2011

Stories of Australian Science

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science stories

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welcome

Welcome to *Stories of Australian Science 2011*.

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 Australian science and to introduce some interesting people and potential stories.

We think science is the major driver of social, economic and environmental change around the world. And yet, at a time when the world needs strong scientific leadership to help us create a sustainable future on this small blue planet, scientists and the scientific method are under unprecedented attack.

It's more important than ever to highlight the people whose discoveries are transforming society and in particular the early career researchers who do most of the heavy lifting in our laboratories.

Among the 50 stories presented here, you'll catch up with past winners of the Prime Minister's Prizes for Science, as well as the brilliant young scientists of the L'Oréal Australia *For Women in Science* Fellowships and of Fresh Science.

This is our third 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. The second was when Melbourne hosted the World Congress of Science and Factual Producers in December 2009.

We welcome your feedback on the stories by email and online at www.scienceinpublic.com.au/stories where you can also see our collections of astronomy stories, Australia-China collaborations, and how Australian science has changed America.

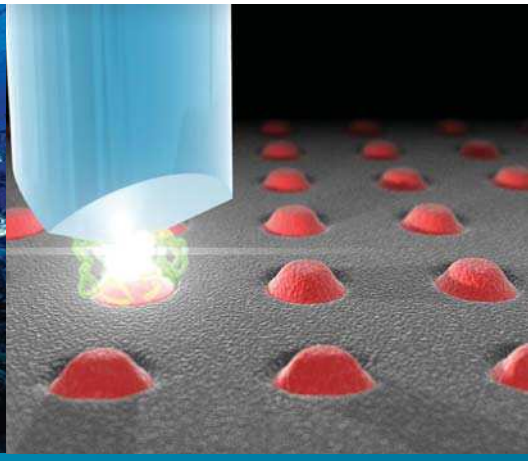
To the friends we made in Montreal in 2004, Melbourne in 2007, London in 2009, and Doha in 2011, we look forward to seeing you in Helsinki for the 8th World Conference of Science Journalists in 2013.

And we look forward to catching up with US and Canadian journalists at the AAAS in Vancouver in 2012.

Sarah Brooker
Managing Director

Niall Byrne
Creative Director

PS Just hours before going to press we heard that an Australian, Brian Schmidt, will receive this year's Nobel Prize for Physics together with Saul Perlmutter and Adam Riess. Their discovery of the accelerating expansion of the Universe is featured in *Stories of Australian Astronomy*—available online and in print.



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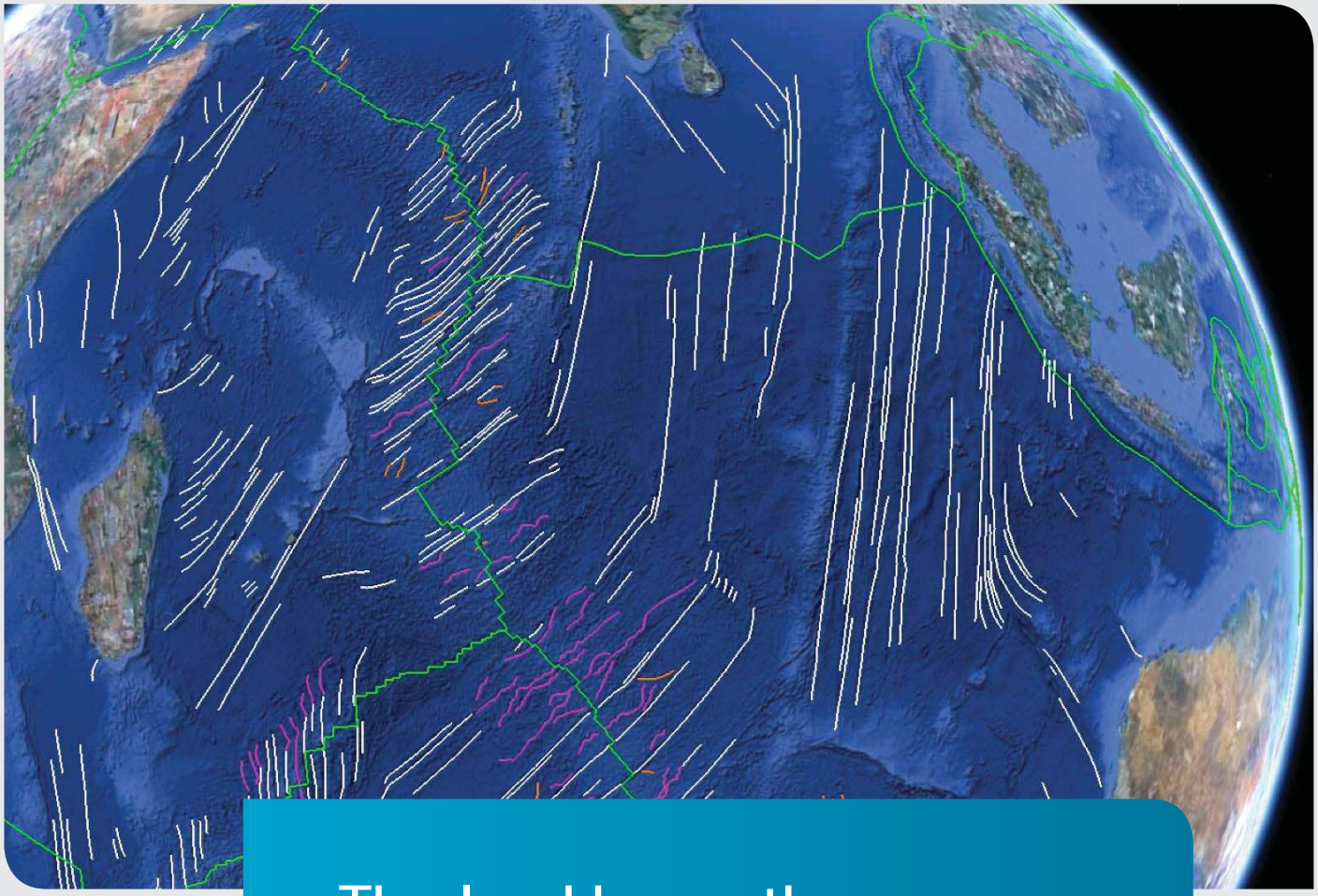

The land beneath

CREDIT: KARA MATTHEWS

Satellite imagery and new software have been used to create a complete digital map of our planet's seafloor.

Parkinson's answers deep in the brain

A Parkinson patient who can walk again, and improved life for people with the behavioural disorder known as Tourette syndrome.

These are two of the results of a partnership between University of Queensland neurologist Prof Peter Silburn and neurosurgeon Dr Terry Coyne who have ventured deeper into the human brain than anyone else in the world.

Peter treats patients at St. Andrew's Hospital in Brisbane with deep brain stimulation, a technique that uses electrodes to stimulate a region some 12 centimetres under the surface of the brain.

"There are 100 billion neurons in the brain and we can't restore all of them. But the deep brain is like a telephone exchange—by stimulating this one section of the brain, you can unblock the flow of messages," Peter says.

For example, Peter's group recently helped a patient with Parkinson's disease to walk again because the stimulation unblocked the flow of messages from the deep brain to the leg nerves.

"Our patients are awake for part of the surgery, so we can actually ask them how they are feeling, give them thinking tasks and actually observe their movement or mood being restored in a matter of seconds in real time."

Each year Peter and his team use this approach to help over a hundred patients with particularly severe cases of Tourette syndrome, Parkinson's disease, obsessive compulsive disorder and depression. The group also published research into how behaviour disorders and movement disorders are related in the deep brain.

"Our group is not just the surgical team —we have mechanical engineers and IT experts to design and run the equipment, we have mathematicians and imaging experts to analyse the information we gather, as well as psychologists and neurophysiologists to further develop therapies," says Peter.

PHOTO: PETER SILBURN AND HIS TEAM ARE USING DEEP BRAIN STIMULATION TO HELP MOVEMENT AND MOOD DISORDER PATIENTS BEYOND THE REACH OF OTHER THERAPIES. CREDIT: SUNDAY MAIL

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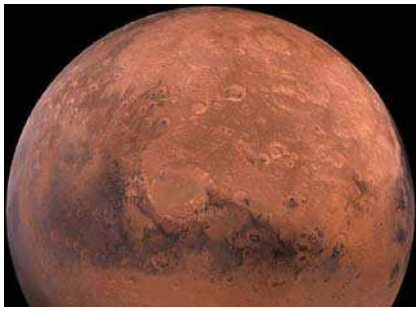

Mapping the seafloor from space

We know more about the topography of Mars than that of Earth because 70 per cent of our planet is covered by water. Now, University of Sydney PhD student Kara Matthews has used satellite data and GPlates, a computer package developed at the University, to create a complete digital map of the many geological features of the seafloor.

Fracture zones—the lines in the image on the opposite page—are deep linear scars on the seafloor that extend perpendicular to the boundaries where tectonic plates are moving apart, revealing up to 150 million years of plate movement. They are accompanied by huge ridges on the seafloor, rising up to 2 km above the abyssal plains, and valleys as deep as 8 km below sea level.

Through her work, Kara has discovered ancient tectonic microplates—tiny plates rotating like spinning tops over geological time—as well as kinks in fracture zones which record sudden shakeups of the global tectonic plate network. "The forces driving these changes are still largely unknown," says Kara, "so I am exploring different mechanisms using supercomputer simulations of the slow convective churning of the Earth's mantle, where rocks flow like warm toffee."

Kara's map is freely available to the community, and her research will enable more accurate mapping of plate movements. Earthquake hazard maps will be improved by considering the intersection of fracture zones with subduction zones, where plates are converging. The detailed topographic data may also improve modelling of deep ocean circulation, and thus enhance our understanding of long-term climate change.

PHOTO: THE TOPOGRAPHY OF MARS IS MORE WELL-KNOWN THAN EARTH'S BECAUSE OUR OCEAN'S HIDE MUCH OF IT—UNTIL NOW. CREDIT: USGS ASTROGEOLOGY

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Fish food and green power from pig waste

The concept of using "everything but the pig's squeal" is being taken to new lengths by a researcher in South Australia.

Andrew Ward, a South Australian biotechnologist, has developed a way to break down pig waste that produces feed for aquaculture, water for irrigation, and methane for energy.

The pig effluent is initially fed into an airtight, two-stage digester. This degrades smelly chemical compounds and kills potentially dangerous bacteria, while at the same time producing methane bio-gas and nutrients for the tiny seaweeds known as microalgae.

"Once we had the algae growing, we knew we could recreate the ocean food chain from algae to zooplankton to fish," Andrew says.

Andrew was able to get the Australian waterflea *Daphnia carinata*, a kind of zooplankton, to eat the seaweed. These small animals not only form the basis of commercial fishmeal, but also help to clean up the water in which they grow, by reducing the levels of nutrients and bacteria. They do such a good job, that the water can subsequently be used for irrigation.

The same 'waste food chain' can be used to recycle waste from intensive livestock farming systems, abattoirs or any other organic source.

"We are hoping this research will lead to elimination of the environmental concerns and costs associated with waste disposal, and that the wastes themselves can be transformed into new and diversified business opportunities," Andrew says.

His work has been underwritten by the Environmental Biotechnology Cooperative Research Centre (CRC) and pulls together ideas from Murdoch University, SARDI, The University of Adelaide and the CRC.

