the University of Queensland have developed a computer tool that improves MRI detection by spotting more subtle indicators of cancer.

"When cancers are just starting to form, they form abnormal blood vessels very early, to feed their rapid cell division," Stuart says.

"By seeing how certain contrast agents move through the tissue, we can pick up the formation of these blood vessels."

This works towards solving two issues with conventional MRIs.

First, it should reduce the number of false positive results and therefore the number of women put through biopsies of benign tumours.

Second, this should catch tumours earlier, not just when tumours are big enough to discern visually.

"The goal is to assist radiologists to identify areas of cancer risk that may not be obvious on conventional images," Stuart says.

Stuart, a Fellow of the Australian Academy for Technological Sciences and Engineering (ATSE), was recently presented with a 2012 Clunies Ross Award for his contributions to the engineering of MRI technology.

The research, funded as an Australian Research Council Discovery Project, is now undergoing trials with 140 women at private radiology firm Queensland X-ray.

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PHOTOS: BREAST CANCER CELLS VISUALISED WITH ANTIBODIES RECOGNISING E-CADHERIN (RED) OR VIMENTIN (GREEN). THE CELL NUCLEI ARE VISUALISED WITH A DNA-BINDING STAIN (BLUE), CREDIT: CLETUS PINTO & RHIANNON COULSON, ST VINCENT'S INSTITUTE; THIS PAGE: CONTRAST-ENHANCED MRI OF A BREAST, CREDIT: YANIV GAL; A SIMULATION OF A RED BLOOD CELL BEING TRAPPED AND STRAINED FOR MEASUREMENT IN THE MONASH DEVICE, CREDIT: YANN HENON, ANDREAS FOURAS & GREG SHEARD.

For Women in Science

Understanding the genetic contribution to epilepsy; the complex life of coral; the mathematics of conservation; intelligent drug design. These were the diverse fields of the Australian women in science recognised by L'Oréal's For Women in Science programs in 2011.

Understanding the genetic contribution to epilepsy

Twenty years ago doctors thought epilepsy was caused by injuries or tumours but, thanks to the work of a Melbourne paediatrician, we now know that there's a large genetic factor.

Prof Ingrid Scheffer, a paediatric neurologist at the Florey Neuroscience Institutes and the University of Melbourne, has spent the last 20 years looking at the genetics of epilepsy, particularly in children.

We now know that genes play a large role and that's opened the way to better diagnosis, treatment, counselling, and potential cures.

In particular, Ingrid's team and her collaborators at the University of South Australia have discovered that one kind of inherited infant epilepsy is due to a single letter change in the genetic code.

For 15 years the mutation was pinned down to a specific chromosome, but Ingrid and her team locked down the exact mutation in 2012.

"Now that we've identified the mutation we can screen infants and predict the risk of seizures," says Ingrid. "For this particular form of epilepsy, there is a risk that patients may have a rare movement disorder that begins in childhood or adolescence: when you try to move a limb, it has a 'mind of its own.'

"By knowing about this disorder, the diagnosis can be readily made and treatment started.

"We know that this gene makes a protein and that means we can hone in on what's happening biochemically and start to develop targeted treatments for this familial form of epilepsy."

For her decades of work on the genetics of epilepsy, Ingrid was announced as the 2012 Asia-Pacific Laureate for the L'Oréal-UNESCO For Women in Science Awards in Paris in March 2012.

The complex life of coral

Dr Tracy Ainsworth's research is changing our understanding of the tiny coral animals that built Australia's iconic Great Barrier Reef. Tracy and her colleagues at James Cook University in Townsville have found that the process of coral bleaching is a far more complex than previously thought, and begins at temperatures lower than previously considered. And she's done so by applying skills in modern cell biology which she picked up working in neuroscience laboratories.

Her achievements won her a $20,000 L'Oréal Australia For Women in Science Fellowship in 2011, which she is using to study the low light, deep water reefs that underlie tropical surface reefs at depths of 100 m or more.

In surface reefs, the coral polyps—relatives of jellyfish and anemones that construct the reef's limestone scaffolding—form a symbiotic relationship with single-celled algae called dinoflagellates.

But the reef also supports communities of bacteria. They live in a mucous coating which the polyps secrete to protect themselves from wave action and the scouring of sand and sediments.

And they provide another layer of protection, producing chemical defences against less benign infective bacteria and microbes that can cause disease. This interaction seems to be important for corals, Tracy found.