Andrew is currently a PhD candidate at the University of Adelaide.

PHOTO: ANDREW WARD HAS FOUND A WAY TO TURN PIG WASTE INTO FISH FOOD WITH THE HELP OF THIS WATER FLEA, *DAPHNIA CARINATA*, WHICH IS USED IN FISHMEAL. CREDIT: ANDREW WARD

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Preparing for the worst

CREDIT: QUEENSLAND FIRE AND RESCUE SERVICE

> Worst-case thinking is a critical skill.

OPAL reactor fingerprints Aboriginal ochre

A Flinders University chemist is using Australia's OPAL research reactor at Lucas Heights in Sydney to investigate ancient Aboriginal Australian society. Using the technique called neutron activation analysis, Dr Rachel Popelka-Filcoff can 'geochemically fingerprint' Aboriginal ochre pigments from different locations, archaeological sites and artefacts.

As the geochemical composition of ochre varies with location, she can correlate each sample with its site of origin, gaining information on cultural practices, travel and exchange patterns, and the relationship of Aboriginal people to the landscape. "Ochre pigments are highly significant in Aboriginal culture," says Rachel. "Cultural expression often requires a specific pigment. Applying ochre to an object such as a spear can transform both its colour and its cultural meaning."

Dr Roman Dronov, also from Flinders, is using the reactor to study the formation of bacterial protein layers. He is applying what he finds to constructing a new type of biosensor based on these layers and porous silicon. These highly sensitive devices can rapidly detect trace amounts of molecules, such as environmental poisons and markers of disease—a great improvement on traditional analytical methods.

"Using such biosensors in point-of-care health settings hastens disease detection and improves disease management," says Roman. "There is large demand for robust and cost-efficient biosensor solutions."

Rachel and Roman are Australian Institute of Nuclear Science and Engineering Inc. Research Fellows for 2011, the first researchers from South Australia to be awarded the honour. Their fellowship gives them access to the research facilities of the Australian Nuclear Science and Technology Organisation, such as OPAL.

PHOTO: RACHEL POPELKA-FILCOFF CAN TRACE THE CULTURAL USE OF OCHRE USING AUSTRALIA'S RESEARCH REACTOR. CREDIT: ASHTON CLARIDGE, FLINDERS MEDIA

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Preparing for the worst

Fire fighters should identify what are potentially the worst-case events and prepare for them, even if they are extremely unlikely to occur, says Bushfire Cooperative Research Centre psychology researcher Claire Johnson.

"A failure to consider worst-case scenario possibilities has been implicated in a number of high-profile investigations into Australian bushfire disasters," says Claire, who submitted her PhD thesis on worst-case scenario planning to La Trobe University in Melbourne in March this year.

For instance, the inquiries following the Canberra bushfires in 2003 and the Wangary fires on South Australia's Eyre Peninsula in 2006 both suggested lack of considering the worst contributed to an underestimation of the threat posed. Claire analysed dozens of interviews with fire fighters at all levels, but particularly experts at agencies in five Australian states, to come to her conclusions.

Although her studies focussed on emergency incident management of fires, her findings could also be relevant to decisions made at the household level during a bushfire. Post-incident interviews by the Bushfire CRC show many people are unable to imagine how a situation can quickly deteriorate into disaster. The research might also inform the management of natural and other hazards, such as air crashes.

"While receiving little previous research attention, worst-case thinking is a critical skill that is challenging to develop and difficult to execute." But the benefits of thinking this way, Claire says, include avoiding the surprise of unexpected events and identifying possible actions to reduce the consequences if the worst cannot be avoided.

PHOTO: THE AFTERMATH OF THE BLACK SATURDAY FIRES NEAR KINGLAKE, VICTORIA. CREDIT: BUSHFIRE CRC

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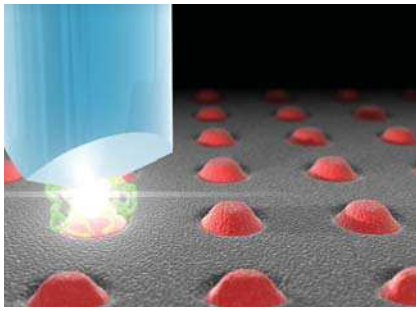

A step towards an everlasting battery

Imagine a future where recharging your tablet could be as easy as typing a tweet—where portable electronic devices power themselves without ever plugging into the grid. Researchers at RMIT University, Melbourne have assessed the capacity of piezoelectric films—thin layers that turn mechanical pressure into electricity—to do this.

The study is the first to evaluate how piezoelectric thin films, a thousandth of a millimetre thick, perform at the molecular level, precisely measuring the level of electrical voltage and current—and therefore, power—that could be generated.

"Piezoelectrics could be incorporated into running shoes to charge mobile phones, for instance, or enable laptops to be powered through typing or even used to convert blood pressure into a power source for pacemakers—essentially creating an everlasting battery," says Dr Madhu Bhaskaran, one of the leaders of the project.

The work combines the potential of piezoelectrics with thin film technology, a cornerstone of microchip manufacturing. "The concept of energy harvesting using piezoelectric nanomaterials has already been demonstrated, but the materials involved can be complex and are poorly suited to mass production. Our study focused on thin film coatings because we believe they hold the only practical possibility of integrating piezoelectrics into existing electronic technology."

The research, which was undertaken with colleagues at RMIT and the Australian National University in Canberra, has been published in the materials science journal, *Advanced Functional Materials*.

PHOTO: ELECTRICITY IS GENERATED AS A FORCE IS APPLIED TO A PIEZOELECTRIC FILM. CREDIT: DANIEL J. WHITE

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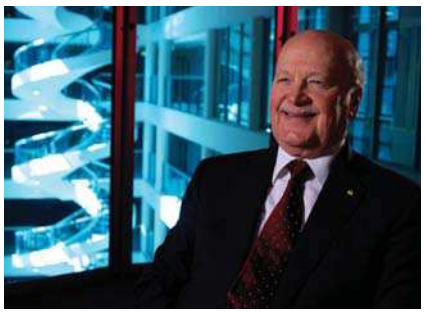
Prime Minister's Prizes

Recognising science leaders since 2000

PHOTO: DR MATTHEW MCCLOSKEY (SCIENCE TEACHING IN PRIMARY SCHOOLS); DR KATE TRINAJSTIC (PHYSICAL SCIENTIST); PROFESSOR JOHN SHINE (PRIME MINISTER'S PRIZE FOR SCIENCE); PRIME MINISTER JULIA GILLARD; SENATOR THE HON KIM CARR, INNOVATION MINISTER; MS DEBRA SMITH, (SCIENCE TEACHING IN SECONDARY SCHOOLS), DR BENJAMIN KILE (LIFE SCIENTIST).

The 2010 Prime Minister's Science Prize winners were recognised for: fathering the biotech industry; seeing fish through rocks; finding the molecular clock in blood cells; and great science teaching.



Back to the future for father of biotechnology

He's back in the lab, working to convert the rich supply of stem cells found in the nose into specialised products to repair nerve damage or replace nerve cells lost in disorders such as hearing loss, Alzheimer's and Parkinson's disease. But that's just the latest phase in the full and distinguished life of the 2010 winner of Australia's Prime Minister's Prize for Science, molecular biologist Prof John Shine.

In 2011, he is stepping down after more than 20 years as executive director of Sydney's Garvan Institute of Medical Research which, under his guidance, has grown to a staff of more than 500, an annual budget of $50 million, and now boasts significant achievements in cancer, immunology, diabetes and obesity, osteoporosis and neuroscience.

John first came to prominence for having discovered, and given his name to, the Shine-Dalgarno RNA sequence which serves to signal the cellular protein factories—the ribosomes—where they should attach to start making proteins.

Along the way he contributed to cloning the first human genes and helped found the pioneering company California Biotechnology. "This was really the birth of modern biotechnology—using bacteria as protein factories—and we were creating the tool-kit that the industry needed."

Back in Australia since 1990, John has acted as a mentor for biotechnology, serving on the boards of dozens of organisations. As chairman of the National Health and Medical Research Council from 2003 to 2006 he spearheaded its transformation into a statutory body that is more effective in the way it awards research grants.

PHOTO: JOHN SHINE, WINNER OF THE 2010 PRIME MINISTER'S PRIZE FOR SCIENCE. CREDIT: BEARCAGE PRODUCTIONS

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Seeing fish through rocks

Dr Kate Trinajstic has used synchrotron light and CT scanning to see through rock, in the process discovering how ancient fish developed teeth, jaws and even a womb. Her work is increasing our understanding of how life on Earth evolved.

About 380 million years ago in what is now the Kimberley Ranges in Western Australia, a vast barrier reef formed. In what would have been the inter-reef basins, large numbers of fish were buried relatively intact. Protective limestone balls formed around them and preserved them. When these balls are treated with acetic acid, the main component of vinegar, the surrounding rock dissolves, leaving only fossilised fish bones.

But in the course of studying hundreds of these dissolving balls, Kate began to see what looked like muscle fibres between the bones. She was eventually able to convince her colleagues that irreplaceable soft tissue detail was being lost in the acid treatments.

To study the fossil fish without destroying this information, Kate turned to x-rays and the latest imaging technology using synchrotron light. Working with museum and university colleagues, perhaps her biggest discovery has been the 'mother fish' with an umbilical cord still attached to its embryonic offspring. This was a vertebrate giving birth to live young some two hundred million years earlier than previously thought.

In 2010, Kate's work led to her being honoured as Australia's Malcolm McIntosh Physical Scientist of the Year. She is now looking for biomolecules—remnants of muscle and bone proteins—and also developing tools for the oil company Chevron to help it date core samples rapidly and accurately.

PHOTO: ONE OF THE GOGO FISH FOSSILS STUDIED BY DR KATE TRINAJSTIC. CREDIT: RON D'RAINE

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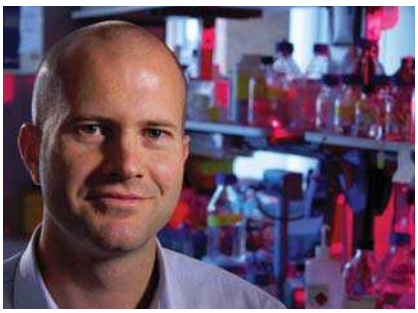

The life and death of blood cells

Dr Benjamin Kile of the Walter and Eliza Hall Institute for Medical Research in Melbourne has found why the blood cells responsible for clotting—platelets—have a short shelf life at the blood bank. There's a molecular clock ticking away inside them that triggers their death. He's also discovered a gene critical for the production of blood stem cells in our bone marrow that happens to be responsible for a range of cancers.

These major discoveries earned Ben the 2010 Science Minister's Prize for Life Scientist of the Year. Now he is trying to use them to extend the life of blood bank products, and get to the heart of some of the big questions in cancer.

"Platelets don't simply wear out," Ben says. "They have a molecular clock counting down their life. And we've shown that, in mice, we can slow it down or speed it up." The researchers might be able to do the same with human platelets, and extend their shelf life. But first they need to know why platelet survival is so tightly regulated.

Ben's second important discovery came while he was investigating how platelets are made. He and his colleagues found a gene that regulates the development of blood stem cells. Without it, there is no blood. But surprisingly this gene, ERG, was already well known and had been implicated in many different cancers. "No one knew what its day job was," Ben says. "It links our studies of blood stem cells and our studies of cancer."

PHOTO: BENJAMIN KILE, WINNER OF THE 2010 SCIENCE MINISTER'S PRIZE FOR LIFE SCIENTIST OF THE YEAR. CREDIT: BEARCAGE PRODUCTIONS

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Saving our skins

Physicist Dr Amanda Barnard has been using supercomputers to find the balance between protection and potential toxicity in a new generation of sunscreens which employ nanoparticles.

The metal oxide nanoparticles which block solar radiation are so small they cannot be seen, so the sunscreen appears transparent. But if the particles are too small, they can produce toxic levels of free radicals.

Amanda, who heads CSIRO's Virtual Nanoscience Laboratory, has been able to come up with a trade-off—the optimum size of particle to provide maximum UV protection for minimal toxicity while maintaining transparency—by modelling the relevant interactions on a supercomputer.

This work, which was published in *Nature Nanotechnology*, won her the 2010 University of New South Wales Eureka Prize for Scientific Research. It's one of string of awards Amanda has accumulated in the past few years, most notably the 2009 Malcolm McIntosh Prize for Physical Scientist of the Year.

The awards highlight her fundamental research in using computers to develop nanomorphology—the science of structures and shapes of materials at the nano- or molecular scale and how this affects interactions with the surrounding environment.

In addition to investigating the health and safety implications of the growing use of nanoparticles in everyday products such as sunscreens, Amanda has also worked on a means of delivering drugs using electrically charged nanodiamonds. Animal trials have shown that this can decrease the amount of chemotherapy drug needed by about 20 times—reducing side-effects significantly. Amanda is also exploring the properties of fluorescent biolabels for use in cancer diagnosis and gene therapy, and of metal nanoparticles as fuel catalysts.

PHOTO: AMANDA BARNARD WITH ONE OF HER NANOPARTICLE SIMULATIONS. CREDIT: L'ORÉAL/SDP PHOTO

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Virtual management of the world's oceans

New computer models are challenging the conventional wisdom in marine science.

These models have revealed for example that: large populations of jellyfish and squid indicate a marine ecosystem in trouble; not all fish populations increase when fishing is reduced—some species actually decline; and, sharks and tuna can use jellyfish as junk food to see them through lean periods.

The models were developed by the 2007 Science Minister's Life Scientist of the Year, Dr Beth Fulton, a senior research scientist at CSIRO Marine and Atmospheric Research in Hobart.

Beth's models are now used in Australian fisheries management, and by governments around the world, to predict and manage human interaction with the marine environment. In particular, Beth works regularly with researchers from the US National Oceanic and Atmospheric Administration and universities. Together they have developed management models for marine life along much of the west and east coasts of continental US and now are studying the Gulf of Mexico and Hawaii.

Beth's original model, based on her PhD work, is called Atlantis. The UN Food and Agriculture Organisation has rated Atlantis as the best model in the world for the strategic evaluation of marine management issues and it was one of the first marine ecosystem models to give equal attention to the biophysical and human components of the marine system.

It's complemented by another program, InVitro, which is used for the evaluation of marine plans as part of sustainable coastal development. This model allows simultaneous consideration of multiple uses of the marine environment—including oil and gas exploitation, transport, tourism, and commercial and recreational fishing.

PHOTO: BETH FULTON'S MODELS ARE PROTECTING FISH STOCKS. CREDIT: ISLAND EFFECTS

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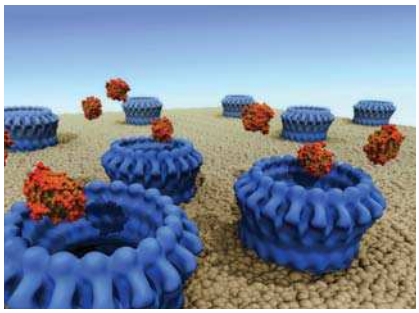

How a molecular assassin operates

The secrets of a molecular assassin could lead to more effective treatments for cancer and viral diseases, better therapy for autoimmune conditions, and a deeper understanding of the body's defences enabling the development of more tightly focused immunosuppressive drugs. These are just some of the wide-ranging possibilities arising from research which has revealed the structure and function of the protein perforin, a front-line weapon in the body's fight against rogue cells.

A pivotal role was played by 2006 Science Minister's Life Scientist of the Year, molecular biologist Prof James Whisstock and his research team at Monash University. It was research fellow Dr Ruby Law who finally worked out how to grow crystals of perforin. And the team was then able to collaborate with Dr Tom Caradoc-Davies of the micro-crystallography beamline at the nearby Australian Synchrotron to reveal its complete molecular structure.

When they put their information together with that of colleagues at the Peter MacCallum Cancer Centre in Melbourne, and Birkbeck College in London, they found they could puzzle out the way the molecule functions to punch holes in the outer membranes of cells invaded by viruses. The immune system then uses these pores as access points for packages of toxic enzymes which kill off the infected cells. The process prevents the replication and spread of virus particles within the body.

"This is a weapon of cleansing and death," James says. "It's the body's key tool for killing off rogue cells, and an essential part of the immune system." The work, published in *Nature* late last year, is also a dramatic illustration of the importance of the Australian Synchrotron, he said.

PHOTO: IN THIS SIMULATION, THE PERFORIN MOLECULE (BLUE) PUNCHES A HOLE THROUGH THE CELL MEMBRANE (BEIGE) PROVIDING ACCESS FOR TOXIC ENZYMES (RED). CREDIT: MIKE KUIPER

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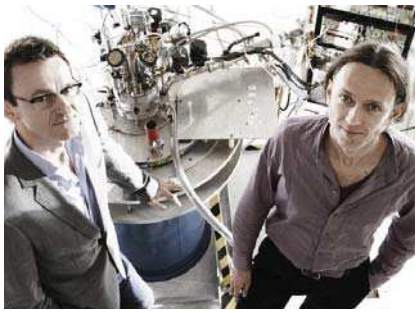
science stories



Computing with a single electron

Australian engineers and physicists have developed a 'single electron reader', one of the key building blocks needed to make a quantum computer.

Quantum computers will use the spin, or magnetic orientation, of individual electrons for their calculations. And, because of the quantum nature of electrons, quantum computers could be exponentially faster at certain tasks than traditional computers.

In order to employ electron spin, a quantum computer needs both a way of changing the spin state (writing information) and of measuring that change (reading information). Together these two form a quantum bit or qubit—the equivalent of the bit in a conventional computer.

The Australian invention is a reader. The team is also working on a writer. Then they will combine pairs of these devices to create a 2-bit logic gate—the basic processing unit of a quantum computer.

The new device was made at UNSW with components from The University of Melbourne, and with assistance from researchers at Aalto University in Finland. By using silicon—the foundation material of conventional computers—rather than light, or esoteric materials, the device opens the way to constructing a simpler quantum computer, scalable and amenable to mass-production.

"Quantum computers won't speed up all day-to-day computing," says project leader Andrew Dzurak from UNSW. "But there are three areas where we know they will be much faster: cracking most modern forms of encryption; searching databases; and modelling atomic systems such as biological molecules and drugs."

PHOTO: ANDREW DZURAK (LEFT), ANDREA MORELLO AND THEIR COLLEAGUES HAVE READ THE SPIN OF A SINGLE ELECTRON.

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Take control of your hearing

Australian researchers have invented a small, smart, self-managed hearing aid that outperforms most conventional hearing aids for less than half the price.

It uses technology first developed for Australia's bionic ear, and is so simple to set up that most users can buy one over the internet and fit it themselves. That brings the cost down to between $1,000 and $1,500, or less than $3000 for a pair.

The user can then easily fine-tune it and even switch the settings to suit the home, work, or the pub.

The new technology was launched in Melbourne in April 2011 by the inventor of one of its core technologies, Dr Peter Blamey, founder of Australia Hears and Deputy Director of the Bionic Ear Institute.

The new hearing aids are the culmination of nearly 12 years of research and development supported at key stages by the Australian government. They use digital technology that allows the user to boost or reduce key frequencies so that all the important sound frequencies for hearing are at a comfortable level.

"This is the hearing aid for the iTunes generation. It's small, smart and it works," says Australian Hears co-founder and audiologist Elaine Saunders.

"We have a generation of middle-aged Australians whose quality of life has already been affected by hearing loss due to loud music or occupational noise," she says. "You may not think you need a hearing aid, but ask your partner or friends."

PHOTOS: SARAH BELLHOUSE MODELLING AN AUSTRALIA HEARS HEARING AID. PHOTO: MARK COULSON

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Could we grow drugs using sunflowers?

Queensland researchers believe future cancer drugs could be grown in sunflowers and ultimately delivered as a seed 'pill'.

They're a long way from that outcome. But, as they reported to the XVIII International Botanical Congress in Melbourne earlier this year, they have already shown that sunflowers make a precursor to cancer drugs as part of their defence against insect attack.

The precursor, a small ring-like protein fragment known as SFTI, has already shown potential as a cancer treatment. Until now, however, it has been considered too expensive to produce by conventional means.

This could all change, using plants as factories, says Dr Joshua Mylne of the Institute for Molecular Bioscience at the University of Queensland.

"Although SFTI and related proteins have shown great promise as drug templates, the cost to manufacture them has been a significant barrier to their widespread use," Dr Mylne said.

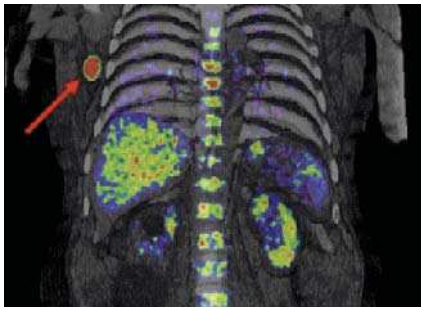
"This issue could be solved using sunflowers. Seeds are an attractive system for the production of pharmaceuticals, as they are cheap to grow, and their contents remain stable at room temperature and are sterile inside the seed coat.

"There are also established systems in place for seed production, harvest, storage and transportation, meaning they could be the ultimate,low-cost, drug delivery system."

PHOTO: DRUGS COULD BE GROWN IN SUNFLOWERS. CREDIT: CDANNA2003

For more information about this and other stories from the XVIII International Botanical Congress:
www.scienceinpublic.com.au/botany2011

science stories



Unmasking melanoma early

There's a new diagnostic tool being developed to target melanoma, the deadly form of skin cancer with which more than 10,000 Australians are diagnosed each year. It's a chemical compound designed to highlight small traces of these cancer cells in the body.

Melanoma occurs when the cells that make melanin, the dark pigment normally found in the skin, become cancerous. Melanoma cells often spread elsewhere in the body before the primary tumours are detected and removed surgically. Clusters of these melanoma cells can be hard to detect before they grow into tumours by which time they are often incurable.

The Cooperative Research Centre for Biomedical Imaging Development (CRCBID) has developed a radiopharmaceutical called MEL050, which has shown promise at highlighting all cells that contain melanin. As melanomas usually contain melanin, a PET/CT scan using MEL050 as a tracer can reveal a three dimensional image of small clusters of tumour cells that may be invisible to conventional imaging scans.

CRCBID CEO Dr Gerry Roe says the first human trials of the tracer are almost complete. "We've even been able to show a normal melanin-containing structure in the back of the eye, even though it is just a few cells thick. We hope to demonstrate that we can find small clusters of melanin-containing cells, or metastases, because early detection has important implications for subsequent treatment selection."