Now she wants to investigate what's happening in the deep reefs. This is a world far removed from the bright, colourful, sunlit environment we associate with coral. It's a place with little or no photosynthesis to provide the energy for reef construction and maintenance. But the biological communities still include algae and are equally diverse. They may even serve as refuges from which devastated shallow reefs can repopulate.

The mathematics of conservation

The Earth is losing species and ecosystems fast, but figuring out the best response is not easy when information, time and money are scarce.

Dr Eve McDonald-Madden, University of Queensland, is using maths to help governments and others make tough decisions on how best to use limited resources to preserve ecosystems under threat.

The young Australian scientist helps to save species, not by going out into the field, but by analysing the data other people have collected on endangered species.

"I sit at a computer and use that data to find the best strategies for managing those species," she says. "My research focuses on making faster, better conservation decisions by analysing the trade-offs between available dollars, our need for information, and the urgency of the conservation issue.

"We can't delay hard choices," she says.

Eve has already helped to develop and implement a policy for monitoring the Sumatran tiger to prevent poaching. She's also come up with a strategy for managing Tasmanian devils under threat from an infectious facial tumour disease.

In April 2012 Eve spent a month in France improving her models by learning more about artificial intelligence.

She also worked with French colleagues to develop new strategies to manage the impacts of climate change.

Eve won a $20,000 L'Oréal Australia For Women in Science Fellowship in 2011, allowing her to undertake her work at France's National Institute for Agricultural Research.

Intelligent drugs

Dr Georgina Such imagines a miniscule capsule designed like a set of Russian babushka dolls.

The capsule is designed to sneak through the blood stream untouched.

When it finds its target—a cancer cell—it passes into the cell, sheds a layer, finds the part of the cellular machinery it needs to attack, sheds another layer; and then releases its cargo of drugs, destroying the cancer cell and only the cancer cell.

Creating such a capsule may take decades, but Georgina and her colleagues at the University of Melbourne have already developed several materials which have the potential to do the job.

Now, with the help of a 2011 $20,000 L'Oréal Australia For Women in Science Fellowship she has begun to push her research further.

So far, Georgina has combined two different techniques—layer-by-layer assembly and click chemistry—to produce the required type of "intelligent" materials that can deliver cancer drugs only to unhealthy cells within the body.

Using a combination of these techniques she can create her "babushka doll" capsules—with each coating tailored to a particular purpose which, when fulfilled, is stripped away to reveal the next layer.

Click chemistry is important because it is an efficient bonding technique which allows her to build "the smarts"— chemical ingredients with highly specific properties—into the polymer capsule coatings.

Already she has, for example, developed "low fouling" capsules, coated, like a stealth bomber, with materials that allow them to pass undetected through the body's immune surveillance systems.

And her L'Oréal Fellowship will be directed towards solving the problem of how to ensure the drug carried by the smart capsule is most effective once it is taken into a target cell.

Find out more about the program and how to nominate at www.scienceinpublic.com.au/loreal

FOR WOMEN IN SCIENCE
L'ORÉAL AUSTRALIA
Australian National Commission for UNESCO

PHOTOS: INGRID SCHEFFER WITH ONE OF HER YOUNG PATIENTS, CREDIT: SDP/ L'ORÉAL; THIS PAGE: 2011 L'ORÉAL FELLOWSHIP WINNERS GEORGINA SUCH (LEFT) AND EVE MCDONALD-MADDEN (RIGHT), CREDIT: L'ORÉAL AUSTRALIA/SDPMEDIA.COM.AU; EVE MCDONALD-MADDEN'S WORK IS HELPING TO SAVE THE ENDANGERED SUMATRAN TIGER, CREDIT: ISTOCKPHOTO; 2011 L'ORÉAL FELLOWSHIP WINNER TRACY AINSWORTH, CREDIT: L'ORÉAL AUSTRALIA/SDPMEDIA.COM.AU.

Light fast-tracking Australian science

Since it opened in 2007, the Australian Synchrotron has been in demand as a research tool—over 2,000 scientists from over 90 institutes have used its beamlines to date. Synchrotron light has helped research into new medical treatments, nutrition, materials science, the composition of the moons of Jupiter and how the ancient Egyptians made pottery.

Clues to switching off your blood clots

Our blood has a built-in system for breaking up heart attack-inducing clots—and we're a step closer to drugs that could switch that system on at will.

Australian researchers have won the decades-long race to define the structure of plasminogen—a protein whose active form quickly dissolves blood clots.

The current crop of clot-busting drugs have many side effects, including bleeding and thinning of the blood, so harnessing the body's own mechanism for clearing clots could offer a better way.