Dr Roe says the development of these tracers might provide important information to assist with the development and application of new, improved therapies for lethal cases of melanoma.

PHOTO: THE RED ARROW SHOWS A MELANOMA TUMOUR. CREDIT: PETER MACCALLUM CANCER CENTRE

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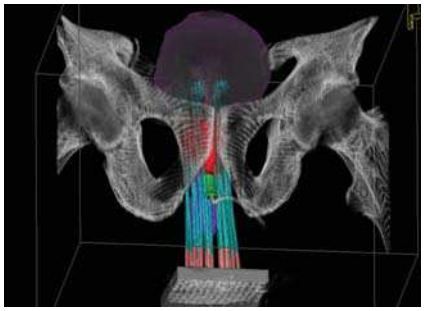

Curing cancer with radiation—safely

Prostate and other soft-tissue cancers are often treated with radioactive sources implanted or inserted into the body. But monitoring the dose is problematic.

Medical physicists at Melbourne's RMIT University are developing a technique to monitor the radiation dose more accurately.

In high dose rate brachytherapy, tumours are targeted by radioactive sources temporarily inserted into the body. "Until now, it has not been possible to check at the time of delivery whether the doses received by the tumour and by surrounding healthy tissue matched the planned levels," says Dr Rick Franich, Medical Radiation Physics group leader at the University's Health Innovations Research Institute.

Rick and researcher Ryan Smith believe their new system will be able to solve this problem, not only enabling closer control of the progress of therapy, but also recording information on patient dosage and outcomes that can be used to conduct much more finely tuned clinical research.

The researchers so far have determined that their approach can achieve what they want, and are now developing the necessary algorithms and safety protocols to control it. They hope their technology will be ready for use in the clinic in late 2011.

The new method relies on placing a silicon flat panel detector behind the patient which acts like a giant digital camera. The images are formed as it detects gamma rays emitted by the radioactive source coming out through the patient's body. The trajectories of the rays can be analysed in real-time, so the movement of the source can be tracked.

The system will also use the information to calculate the radiation dose received at the panel surface, and the three-dimensional dose distribution in the patient. If a discrepancy with planned therapy is detected, treatment can be interrupted.

PHOTO: COMPUTER SIMULATION OF BRACHYTHERAPY PROSTATE TREATMENT SHOWING RADIOACTIVE SOURCE TRAJECTORIES THROUGH THE PELVIC REGION. CREDIT: RICK FRANICH

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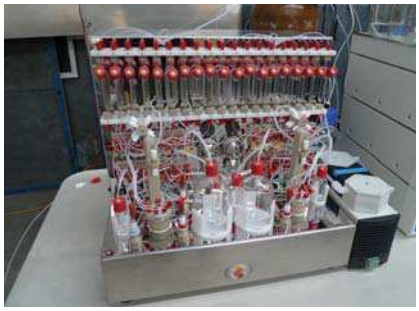

Two steps forward for cancer detection

An Australian invention is making it cheaper, quicker and safer to manufacture the radioactive tracers used in latest medical imaging techniques to track down increasingly smaller clusters of cancer cells.

Like preparing a cake in a mixing bowl, the chemical reactions to make the tracers involve putting the ingredients together in the right proportions. The next generation of tracers can have a more complex recipe—and so can be more difficult to produce using just one 'mixing bowl' at a time.

So, researchers at the Cooperative Research Centre for Biomedical Imaging Development (CRCBID) developed FlexLab, an apparatus that takes two reactions previously conducted separately and joins them in a dual-step reactor.

CRCBID CEO Gerry Roe says once the need was identified for the new apparatus, it quickly grew into the prototype, which has been used by the Australian Nuclear Science and Technology Organisation (ANSTO) since early in 2011. Now, FlexLab is available as a commercial product marketed by Cyclotek Australia Pty Ltd and manufactured by iPHASE Technologies in Melbourne.

Tracers are often made on-site, Gerry says, so there is a potential market for FlexLab in hospitals and radio-medicine facilities around the globe. FlexLab can be used to make a wide range of radioactive tracers being developed for Positron Emission Tomography (PET) imaging. As they move through the body, the tracers release gamma rays that, when detected, produce vivid, detailed three-dimensional images that can be used to locate many different cancers.

PHOTO: THE TWO-STEP DUAL REACTOR, FLEXLAB. CREDIT: IPHASE TECHNOLOGIES

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Helping eyes to help themselves

Donor corneas conditioned with DNA before being transplanted into new eyes are already actively contributing to their own success in experimental animals such as sheep. The DNA is inserted into the cells of the cornea after it has been harvested. Then, following implantation, it produces proteins that help overcome immunological rejection.

This is one of many strands of research aimed at increasing the success rates of corneal transplants and other eye disease treatments undertaken by Prof Keryn Williams at Flinders University.

If such gene therapy can be developed for human corneal transplants, it will not only increase success rates, but also free recipients of the need to take drugs all their lives to suppress rejection. "I hope this will become a 'one-stop-shop' against rejection," says Keryn, who is testing which combinations of genes are most effective.

Keryn is also creating drugs to act against rejection incorporating fragments of genetically engineered antibodies. But getting drugs into the cornea is difficult—injected drugs often do not reach it. So Keryn is looking at two approaches; delivering her antibody-fragment drugs using eye-drops rather than injection or, in a separate project, developing a porous silicon biomaterial to apply drugs and cells to the eye.

"Australia is a leader in corneal transplant research," says Keryn, "helped by the clinical database of 23,000 cases in the Australian Corneal Graft Registry." About 1200 corneal transplants are done each year, and the overall success rate 10 years after surgery is 62 per cent.

Keryn's pivotal work in eye health recently earned her a major National Health and Medical Research Council Fellowship.

PHOTO: AN AUSTRALIAN RESEARCH GROUP IS MAKING CORNEAL TRANSPLANT EASIER. CREDIT: STEFAN DJAKOVIC

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Life's work closer to saving lives

What began decades ago as the discovery of an antibody from mice that targets human cancer cells is now undergoing human trials in the US as the basis of a treatment for acute leukaemia.

The antibody targets a protein called EphA3, which is found in about half of all acute leukaemias as well as many other human cancers including a significant proportion of malignant melanomas, brain tumours and lung cancers. The antibody, called KB004, has been shown to kill certain types of cancerous tumours grown from human samples.

"The KB004 project has a special place in my heart as it originated in my own lab nearly 25 years ago," says Prof Andrew Boyd, Professor of Experimental Haematology at the University of Queensland and head of the Queensland Institute of Medical Research's Leukaemia Foundation Laboratory.

The most common tumours in children are caused by one type of acute leukaemia, the result being an overproduction of immature white blood cells.

"Although the project now involves two other research groups in Australia and an American company, there is a sense of nearing the goal I set out to achieve when I first started my research career."

KaloBios Pharmaceuticals, a US-based biotech company took the original antibody Andrew's group discovered in mice and adapted it into a form that would allow it to be accepted by the human body as part of the immune system rather than an intruder.

Phase 1 clinical trials of antibody KB004 have now commenced, Andrew says.

"I'm a medical researcher, but I also still treat patients. You always hope to see your work end up as a treatment."

PHOTO: PROFESSOR ANDREW BOYD, WHO HAS SEEN HIS ANTIBODY DISCOVERY INCORPORATED INTO A POTENTIAL CANCER TREATMENT. CREDIT: QIMR

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Milk could soothe the savage gum

Melbourne dental health researchers have discovered a painless, low-cost treatment which may prevent gum disease. And the key ingredients—protein fragments known as peptides—come from cows' milk.

The link between the peptides and gum disease was forged at the Melbourne Dental School node of the Oral Health Cooperative Research Centre by Dr Elena Toh. "This could provide a cheap and simple way to help prevent gum disease," she says. "And because the peptides are derived from milk, there should be no toxicity issues." The discovery builds on previous work at the Dental School that led to the product Recaldent—also extracted from cows' milk —which reverses tooth decay.

Up to 30 per cent of Australians experience serious gum disease—nasty bacterial infections that can cause bleeding, swollen gums and bad breath. But gum disease can lead to much worse outcomes. It is a major cause of tooth loss and has been linked to increased risk of other health problems including heart disease, diabetes and certain types of cancer.

"The current treatment involves painful and expensive surgery, so it is better to prevent the onset of the disease if we can," Elena says.

"The bacteria that cause gum disease have many enzymes on their surface that play a role in causing the bleeding and swelling of the gum tissue," she says. "We discovered several peptides in cows' milk that reduce the activity of these enzymes, and we have shown they have the potential to protect animals from gum disease."

The peptides could be added to a toothpaste or gel that could be applied to your gums to help prevent gum disease, Elena says.

PHOTO: A PEPTIDE FOUND IN MILK MAY HELP PREVENT GUM DISEASE AND PROTECT TEETH. CREDIT: DMITRIY SHIRONOSOV

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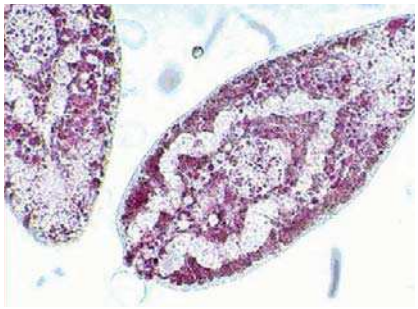
The right forecast

CREDIT: JOHN CARNEMOLLA

Farmers are helping climate scientists produce more useful weather and climate predictions.



Stopping parasites means more and safer meat

The world's meat production could be lifted by 10 to 15 per cent if a vaccine can be found to combat the liver fluke. This is the aim of a collaborative bioscience group at the new $288 million Centre for AgriBioscience (AgriBio).

An effective vaccine against liver fluke would not only boost meat production but would also lead to a large reduction in the amount of drugs given to livestock, says Prof Terry Spithill, who is co-director of AgriBio and based at La Trobe University.

The liver fluke, a flat worm which infects cattle and sheep, is estimated to cost the Australian meat industry $60-90 million a year. Now, flukes in New South Wales have shown resistance to the drugs used to control them, so developing a vaccine that targets very specifically to the worm and has a much smaller chance of resistance is attractive.

"We've found half-dozen genetic sequences that are unique to the [liver fluke] worm. This makes them excellent vaccine targets because the vaccine will not interfere with anything in the host animals."

Parasites are just one of the many research areas at AgriBio. The Centre will bring together scientists from the Victorian Department of Primary Industry and researchers from La Trobe, with a strong focus on plant and animal science. Combined, the researchers cover a diverse range of disciplines including plant biotechnology, animal genetics, soil science and plant and animal disease. "The Centre will lead to better science and more rapid progress," Terry says. "A colleague who used to be on a different campus is now in the next office or down at the café—we will interact more."

With geneticists, plant biologists and bioinformatics researchers all sharing the same space, Terry says, there's more chance for someone to say, "Why don't you look at things this way?"

PHOTO: JUVENILE LIVER FLUKE PARASITES WHICH CAUSE SERIOUS DISEASE IN LIVESTOCK AND HUMANS. CREDIT: D PIEDRAFITA (MONASH); T SPITHILL (LA TROBE).

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Giving farmers more timely weather and climate forecasts

Seven days. Three months. We can now get accurate rainfall and temperature forecasts for these periods, but what if a farmer had access to quality outlooks that sat between the two—multi-week forecasts?

Multi-week forecasts would allow farmers to make better harvesting and sowing decisions before or after drought or flood events.

Australia's Managing Climate Variability research and development program is working with the Bureau of Meteorology and CSIRO scientists to fill this gap. Progress made in the past two years has been so significant that scientists here and abroad have dubbed the models so far developed as 'future prediction tools'.

The researchers are working to improve the physics of Australia's dynamic modelling system known as the Predictive Ocean Atmosphere Model for Australia (POAMA), to make accurate multi-week forecasts a reality. For farmers and other decision-makers world-wide, this will mean more timely access to climate information.

Forecasting for periods between days and months is difficult because they sit between weather and climate. Seven-day forecasts are built from good local weather observations, while three-month seasonal outlooks are driven by larger scale climate elements such as the temperatures of the Pacific and Indian Oceans.

POAMA's most significant achievement to date has been improved forecasting of El Niño and La Niña events, says Dr Andrew Watkins from the Bureau. "The POAMA model started tipping a strong La Niña as early as autumn, which traditionally is the hardest period for models to forecast. It also correctly forecast the 2009-10 El Niño well before it arrived in the tropical Pacific."

This helped farmers to make better decisions during the recent droughts in the west and floods in the east of Australia.

PHOTO: DR ANDREW WATKINS FORECASTS FOR FARMERS. CREDIT: BUREAU OF METEOROLOGY

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Australian farmers bring climate research to the paddock

Leading grain farmers are guiding climate researchers as part of Australia's Climate Champion initiative.

They hope the results will help farmers to adapt to Australia's increasingly challenging and variable climate.

Scientists supported by the Managing Climate Variability program asked the farmers about what they needed to know about climate in their areas—what forecasts and predictions would be most helpful and how they should be presented.

They have also worked with the farmers to:

- prioritise five region-specific climate products for farmers based on 100 years of Bureau of Meteorology regional weather data (Dr Anthony Kiem);
- find out how farmers like to access climate tools so they can be repackaged into easy-to-use internet- and smartphone-based applications (Dr David Freebairn); and
- find out what types of rainfall, frost, spring heat, and temperature forecasting are most useful to farmers.

And the farmers have also been working with researchers on how to improve the resilience of grain growing in low rainfall areas.

"Working with scientists has given me a better understanding of how to make comparisons of different farming techniques in the field," says Climate Champion farmer Simon Wallwork from Western Australia. "We try to take the science and convert it into practical farming applications."

"It's really important that farmers provide feedback to scientists about the big ticket items that will make a difference. That's why the initiative has been so good; our access to the science and the ability to provide feedback—it's a perfect situation," he says.

PHOTO: FARMER SIMON WALLWORK IS TURNING CLIMATE SCIENCE INTO PRACTICAL APPLICATIONS CREDIT: GRDC

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also available

2011

Stories of Australian Astronomy

In 1768 the British Admiralty sent Lieutenant James Cook to the Pacific to monitor the transit of the planet Venus across the Sun. On his way home to England, Cook mapped Australia's east coast, and claimed New South Wales.

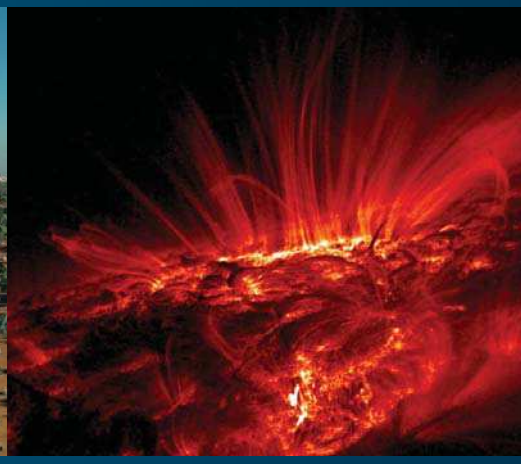
For about 40,000 years before that, the indigenous peoples of Australia had been developing remarkably sophisticated explanations of the workings of the Southern Sky.

And just 200 years afterwards, an independent Australia was at the forefront of radio astronomy and receiving the first signals from the Moon.

Today Australian astronomers continue to unravel the mysteries of the southern sky.

Read about their achievements in Stories of Australian Astronomy. It's Science in Public's latest collection of stories of Australian science and is available in print and online.

Read about: invading alien stars > searching for extra-solar planets > detecting gravitational waves > quaking stars and what they can tell us > looking at the skies through Aboriginal eyes > understanding our home—the Milky Way > a 268-megapixel camera > unmasking the Universe's dark secret > stimulating the Arts > Australia's role in creating a giant radio telescope—the Square Kilometre Array—that will look out to the beginning of time > and much more.



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IMAGES (LEFT TO RIGHT) PHOTO: AUSTRALIAN ASTRONOMERS ARE HUNTING FOR EXOPLANETS (ARTIST'S IMPRESSION OF AN EXOPLANET WITH MOONS, ORBITING THE STAR HD70642). CREDIT: DAVID A. HARDY, ASTROART.ORG (C) PPAR; THE SQUARE KILOMETRE ARRAY WILL BE BUILT IN EITHER SOUTH AFRICA OR AUSTRALIA AND WILL LOOK BACK ALMOST TO THE DAWN OF TIME. CREDIT: SWINBURNE ASTRONOMY PRODUCTIONS/ SKA PROGRAM DEVELOPMENT OFFICE; SYDNEY ASTRONOMERS HAVE CREATED AN EARLY WARNING SYSTEM FROM SOLAR FLARE ATTACK. CREDIT: NASA/TRACE; BACKGROUND IMAGE: THE ABORIGINAL "EMU-IN-THE-SKY" CONSTELLATION. CREDIT: BARNABY NORRIS

science stories

Plastic not fantastic for seabirds

Seabirds on one of Australia's remotest islands have plastic in their stomachs. A recent survey found more than 95 per cent of the migratory flesh-footed shearwaters nesting on Lord Howe Island, between Australia and the northern tip of New Zealand, had swallowed plastic garbage.

As if that wasn't bad enough, plastic has been shown to bind poisonous pollutants. As a result, some shearwaters were found with concentrations of mercury more than 7,000 times the level considered toxic. Only six of more than 200 nests visited contained chicks. The overall population is plummeting.

That's why Dr Jennifer Lavers, a research fellow of the Institute for Marine and Antarctic Studies at the University of Tasmania, is investigating ways of removing the plastic from the stomachs of the shearwaters, and trying to determine whether this would help stop the decline of the seabirds, which she has been surveying on Lord Howe since 2007.

The oceans of the world are fed by more than 3.2 million plastic items a day, she says. What's more, that figure is increasing. Wind and wave patterns lead to the development of ocean-sized whirlpools or gyres which redistribute the plastic all over the globe, so one country's rubbish washes up in another's backyard—including our own.

"When I and local naturalist Ian Hutton examined the stomachs of the shearwaters on their arrival in Lord Howe in September, they were clean—not a single piece of plastic," Jennifer says. "A few months later, after foraging in the Tasman Sea, we are finding them full of plastic."

PHOTO: A FLESH-FOOTED SHEARWATER SURVEYS THE CONTENTS OF ITS STOMACH. CREDIT: IAN HUTTON

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Saving koalas by vaccination

The first Australian trials have started of a vaccine to prevent koalas from contracting and spreading the deadly sexually transmitted disease, chlamydia.

The trials—supervised by Prof Peter Timms and Prof Ken Beagley from Queensland University of Technology (QUT)'s Institute of Health and Biomedical Innovation—have been undertaken safely both in healthy koalas and koalas that already have chlamydial disease. All vaccinated koalas developed a good immune response to the anti-chlamydia vaccine, which shows great promise of making a significant impact on the disease in the near future.

Chlamydia is a major threat to the continued survival of koalas. Almost all populations in Australia are affected by the disease. It is a significant cause of infertility, urinary tract infections, and inflammation in the lining of the eye which often leads to blindness.

Koala numbers are declining across virtually its whole range. In the Koala Coast region of southeast Queensland in 2008 it was estimated that 2332 koalas had been lost in a three-year monitoring period. That represented a 51 per cent decrease.

By studying chlamydial disease in koalas, QUT researchers hope to understand the condition better in general. They believe their work may also hold the key to developing a successful vaccine for use against the human sexually transmitted disease Chlamydia trachomatis, a major cause of infertility in women.

PHOTO: PROFESSOR PETER TIMMS IS TRIALLING A CHLAMYDIA VACCINE FOR KOALAS. CREDIT: QUT

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Rapid identity check for border security pests

When Australian biosecurity officers find a suspicious insect or other invasive pest, they can now quickly identify it, drawing upon experts around the world using microscopes linked via the internet.

The Remote Microscope Network (RMN), developed by the Cooperative Research Centre for National Plant Biosecurity (CRCNPB), allows the officers to examine an insect or specimen closely in real time, manipulating it under the microscope while discussing its identification with national and international experts.

The system is coupled to a comprehensive diagnostic information database, allowing comparison with images and information about the suspect.

Until now identification in the field of invasive insects and other pests has been a slow and cumbersome process. It often involved sending a sample to a capital city and waiting several weeks for results.

The RMN is used in conjunction with a Pest and Disease Image Library and a Plant Biosecurity Toolbox, which includes high quality images as well as information about pest distribution. Together they enable field officers to identify pests quickly and accurately, and respond to any threats. This could save millions of dollars in eradication costs and lost market access for Australian producers.

"We've added a new, innovative tool to our system which is very cost effective and efficient, and decreases the response time when dealing with potentially harmful pests and diseases," says Dr Simon McKirdy, CEO of the CRCNPB. "Now relevant diagnostic information is available to field officers around Australia and to our near neighbours."