An Australian team led by Prof James Whisstock and Dr Ruby Law from Monash University, and Dr Tom Caradoc-Davies from the Australian Synchrotron, was able to manipulate the protein into a crystal that diffracts X-rays—allowing them to reveal the complex 3D structure.

"Because we could look at the atomic nature of plasminogen using the synchrotron, we were able to answer an almost century-old scientific question—how is plasminogen really activated in the body," Tom says.

In the past, the molecular details of plasminogen-activating drugs used to treat strokes were not entirely understood.

This latest discovery means that drug companies can fine-tune their development of next generation anti-clotting and "clot busting" drugs and cancer treatments—using their knowledge of the molecule's structure to design drugs that "switch on" the protein.

This means finding a drug that would mimic the body's own messengers by fitting into a special site on the protein.

"Once you know what the lock looks like, it's much easier to make a key," Tom says.

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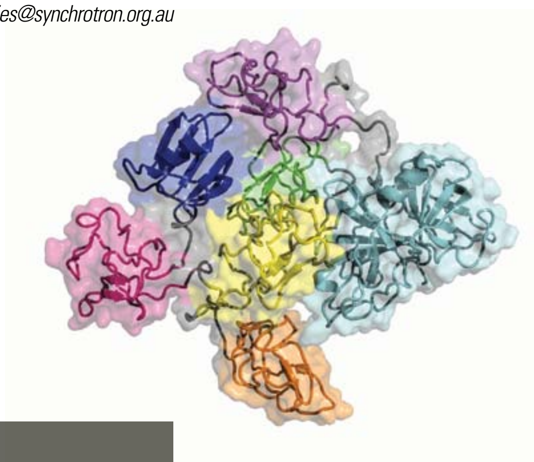

New light on storing energy

Solving the problem of how to store energy is essential for a future run on renewables.

That's why promising materials for hydrogen fuel cells and high capacity, long-lived batteries are being explored at the atomic level by the Australian Synchrotron.

Australian Synchrotron scientist Dr Qinfen Gu is investigating a new class of hydrogen storage materials being developed by scientists at the University of Wollongong and their international collaborators.

Qinfen is using the powerful X-rays of the synchrotron to observe and analyse the structure of these materials. The scientists can see at the atomic level how the hydrogen is stored and then design and test materials to increase their storage capacity.

Although years away from commercial use, a number of these materials have a shown a good capacity for releasing pure hydrogen—an important milestone in developing the next generation of hydrogen car.

Another energy project at the Australian Synchrotron is looking at lithium-ion batteries to see if there's a way to make a material that would allow many more "recharges" in a battery's lifetime.

Current lithium batteries lose capacity during repeated cycles of charging—something that needs to be solved if they are to be used in electric vehicles or as storage for renewable energy systems.

Dr Neeraj Sharma from ANSTO and Dr Rosalind Gummow from James Cook University have already used the synchrotron to show how the crystal structure of their material changes as lithium ions move during charging and use.

They are aiming to understand this process to one day allow lithium-ion technology to be used widely, not only in laptops and phones but also for cars and renewable energy storage.

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Australian Synchrotron

SEE ALSO PAGES 4-5.

PHOTOS: TOP: QUINFEN GU IS INVESTIGATING A NEW CLASS OF HYDROGEN STORAGE MATERIALS, CREDIT: ISTOCKPHOTO; BOTTOM: THE MOLECULAR STRUCTURE OF PLASMINOGEN, CREDIT: TOM CARADOC-DAVIES, AUSTRALIAN SYNCHROTRON.

The Higgs and high energy physics down under

The discovery of the Higgs boson in July 2012 was announced jointly in Geneva and Melbourne because Melbourne was hosting the International Conference on High Energy Physics. The conference focussed attention on Australia's contribution to CERN (see page 5) and illustrated the benefits of conferences to the local economy.

Melbourne takes centre stage in physics

Melbourne shared in the announcement of the discovery of a Higgs boson-like particle in 2012, and the city is expected to reap millions of dollars in economic benefits brought by the conference at which this discovery was announced.

The announcement that a suspect matching the elusive subatomic particle's description had been found came at the 36th International Conference on High Energy Physics, held at the Melbourne Convention Centre in July, in a joint announcement with CERN in Switzerland.

The conference brought more than 800 delegates to the city over an eight-day period and the Melbourne Convention + Visitors Bureau (MCVB) expects it to generate $8 million in economic impact for Victoria.