PHOTO: THE REMOTE MICROSCOPE NETWORK WILL ALLOW EXPERTS TO 'LOOK OVER THE SHOULDER' OF BIOSECURITY OFFICERS AND HELP THEM IDENTITY PESTS. CREDIT: CRCNPB

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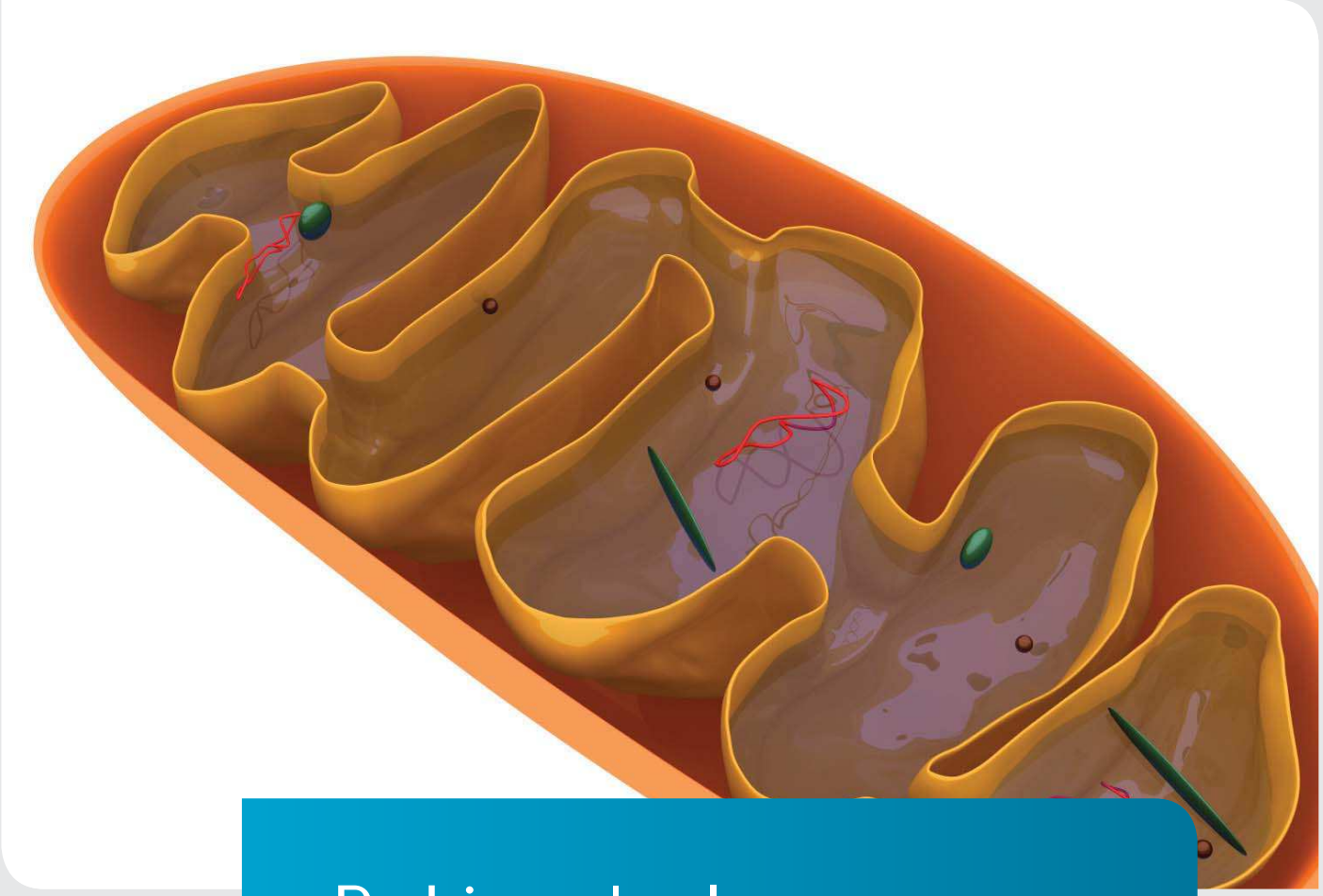
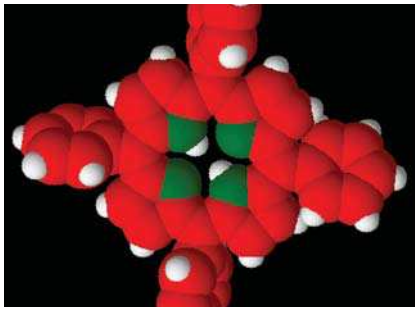


Parkinson's clues

CREDIT: DAVID MARCHAL

Mitochondria, the power plants in our cells, could hold clues to warding off Parkinson's disease.



Diamonds for extreme electronics

Keeping electronics cool in high power applications, such as telecommunications, and building electronics on the nanoscale are two areas where there is an alternative to traditional silicon—diamond.

To study the potential of diamond-based electronics, Dr Chris Pakes and his team at the Atom-scale Research Laboratory at La Trobe University have been inducing electrical conductivity—allowing an electrical current to flow—on the surface of synthetic diamonds.

The researchers do this by seeding the diamond surface with molecules called fullerenes. The group has recently shown that by introducing porphyrin, a molecule that interacts with fullerene, the level of conductivity in the diamond can be controlled.

In contrast to silicon-based circuits, diamond can withstand temperatures of a few hundred degrees without cooling and is much more durable.

"The electrical conductivity is confined to a very thin sheet just below the surface, so the diamond can be used to build nanoscale devices for miniature chemical and biological sensors and devices for microwave electronics, like those in mobile phones," Chris says. "The interaction between different molecules on the surface can now be used to control the properties of these devices."

The next step for the group, which works closely with the Australian Synchrotron in Melbourne, is to find a way to control the conductivity of the diamond remotely—being able to switch currents on and off using a magnetic or light signal.

One of the key collaborators in the project is Prof Lothar Ley, a leading figure in the field in diamond science, who has recently taken up a distinguished professorship at La Trobe University.

PHOTO: INTRODUCING THE PORPHYRIN MOLECULE ONTO THE SURFACE OF THE DIAMOND CAN CONTROL THE LEVEL OF CONDUCTIVITY. CREDIT: ATOM-SCALE RESEARCH LABORATORY

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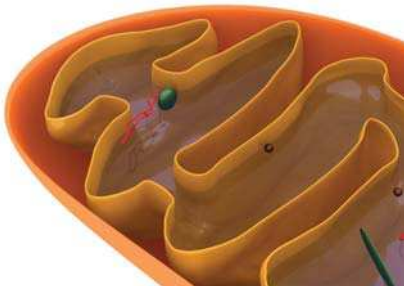

Body's power plants offer clues to Parkinson's disease

How do the power plants of the cell—the mitochondria—use their defence mechanisms to fight diseases such as Parkinson's disease? This debilitating disorder is caused by an accumulation of proteins that have folded incorrectly. The misfolded proteins then clump together and form sticky, cell-damaging deposits called plaques.

"We know that mitochondria are at the centre of the aging process," says Prof Nick Hoogenraad, executive director of the La Trobe Institute for Molecular Science (LIMS). Nick and his team have found a mechanism mitochondria use to remove the plaques that are prone to form as we age.

While cells possess mechanisms to prevent misfolded proteins, the mitochondria—which are composed of membranes and genetic material similar to a miniature cell—have their own defences to remove unfolded proteins, including enzymes called proteases and chaperones, which break down proteins.

"Mitochondria import most of the compounds used to protect them from misfolded proteins from elsewhere in the cell," Nick says. "So far, we've worked out the signalling pathway that tells the cell nucleus to produce the right protective proteins, but we don't know how the mitochondria senses misfolding or how it starts the signalling process."

Nick, a global authority on mitochondria, has the goal of finding a way to stimulate the cell to make higher levels of these protective proteins. "We're trying to find a drug that increases the level of proteases. This would mean greater protection against the misfolded proteins that cause Parkinson's disease."

Nick and his colleagues will continue their work in the $94.1 million La Trobe Institute for Molecular Science (LIMS) when it opens in 2013.

PHOTO: THE BODY'S POWER PLANT—MITOCHONDRIA. CREDIT: DAVID MARCHAL

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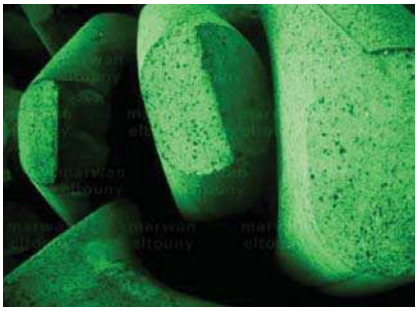

Cementing a greener future

Making cement is the third largest source of carbon emissions in the world after the burning of fossil fuels and deforestation—but the Australian roads of the future could be paved with cement that is made in a process that generates less than half the carbon emissions of traditional methods.

Each year, the world produces about 12 billion tonnes of concrete and about 1.6 billion tonnes of its key ingredient, Portland cement, which is generated by breaking calcium carbonate into carbon dioxide and calcium oxide.

This produces some 2 billion tons of carbon dioxide—so the Geopolymer and Mineral Processing Group (GMPG) at the University of Melbourne, now led by Dr John Provis, went looking for a lower carbon way of making cement.

They have now developed binders and concretes based on a low-CO_2 aluminosilicate compounds called geopolymers.

The former head of GMPG, Prof Jannie van Deventer, founded Zeobond Pty Ltd to turn these geopolymers into a product called E-Crete™.

Consisting of fly ash, a coal-fired power station by-product, and slag from steel manufacturing, E-Crete™ reduces the embedded carbon dioxide of concrete by at least 60 per cent compared to ordinary Portland cement (OPC)-based concrete.

The researchers used the Australian Synchrotron to look at the shapes of the materials that make up the cement at the nanometre scale and see how those shapes affect how they pack together. This allows them to experiment with different proportions of materials to see which will be the most stable and long-lasting.

Now, in collaboration with the state of Victoria's road authority, VicRoads, Zeobond has been able to demonstrate that E-Crete™ is every part the equal to OPC-based concrete. E-Crete™ is now used in VicRoads concrete applications including pavement and pre-cast. And VicRoads has changed its building standards to allow green cement paving. John is now hoping to have the international standards changed.

PHOTO: GREEN CEMENT IS NOW BECOMING PART OF VICTORIA'S ROADS. CREDIT: AUSTRALIAN SYNCHROTRON

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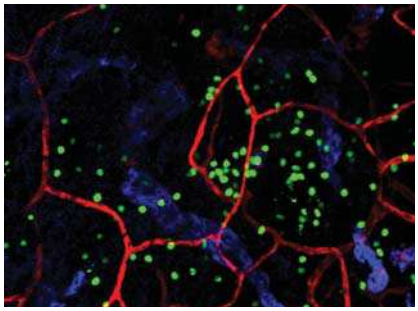
science stories



Skin deep discovery reveals immune mysteries

Cells involved in the first line of our immune defence have been located where they never have been found before—a discovery that could provide insight into diseases like psoriasis and other auto-immune conditions of the skin.

While researchers have known about these cells, called gamma delta T cells, in the epidermis or top layer of skin for more than 20 years, this is the first time their presence has been detected in the next layer of skin down, the dermis.

Wolfgang Weninger, who led the study at Sydney's Centenary Institute, says that gamma delta T cells are of particular interest because they produce a protein thought to be the 'first responder' when intruders are detected by the immune system.

"Interleukin-17 is a cytokine that has been getting a lot of interest because of its role in inflammation," Wolfgang says.

The researchers used mycobacteria—related to the bacteria which cause tuberculosis—to investigate the defence mechanisms of these immune cells in the dermis. When exposed to mycobacteria the gamma delta T cells in the dermis produced Interleukin-17, while their better known counterparts in the epidermis did not contribute to immune defence.

"This supports the notion that related immune cells have specialist and unique functions in each layer of the skin. The likely reason for this is that different microbes tend to infect different skin layers. For example, herpes viruses infect the epidermis while bacteria tend to invade the dermis and deeper layers of the skin," Wolfgang says.

PHOTO: A STAIN SHOWING THE PRESENCE OF GAMMA DELTA T CELLS (GREEN) IN THE DERMIS. THE BLOOD VASCULATURE IS SHOWN IN RED, WHILE BLUE REPRESENTS COLLAGEN. CREDIT: CENTENARY INSTITUTE

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Improved myopia treatment in sight

New glasses that slow the progression of short-sightedness or myopia are now available. The glasses which incorporate a novel lens design could potentially benefit some of the 3.6 million Australians with myopia and hundreds of millions of people worldwide.

Until now, correcting myopia has relied on measuring the clarity of vision at the very centre of the retina. Corrective lenses were designed to provide the wearer with clear central vision but did nothing for peripheral vision. Studies have now shown that short-sightedness progressively worsens in spite of correction using these traditional lenses.