MCVB partnered with the University of Melbourne to bid for the 2012 conference, with the director of the ARC Centre of Excellence for Particle Physics at the Terascale (CoEPP), Prof Geoffrey Taylor, as the local host.

Researchers at the ARC Centre are actively involved with CERN research. The Centre brings together particle physicists based at the Universities of Melbourne, Sydney and Adelaide, and Monash University.

MCVB CEO Karen Bolinger says Melbourne was the obvious choice for hosting the conference because the city is the knowledge, research and innovation capital of Australia.

"Over the next two and a half years, Melbourne will host seven of the world's largest and most prestigious conferences including the World Diabetes Congress in 2013 and the World Congress of Cardiology and the International AIDS Conference in 2014, all of which were secured by the MCVB," she says.

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www.mcvb.com.au

Australian Synchrotron helps its big brother in Geneva

New technologies and techniques needed for the next upgrade of the Large Hadron Collider (LHC) are being tested at the Australian Synchrotron.

In 2013, the LHC will shut down for enhancements that will enable it to generate a reliable supply of Higgs-like particles.

One of CERN's technology experts, Dr Ralph Steinhagen, has been working with synchrotron researchers in Melbourne to develop ways to increase the precision of measurements and control of particle beams at the LHC. Australian Synchrotron researchers have expertise in making highly focused particle beams.

"We broke the world record for producing the smallest, brightest, most intense beam of electrons—a billionth of a millimetre tall," says Dr Mark Boland, principal scientist in accelerator physics at the Australian Synchrotron. "It's all a matter of control, and we are also working on developing new technologies to make the beam as stable as we can."

That's of interest to CERN, says Ralph, because the characteristics of light generated at the Australian Synchrotron are in many ways very similar to the LHC. "But it's much more accessible," he says. "So we are trying to pioneer future beam technology in Melbourne."

Apart from generating Higgs bosons, the Australian research is important to developing more intense and compact X-ray beams for other synchrotrons around the globe. "These so-called 4th generation sources will allow us to take movies of chemical reactions and the processes of molecular biology," Mark says.

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bit.ly/VkNhms

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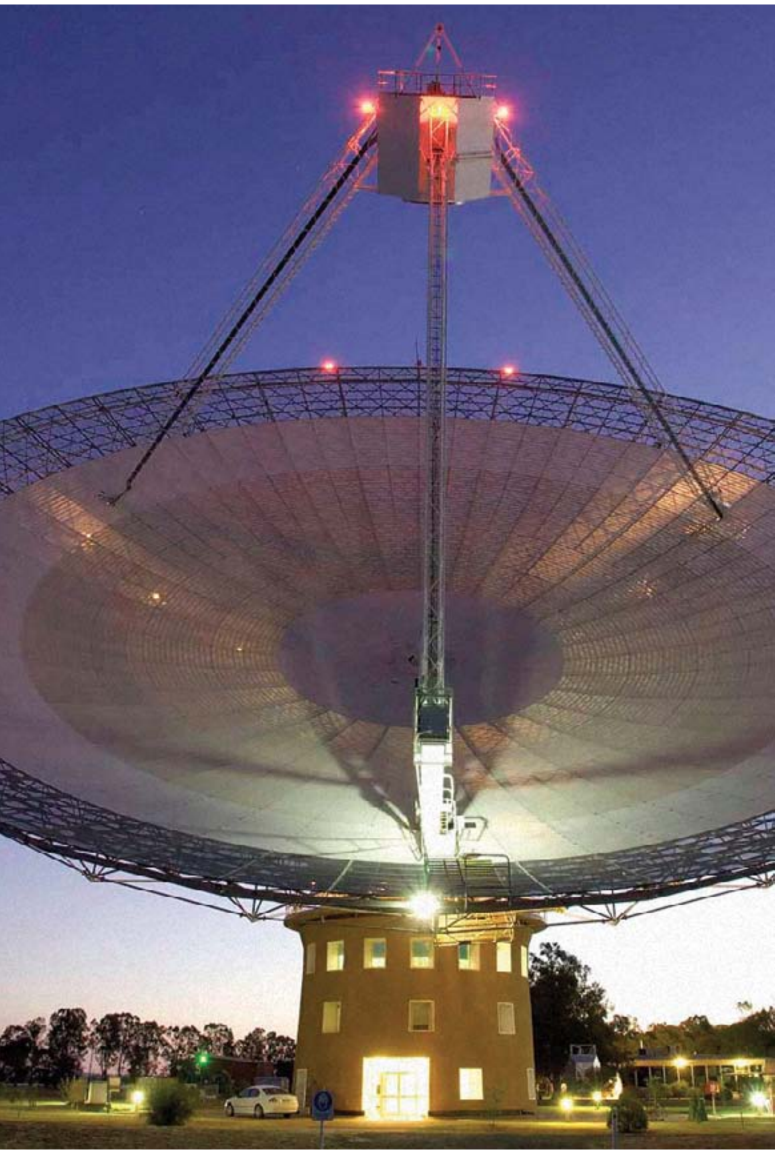
CoEPP
ARC Centre of Excellence for Particle Physics at the Terascale