Based on these findings, new spectacle and contact lenses were created that provide a clearer peripheral image while maintaining the clarity of central vision. The work is part of an international project to improve the management of myopia which was coordinated by the Vision Cooperative Research Centre (Vision CRC) with partners in the US, UK, China and India.

Clinical trials in China showed that the new lenses slow the progression of myopia in young children whose parents are also myopic, says A/Prof Padmaja Sankaridurg, myopia program leader at the CRC. The new lens design has been licensed to Carl Zeiss Vision and is now available commercially in Asia.

Australians are likely to benefit from the lifestyle and eye-health benefits that arise from improved ophthalmic products such as these, Vision CRC CEO, Prof Brien Holden says. "Less myopia and less severe myopia would also reduce the risk of serious eye diseases such as retinal detachment, glaucoma and cataracts."

PHOTO: NEW CORRECTIVE LENSES SLOW THE PROGRESSION OF SHORT-SIGHTEDNESS. CREDIT: JANI BRYSON

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Pain relief from the sea

For the one in five Australians of working age suffering from serious chronic pain, the options for relief are strictly limited. There's morphine and... well, there's morphine. But now one of the most powerful toxins in the natural world—the venom of marine cone snails—offers hope of a future free of pain and addiction, say researchers at RMIT University.

"The big problems with morphine are addictiveness and the fact that people develop a tolerance to it," says Professor David Adams, director of the RMIT Health Innovations Research Institute. "With the painkillers derived from cone snail venom, we don't have those problems. People don't develop tolerance, and they don't get hooked.

"Also, there's a wide safety margin. With morphine, there's little room for error. If you overdose, you're likely to die. But with the venom peptides, there may be side-effects but you will survive."

David leads research into the cocktail of peptides—fragments of protein—with which the cone snail paralyses its prey. "These peptides have exquisite selectivity for their molecular targets," he says. So his team is geared to developing new treatments for chronic nerve-based pain by discovering and purifying peptides that target particular pain receptors.

Worldwide, there are more than 700 species of cone snails, about two-thirds of which are found in the Great Barrier Reef. Each species' venom contains between 100 and 200 unique peptides —more than 100,000 different peptides overall, of which fewer than 100 have been classified.

It's a huge enterprise, and the RMIT researchers collaborate internationally with groups in the US, Canada and Belgium. "There are many other possibilities for cone snail venom, such as treatments for cardiovascular conditions," David says.

PHOTO: CONE SNAILS MAY OFFER PAIN RELIEF. CREDIT: ISLAND EFFECTS

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Faster flash flood warnings

Flash flooding, brought on by sudden torrential rain, killed dozens of people in Australia in 2011. Because of their very nature, it has been difficult to provide effective warnings. And that is a significant gap in Australia's natural disaster management, according to the submission of RMIT University's Centre for Risk and Community Safety to the 2011 Queensland Floods Commission of Inquiry.

We now have the technology to deliver such warnings, says director of the Centre, Prof John Handmer. "But using it would raise issues about how quickly both the authorities and people at risk are prepared to make critical decisions when they receive the information."

Based on more than a decade of local and international research, the Centre argues that improving warning systems, and eliciting community responses to them, is one of the most cost-effective ways of reducing losses and saving lives. "We know how to raise awareness [of flooding], but not how to ensure action," John says.

The submission also underlines the general problem of communicating the uncertainties of warnings—an issue relevant not just to flooding, but to many other natural disasters, such as bushfires, tsunamis and violent storms. Because public understanding of numerical estimates of probability is limited, the submission suggests defining and using language such as 'could', 'at least' or 'between X and Y' to accompany them.

The Centre, which is based in the University's School of Mathematical and Geospatial Sciences, was established in 2001 as a collaborative project with the Centre for Resource and Environmental Studies (now the Fenner School) at the Australian National University, and the-then peak body for dealing with natural disasters, Emergency Management Australia (now part of the Attorney-General's Department).

PHOTO: TECHNOLOGY COULD MEAN MORE EFFECTIVE WARNINGS AGAINST FLASH FLOODING, LIKE THE KIND THAT HIT TOOWOOMBA, QUEENSLAND IN JANUARY 2011. CREDIT: KINGBOB.NET

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Parasites betrayed by their genome

Melbourne veterinary researchers are using genomic techniques and bioinformatics to lead them to new specific candidate drugs for the treatment of a devastating parasite known as barber's pole worm, which causes anaemia, deaths and massive production losses in the sheep industry.

Using the latest gene sequencing technology and the supercomputers of the Victorian Life Sciences Computation Initiative, Prof Robin Gasser's research group from the University of Melbourne's Veterinary School have been able to compare barber's pole worm's DNA and RNA with that of other organisms in order to track down genes essential to the worm's growth, development, reproduction and survival.

The researchers, who call themselves molecular parasitologists, are now working hard to decode the genomes of a number of other debilitating parasites, to find new ways controlling them.

Hundreds of millions of humans and animals worldwide, particularly in developing countries, are seriously affected by a broad range of destructive parasitic worms. The parasites have long-term negative impacts on human and animal health and welfare, but in spite of this, Robin says, they are seriously neglected in terms of funding for fundamental research and R&D of drugs, vaccines and diagnostics.

Unlocking the genomes of these neglected pathogens will have substantial outcomes, Robin says, through the development of new drugs, vaccines and/or diagnostic tests. At the same time, a vast body of knowledge will be acquired about the biology and evolution of these complex organisms.

PHOTO: THE BARBER'S POLE WORM CAUSES DEATHS AND MASSIVE PRODUCTION LOSSES IN THE SHEEP INDUSTRY. CREDIT: JAMES BOWYER

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Putting a cap on fatigue

Drivers of trucks, dozers, graders and excavators at Australian mines could soon be saved from the risks of fatigue by their headgear.

Incidents on mine sites caused by tiredness are a significant cause of injuries and deaths, and cost the industry hundreds of millions of dollars in lost production and accidents each year. So Dr Daniel Bongers at the Cooperative Research Centre for Mining (CRCMining) in Brisbane has invented a SmartCap, fitted with sophisticated sensors which can "read" the brain's nerve activity through hair and detect the level of fatigue of the wearer.

Even with the built-in sensors, the SmartCap looks and feels like a typical baseball cap. A detachable lightweight processing card fits under the brim. Fatigue levels are recorded on a display in the cabin of the vehicle, and can be relayed back to a base station.

The invention is the result of collaboration between mining companies, fatigue and sleep experts, and mining industry funding bodies.

Global mining operations represent a market for thousands of SmartCaps, with the potential of expanding to millions if heavy trucks are included.

CRCMining CEO Professor Mike Hood said the system could eventually be used well beyond the mining environment. "The many advantages of the SmartCap include the fact that it is lightweight, mobile and highly accurate," he says. "This means the technology is easily adaptable to a passenger car environment."

PHOTO: THE SMARTCAP PROTECTS AGAINST FATIGUE. CREDIT: CRC MINING

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L'Oréal Fellows

Science needs women

CREDIT: L'ORÉAL AUSTRALIA/SDPMEDIA.COM.AU

The 2010 L'Oréal Australia *For Women in Science* Fellows are: revealing how breast stem cells can turn to cancer cells; creating crystals to capture carbon dioxide; and fighting drug resistance in malaria.

Preventing breast cancer relapse

Mystery still surrounds why women who recover from breast cancer often relapse years later —Dr Marie-Liesse Asselin-Labat is hoping to use her knowledge of breast tissue stem cells to unravel it. In 2006, she was part of the Walter and Eliza Hall Institute team that discovered breast stem cells. She then built on this finding with a series of studies exploring how these cells develop and are influenced by oestrogen and other steroids.

Her achievements won her a $20,000 L'Oréal Australia *For Women in Science Fellowship* in 2010.

Breast stem cells are critical to normal breast development, but if the breast becomes cancerous they are also likely to be at heart of the problem. And that's been the focus of Marie-Liesse's work. In a series of high impact papers working with mice, she has explored how these breast stem cells develop into the wide range of cells found in a normal breast and how some of them become aggressive cancer cells.

In 2010 she was lead author of a *Nature* paper revealing that oestrogen and other steroids can control the function of breast stem cells. "It's via an indirect mechanism important in understanding how stem cells proliferate, and it could lead to new treatments and new drugs," she says.

"But there are basic questions we still need to answer about breast cancer—such as, 'What is the cell of origin?' and 'What causes a cell to go wrong and turn to cancer?'"

PHOTO: MARIE-LIESSE ASSELIN-LABAT, THE WALTER & ELIZA HALL INSTITUTE OF MEDICAL RESEARCH, MELBOURNE. CREDIT: L'ORÉAL AUSTRALIA/SDP MEDIA

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Soaking up gases with molecular sponges

Absorbing carbon emissions from power stations and creating a new generation of hydrogen fuel tanks in future vehicles are just some of the potential applications of Dr Deanna D'Alessandro's discoveries in basic chemistry. She has created new, incredibly absorbent chemicals that can capture, store and release large volumes of gas.

It's all to do with surface area, says Deanna, a postdoctoral research fellow in the School of Chemistry at The University of Sydney. She has constructed crystals that are full of minute holes. One teaspoon of the most effective of these compounds has the surface area of a rugby field. What's more, the size and shape of the pores can be customised and changed using light. So she believes she can generate molecular sponges that will mop up carbon dioxide, hydrogen, or in theory almost any gas—and then release it on cue.

In 2010, her achievements won her a $20,000 L'Oréal Australia *For Women in Science Fellowship* which provided equipment, travel support and a student to assist her.

Deanna's compounds have similar molecular structures to those in seashells and the microscopic marine plants called diatoms. These naturally-occurring materials are commonly used in toothpaste, laundry detergents, kitty litter and other industrial applications.

But her high tech equivalents are crystals known as metal-organic frameworks—clusters of charged metal atoms linked by carbon-based groups. While she didn't invent these frameworks, Deanna has developed new kinds of them which are more robust and possess the molecular pores that can be shaped by light.

PHOTO: DEANNA D'ALESSANDRO, THE UNIVERSITY OF SYDNEY. CREDIT: L'ORÉAL AUSTRALIA/ SDP MEDIA

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Fighting back against malaria

Some of the biochemical tricks the malaria parasite uses to become resistant have been unravelled thanks to a series of discoveries by Dr Rowena Martin and her colleagues at the Australian National University. She is using those insights to give a new lease of life to chloroquine, the wonder drug against malaria first discovered in the 1950s.

For more than half a century chloroquine saved hundreds of millions of lives, but now chloroquine-resistant malaria strains have become common in developing countries. Rowena is working to understand what happened.

The single-celled malaria parasite enters our bodies when we are bitten by an infected mosquito. It eventually invades and plunders our red blood cells, consuming the haemoglobin contained within. The digestion of haemoglobin, which takes place in the parasite's stomach compartment, releases the iron-containing, non-protein component, haem. Free haem is toxic to the parasite, which responds by converting it to a harmless crystal. Chloroquine works by blocking the formation of these crystals.

Ten years ago researchers discovered that just a few small changes in a protein PfCRT were enough to give the parasite resistance to chloroquine. But they did not know what the changes did.

Rowena developed a system to study PfCRT in frog eggs—allowing her to examine it in isolation and in detail. "We found that it moves chloroquine out of the parasite's stomach compartment so that the drug can't accumulate at its site of action."