PHOTOS: WORKING IN THE ATLAS CAVERN, CREDIT: CERN; THE MELBOURNE CONVENTION CENTRE HOSTED THE 36TH INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS, WHERE THE DISCOVERY OF A HIGGS BOSON-LIKE PARTICLE WAS ANNOUNCED IN 2012, CREDIT: MCEC.

Better data, better research

Australian National Data Service is helping more Australian researchers reuse research data more often.



Regular source of ocean data now underway

More than 50 different environmental measures routinely collected by Australia's national ocean research vessels—including sea surface temperature, dissolved oxygen concentration, and salinity—can now be accessed online almost as they are recorded.

The data is incorporated, often automatically, into predictive meteorological and ocean models, improving their accuracy. "So we end up with an improved representation not only of the weather but of processes like large scale ocean circulation or the state of the seas during tropical cyclones," says Dr Roger Proctor, director of the e-Marine Information Infrastructure Facility of Australia's Integrated Marine Observing System.

Two research vessels, the *Southern Surveyor*, managed by CSIRO, and the *Aurora Australis*, operated by the Australian Antarctic Division, ply the oceans around the continent and down to Antarctica respectively. As well as taking specific measurements for research purposes, since 1985 they have been accumulating routine "underway" data to assist their passage.

Initially, this information was simply stored and taken back to the laboratory for further analysis once the ship docked. But for several years now, a suite of weather information has been transmitted directly to the Bureau of Meteorology computers for inclusion in the Global Telecommunications System operated by the World Meteorological Organisation. Now, with funding and assistance from Australian National Data Service, the rest of the underway data—to do with the ship's movements, the state of the ocean and sea-atmosphere interaction—is being labelled and transmitted as soon as it is gathered.

The data, including archival information, is available to all through Research Data Australia (researchdata.ands.org.au) and the Australian Ocean Data Network (AODN) at portal.aodn.org.au. Many other commercial vessels, collectively known as ships of opportunity, also carry instruments that provide measurements across Australia's surrounding oceans: this data is also available through the AODN portal and Research Data Australia.

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imos.org.au/rtunderway.html

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Mapping a future for Australian birds

Australia's birds are bright and noisy compared with birds elsewhere, so perhaps it is no surprise they account for over 18 million of the more than 30 million observations of fauna and flora in the Atlas of Living Australia; including records from before European settlement.

Now, funded by the Australian National Data Service (ANDS), a team led by spatial ecologist Dr Jeremy VanDerWal of the Centre for Tropical Biodiversity and Climate Change at James Cook University (JCU) is developing a website, known as "Edgar", to clean up existing records and augment them with reliable observations from enthusiastic and knowledgeable bird watchers.

The data is initially analysed automatically using algorithms that can weed out any obvious errors, such as cassowaries occurring in the Indian Ocean. Regional bird experts are then asked to curate the data for their area, examining any new observations and noting older ones, which do not seem right. These experts are provided with a log-in that allows them to locate and annotate or comment on any of the records.

The public face of the "Edgar" website (tropicaldatahub.org/goto/Edgar) provides information on bird populations and distributions—now and into the future. The data can also be found via the Tropical Data Hub (tropicaldatahub.org) and Research Data Australia (researchdata.ands.org.au).

The user first nominates a bird species of interest via either common or scientific name. The website, which is still under development, responds by presenting a distribution map based on current observational data, and is colour-coded to indicate intensity of sightings. Users can then overlay a model showing areas with climatic conditions suitable for that species by integrating the 'cleaned' observations with climate data within the Tropical Data Hub. This information can be used to project the impact of future climate change.

"There will no doubt be improvements over time. And the website model applies to more than birds—it is just as applicable to other datasets," says Prof Ian Atkinson, eResearch director at JCU.

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tropicaldatahub.org/apps/edgar

Finding pulsars in the archives

China has a large community of astronomers awaiting the construction of new telescopes to study pulsars. When CSIRO pulsar researcher Dr George Hobbs described the high-quality data stored in the Parkes Observatory Pulsar Data Archive—which is openly available—it led to Australian pulsar data being the basis of collaboration between Chinese and Australian pulsar researchers. And they have already published several papers on what they have discovered. The archive is also serving as a major resource in an international search for gravitational waves.

These are two of the more unexpected outcomes of a project that initially set out to fulfil a CSIRO commitment—to make data from the Parkes telescope available publicly within 18 months of observation.

"The data archive, which is fully automated and was established with financial support from the Australian National Data Service, ensures that important information is not lost," CSIRO pulsar researcher Dr George Hobbs says. It also has freed CSIRO astronomers from the time consuming task of satisfying requests for data from all over the world.

Pulsars are collapsed stars, known as neutron stars. They are highly magnetic and rotate rapidly emitting radio waves in specific directions which sweep through space like lighthouse beams. From Earth, therefore, they appear to pulse in an extremely regular manner. About two-thirds of known pulsars have been detected by the Parkes telescope.

Not only are pulsars interesting astronomical objects in their own right, they can also be used as natural stopwatches to time other events in space. In late June 2012, a conference on the International Pulsar Timing Array was held in Sydney. This project aims to show the existence, or otherwise, of the gravitation waves proposed by Einstein. The idea is that such waves passing through Earth should actually move it slightly, enough to be detected through tiny fluctuations in the pulsar timing.

The archive is accessible through both Research Data Australia (researchdata.ands.org.au) and CSIRO's Data Access Portal (data.csiro.au).

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www.atnf.csiro.au/research/pulsar/index.php?n=Main.ANDSATNF

ands
AUSTRALIAN NATIONAL DATA SERVICE

PHOTOS: PARKES RADIO TELESCOPE HAS DETECTED ABOUT TWO-THIRDS OF KNOWN PULSARS, CREDIT: CSIRO; THIS PAGE: THE MARINE NATIONAL FACILITY VESSEL SOUTHERN SURVEYOR, ONE OF AUSTRALIA'S SCIENTIFIC RESEARCH SHIPS, CREDIT: CSIRO; THE ATLAS OF LIVING AUSTRALIA CONTAINS MORE THAN 18 MILLION BIRD OBSERVATIONS, CREDIT: ISTOCKPHOTO; BOTTOM: SCREEN CAPTURE FROM EDGAR DISPLAYING DATA FOR THE SOUTHERN CASSOWARY, CREDIT: JEREMY VANDERWAL.

Making use of our energy

Harnessing waste energy to power factories

Manufacturers are looking for ways to make their factories more sustainable, but before whacking a solar panel on the roof, they've got to plan carefully.

University of New South Wales researcher A/Prof Sami Kara says production lines need a steady supply of electricity, and if the sun goes behind a cloud, businesses get hit with penalty rates for suddenly drawing more energy from the grid.

"Manufacturing is a highly dynamic environment, it's not like an office or a residential building where the energy consumption stays pretty much steady; in manufacturing, it fluctuates minute by minute," Sami says.

"The question is, with respect to fluctuating demand, how do you actually manage all of those different energy supplies in order to minimise the cost and environmental impact, but still get quality energy on a timely basis."

Before a factory can retrofit solar or thermal energy systems, they need work out smart ways to manage energy use across the whole factory.

Sami's building a real-time tool to monitor the energy management systems of manufacturer Baxter Healthcare, and looking for literal "hotspots" where waste heat energy can be captured and reused.

For example, Baxter runs 11 huge autoclaves which they use to sterilise every single product they make. Using cogeneration, they can reclaim the excess steam to power turbines that provide energy to other parts of the factory.

The energy monitoring data also allows Baxter to choose renewable energy options—if the energy supply from solar panels or steam turbines drops, they can respond by altering production before they're hit with peak electricity charges.

The research is an ARC linkage project, with funding from government and the industry partner, Baxter Healthcare.

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Australian science's place in Asia

Australia's scientists are among the most productive in the region. That's the picture that emerges from the Nature Publishing Index 2011 Asia-Pacific released in March 2012.

Australia ranks second only to Singapore in terms of science output per capita and per scientist in the Index, which measures the publication of research articles in Nature research journals by Asia-Pacific nations and institutions. Singapore and Australia are also first and second in the Asia-Pacific respectively in terms of GDP per capita.

In terms of absolute numbers of articles published, Australia is third in the rapidly developing region, behind Japan and a fast-growing China but well ahead of fourth-placed Korea and fifth-placed Singapore.

Australia's investment in science infrastructure, when paired with the industriousness of its research scientists, seems to be paying off as it has consolidated its position since the 2010 rankings.

The top-performing research institutions in Australia over the past three years are the University of Melbourne, University of Queensland and Australian National University. At 64, 86 and 97 respectively, these three are the only Australian institutions in the Nature Publishing Index 2011 Global Top 100 (beta) rankings, also published in March 2012. Among other Australian institutions, the rapid rise of James Cook University (JCU) to number ten in the national rankings is notable.

For more information:

Nature Publishing Group

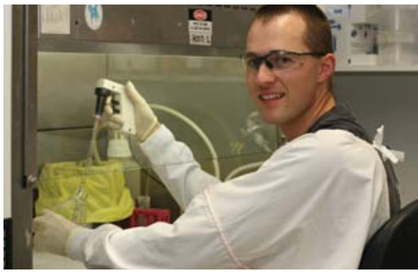
www.natureasia.com/en/publishing-index/asia-pacific/2011

PHOTOS: AUSTRALIA RANKS THIRD IN THE ASIA-PACIFIC REGION IN TERMS OF PUBLICATIONS IN NATURE GROUP JOURNALS, CREDIT: NASA VISIBLEEARTH.NASA.GOV; SAMI KARA IS DEVELOPING A TOOL TO HELP INDUSTRY BECOME MORE SUSTAINABLE, CREDIT: ISTOCKPHOTO.

freshscience

Each year we identify early-career scientists with a discovery and bring them to Melbourne for a communication boot camp. Here are some of their stories.





Samurai of the sea – What sawfish really do with their saw

Sawfish do not use their saw to probe the sea bottom for food, as marine scientists previously thought. They actually locate and dismember free-swimming prey with it. We know this thanks to Cairns researcher Barbara Wueringer, who studies sawfish in the northern waters of Australia, in order to conserve them better. She has discovered special pores in the saw that give these endangered five-metre-long fish a sixth sense that detects the electric fields of their prey.

A smart bandage reveals healing

A bandage that changes colour in response to the wound beneath could reduce the $500 million cost of chronic wound care in Australia. CSIRO material scientist Louise van der Werff and her colleagues created a fabric that changes colour in response to temperature—displaying changes of less than half of a degree. This will allow nurses to quickly identify healing problems such as infection or interruptions to the blood supply, which are typically accompanied by a localised change in temperature.

A little lupin reduces blood pressure

Most would know lupins as ornamental garden flowers—but flour made from the seeds of these legumes can lower your risk of heart disease significantly. Victoria University dietician Dr Regina Belski (now at La Trobe University) and colleagues from the University of Western Australia found that people eating foods containing flour made from 40 per cent lupin beans had lower blood pressure and reduced risk of heart disease.

About 80 per cent of the world's commercial lupin crop is produced in Western Australia and food manufacturers there have already begun making and selling products made with lupin flour.

HIV can hide out in the brain

HIV can elude the immune system and antiviral drugs by hiding in the brain, Dr Lachlan Gray and his colleagues at Monash University and the Burnet Institute have found. One in five of those infected by HIV ends up with dementia and Lachlan's discovery is an important step in understanding the link between the two. The researchers hope their findings will aid the development of novel drugs that will prevent HIV using the brain as a sanctuary.

Match your treatment to your cancer

Three 'cell death' genes have been identified that could make anti-cancer drugs more effective. The discovery, by Lina Happo and colleagues at the Walter and Eliza Hall Institute, could be the first step in developing new cancer treatments that target only cancer cells. It will also allow medical researchers to work out how conventional cancer therapies work, and why they sometimes fail. This is important because most chemotherapy drugs do not distinguish between normal and cancerous cells, leading to collateral damage to healthy cells.

How ocean arteries carry life across the Indian Ocean

The open waters of the southeast Indian Ocean flow east-west in bands rather than the expected circular gyres, University of Melbourne and Bureau of Meteorology researchers have shown.

The conventional idea of ocean circulation has currents moving in large circles, or gyres—clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere. But Prasanth Divakaran, a PhD candidate in the University of Melbourne's School of Earth Sciences, and his colleagues have shown a different pattern in the southeast Indian Ocean. This new understanding of ocean flow has important implications for our understanding of all sorts of ocean events from the movements of fish and marine life to the prediction of weather and climate.

PHOTOS: LEFT TOP: CAIRNS RESEARCHER BARBARA WUERINGER HAS FOUND THE FRESHWATER SAWFISH USES ITS SAW LIKE AN ANTENNA TO HUNT DOWN FISH, CREDIT: DAVID WACHENFELD, DAVIDWACHENFELD.REDBUBBLE.COM; RIGHT BOTTOM: THE SMART BANDAGE FIBRES CHANGE COLOUR WHEN EXPOSED TO HEAT, CREDIT: LOUISE VAN DER WERFF, CSIRO; RIGHT TOP: COMMERCIAL FOODS MADE WITH LUPIN FLOUR, CREDIT: IOURI BELSKI; LEFT BOTTOM: LACHLAN GRAY IN THE LAB, CREDIT: HAZEL SQUAIR.

Tammar wallaby's clever immune tricks revealed

It has been a mystery why many marsupials, unlike other mammals, have two thymuses—key organs in the immune system. But Dr Emily Wong, from the University of Sydney, and her colleagues now suspect it is because marsupials are born without immune tissue.

Waste heat slashes fuel consumption

A minor modification to your car could reduce your fuel consumption by more than seven per cent, according to engineers at Deakin University. Frank Will, who developed the design during his PhD, is now talking to car manufacturers and developing aftermarket conversion kits.

A planet going the wrong way

Not all planets move around their stars in the same direction as the star spins. This discovery by Australian National University astronomer Dr Daniel Bayliss and his collaborators throws traditional theories about how planets form into doubt.

Seeding the regrowth of nerves with tamarind

An injectable material that encourages nerves in the brain and spinal cord to regrow has been developed by PhD student Andrew Rodda and his Monash University colleagues. Their work could lead to new ways of treating nerve-based injuries or conditions such as Parkinson's disease and Huntington's disease.

Fire, carbon capture and the NT

Decreasing the frequency of wild fires in northern Australia would lead to an increase in the amount of carbon stored in the soil, significantly lowering greenhouse gas emissions, according to CSIRO ecologist, Dr Anna Richards.

Printing solar cells

Australian researchers have invented nanotech solar cells that are thin, flexible and use 1/100th the materials of conventional solar cells. They could dramatically decrease the cost of renewable energy and have been developed by PhD student Brandon MacDonald in collaboration with his colleagues from CSIRO's Future Manufacturing Flagship and the University of Melbourne's Bio21 Institute. See the stories on pages 20 and 21 for more advances in solar cell manufacture.

You're going to fall over soon

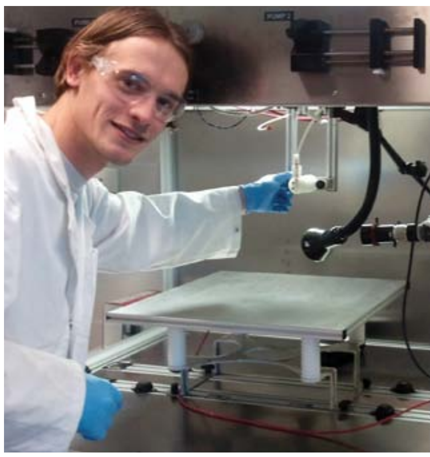
Dr Stephen Redmond and colleagues at the University of New South Wales have developed a simple way of predicting the likelihood of an elderly person falling over in the near future, so action can be taken to reduce the chances of it happening. The researchers hope their work will allow older people stay in their own homes longer.

Multi-layered armour protects body against immune failure

The human body incorporates multiple fail-safe mechanisms to protect it against the "friendly fire" from the immune system—also known as autoimmune disease. This was the finding of Charis Teh and colleagues at the John Curtin School of Medical Research (JCSMR) at the Australian National University.

Designer roots to counter drought

Genetics can be used to shape plants underground so they absorb water better, says Dr Vijaya Singh from The University of Queensland. Her discoveries are already being used by plant breeders to develop drought-resistant sorghum crops.



PHOTOS: LEFT: ANNA RICHARDS COLLECTS CARBON DATA WITH TIWI LAND RANGER KIM BROOKS, CREDIT: BARBARA MCKAIGE; RIGHT, FROM TOP TO BOTTOM: A TAMMAR WALLABY, PHOTO: AGRF/VICCI CROWLEY-CLOUGH; VIJAYA SINGH, CREDIT: FRESH SCIENCE/MARK COULSON; CLOSE-UP OF SOIL SURFACE COVERED IN ASH AND CHARCOAL FOLLOWING A SAVANNA FIRE, CREDIT: ANNA RICHARDS; A COMPLETED NANOCRYSTAL SOLAR CELL CREDIT: ANTHONY CHESMAN; ANDREW RODDA IN THE LAB, CREDIT: TING-YI WANG.

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