For her achievements to date, in 2010 Rowena won a $20,000 L'Oréal Australia *For Women in Science Fellowship*.

PHOTO: ROWENA MARTIN, THE AUSTRALIAN NATIONAL UNIVERSITY, CANBERRA/THE UNIVERSITY OF MELBOURNE. CREDIT: L'ORÉAL AUSTRALIA/ SDP MEDIA

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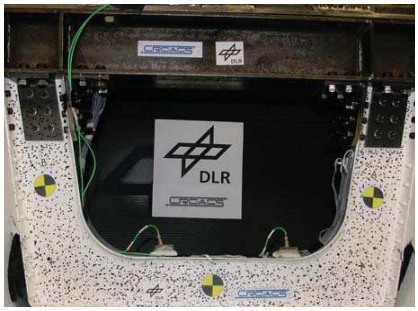
Chemistry beats corrosion

CREDIT: ROYAL AUSTRALIAN NAVY

A non-toxic coating will reduce environmental and maintenance costs in Australia's Seahawk helicopters.



Crashing helicopters for safety

Mathew Joosten crashes several helicopters a day—without any deaths or injury. He uses computer simulation. A research student of the Cooperative Research Centre for Advanced Composite Structures, Mr Joosten has designed 'virtual crash test' software to help accelerate the development of safety systems.

This is particularly helpful for the application of advanced composite materials to building helicopters. These materials are very light and compact and can absorb vast amounts of energy in a crash. They work in the same way as a crumple zone in a car. "Beneath the seats of a helicopter we can install devices that absorb the impact of a crash, so less is transmitted to passengers," Mathew says.

But using composites demands extensive effort in designing and testing these crash structures. "Without a computer model, assessing the performance of energy absorbing structures would require time consuming and expensive crash tests," says Mathew. "Up until now we have not been able to model these collapses with the accuracy required."

With the support of the CRC, Mathew has designed such a model. "We now have a tool to predict enough of the performance of the structures so that only a minimal number of real-life tests are needed. This is great because it means that if the design is changed slightly, we don't have to perform another series of tests."

Although his model is for helicopters, Mathew says it can be applied to many other aircraft. During development of the new model, Mathew spent several months conducting crash tests at the German Aerospace Center.

PHOTO: CRASHING HELICOPTERS CAN NOW BE DONE FROM THE SAFETY OF THE KEYBOARD. CREDIT: ACSCRC

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Silicon solves helicopter corrosion

An inexpensive, environmentally friendly alternative to a toxic coating currently used in Australian naval helicopters has been developed at Monash University in collaboration with CAST Cooperative Research Centre (CAST CRC) in Melbourne.

The magnesium alloy used to house the gearbox of Royal Australian Navy SeaHawk helicopters is prone to severe corrosion in marine environments, costing millions of dollars in maintenance every year. To protect the alloy from corrosion, it is covered with a chrome-based coating that is toxic to humans and the environment.

Under joint supervision of the Defence Science and Technology Organisation (DSTO) and researchers at Monash and Swinburne Universities, PhD student Ms Parama Banerjee has developed a much-needed alternative which provides superior corrosion protection. It is made from a silicon-based material called silane.

"The silane coating is completely biodegradable and non-toxic so people can handle it safely. It also delivers the maximum corrosion resistance ever achieved for magnesium alloys."

Ms Banerjee says while the new technology is still at a preliminary stage, it could be used to repair the corroded gearbox housings of SeaHawk helicopters in the near future.

DSTO worked with the CAST CRC—which specialises in industry-driven research into metals technology—to address the corrosion issues for magnesium alloys.

PHOTO: A NON-TOXIC COATING WILL REDUCE ENVIRONMENTAL AND MAINTENANCE COSTS IN SEAHAWK HELICOPTERS. CREDIT: ROYAL AUSTRALIAN NAVY

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Australian scientists elected to Royal Society

Four of Australia's most accomplished scientists have been elected to the oldest scientific academy in continuous existence, the Royal Society of London.

Prof Ian Frazer, Prof Alan Cowman, Prof Mark Randolph and Dr Patrick Tam join 40 other scientists to be elected to the Royal Society in 2011, which celebrated its 350th anniversary last year.

"To be honoured and recognised by one of the world's most prestigious scientific academies is a significant achievement, and well deserved by each of these Fellows of the Australian Academy of Science," the Academy's President, Prof Suzanne Cory said.

Ian Frazer, from the University of Queensland's Diamantina Institute and a former Australian of the Year, was elected for his work on the development of a vaccine against cervical cancer.

Alan Cowman, the head of the Infection and Immunity Division at the Walter and Eliza Hall Institute of Medical Research, was elected for his work on the molecular workings of the malaria parasite and on developing antimalarial drugs, including potential vaccines.

A geotechnical engineer at the University of Western Australia's Centre for Offshore Foundation Systems, Mark Randolph was elected for advancing the design of piled foundations, and developing new techniques for offshore site investigation and the analysis of soil penetration.

Patrick Tam, a senior principal research fellow at the Children's Medical Research Institute at the University of Sydney, was elected for advancing the understanding of early embryonic development and the origins of congenital malformations.

PHOTO: PROF IAN FRAZER LAUNCHES THE CERVICAL CANCER VACCINE GARDASIL. CREDIT: UNIVERSITY OF QUEENSLAND

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science stories

Is that you in the video?

A Queensland University of Technology (QUT) engineer is developing techniques to automatically identify people in surveillance videos and recognise their movement and behaviour.

The explosion of video surveillance to make public places safer, says Dr Clinton Fookes of the University's School of Engineering Systems, has created a new challenge for researchers —to make sense of what cameras and computers see. So he is investigating ways to extract and interpret important information from these visual sources.

The data generated by the proliferation of surveillance cameras, as well as the countless images and videos online, he says, are impossible to intelligently use without sophisticated computer vision technology that can automatically extract information from these sources, collate and report on it in real time.

As Clinton's work is ideally suited to improving security in public places such as airports, one of his roles is technical director of QUT's Airports of the Future—a major research project aimed at improving the experience of passengers passing through Australia's airports.

His research in this field could lead to new discoveries in a range of areas including human-computer interaction, security, medical imaging and robotics.

PHOTO: CLINTON FOOKES IS TECHNICAL DIRECTOR OF QUT'S AIRPORTS OF THE FUTURE. CREDIT: QUT

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Building a better banana

The Bill and Melinda Gates Foundation are supporting the efforts of Queensland University of Technology scientists to design a better banana.

The researchers have already added provitamin A—a compound the body converts to Vitamin A—to the East African Highland banana. Now they are working to boost the iron content of the cooking banana that is a staple food of Uganda.

Led by Prof James Dale, director of University's Centre for Tropical Crops and Biocommodities, the researchers are working with the Ugandan National Agricultural Research Organisation to modify the bananas genetically to raise their micronutrient levels, and then develop disease-resistant strains to distribute to East African farmers. The research is being funded by a $10-million grant from Bill and Melinda Gates Foundation's Grand Challenges in Global Health Program.

James and his team developed efficient technology for raising nutrient levels in Cavendish bananas through to field trials in Queensland and then transferred it to Uganda. Ugandan scientists are now using these methods to modify East African Highland bananas genetically to increase their biosynthesis of provitamin A and their accumulation of iron.

Part of the project includes ensuring Ugandans will accept the new fruit, which has deep yellow flesh, thanks to the addition of the Vitamin A precursor, beta-carotene.

PHOTO: JAMES DALE AND A BETTER BANANA PALM FOR AFRICA. CREDIT: QUT

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Dirt solves murder mysteries

Australian detectives can now use a pinch of dirt or a speck of dust to help solve crimes, thanks to techniques developed at the Australian Synchrotron.

Soil composition is as unique as a fingerprint so scientists can analyse dirt samples and, in theory, match their results to specific regions of the Earth's surface. Until recently, large sample sizes were needed to make this work.

Dr Rob Fitzpatrick, from the Centre for Australian Forensic Soil Science, has used the new technique to help detectives to determine the origin of a sample as small as a single grain of sand. Any soil can help with an investigation and the technique has even been used to solve a murder case.

The process works by shining beams of high energy synchrotron light through the sample. Different minerals respond to these rays in different ways. Each grain of dirt shows a specific signature which can be matched in a similar way to detectives comparing fingerprints with those in a database.

The Centre for Australian Forensic Soil Science was established by the CSIRO to keep Australia at the forefront of this area of forensic science. The centre comprises soil and forensic scientists researching ways to fight crime and terrorism. Soil analysis has been so successful in solving crime, that it is now used by every police force in Australia, with possible applications overseas.

PHOTO: A SPECK OF DUST OR A PINCH OF DIRT IS NOW ENOUGH TO SOLVE A MURDER. CREDIT: MITARAT

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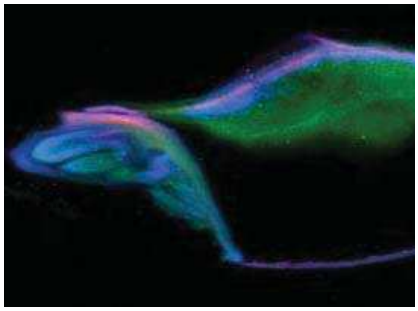
Physics and better food

CREDIT: ERNST VIKNE

X-rays from the Australian Synchrotron are being used to improve the nutrition of crops like barley by pinpointing where in the grain micronutrients are found.



Spot the nutrients

South Australian researchers are using the Australian Synchrotron in their work on how to increase levels of iron and other micronutrients in staple grains such as rice and barley. The intense x-rays of the synchrotron can pinpoint where in the grain those micronutrients are found.

One third of the world's population suffers from iron deficiency. One of the reasons for this is that more than three-quarters of the iron in rice is lost when the outer layers of the grain are removed during milling.

Enzo Lombi and Erica Donner from the Centre for Environmental Risk Assessment and Remediation at the University of South Australia are using the x-ray fluorescence microscopy (XFM) beam to probe grains of rice, barley and other staple grains that have been designed to boost levels of key micronutrients like iron.

The researchers use the intense synchrotron light to produce images showing concentrations of elements, like iron, copper, zinc and selenium.

One of the new plants they are studying is a strain of rice that has multiple copies of the gene for nicotianamine, which is involved in the long-distance transport of iron. The idea is that more iron will be moved into the inner layers of the rice grain.

The technique used by Enzo and Erica is the only one sensitive enough to determine the chemical form of these elements at the low levels found in cereal grains. It will show how much of the iron will be available when it reaches the consumer.

PHOTO: TRI-COLOUR MAP OF: FE (RED), CU (GREEN) AND ZN (BLUE) IN A GRAIN OF BARLEY. CREDIT: ENZO LOMBI

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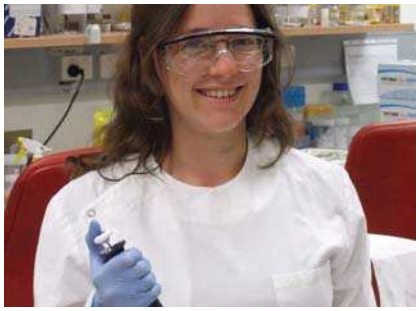

Yeast to make jet fuels

Baker's yeast could soon be turning sugar cane into jet fuel. Dr Claudia Vickers from the Australian Institute for Bioengineering and Nanotechnology (AIBN) at the University of Queensland leads a team studying strains which already produce ethanol, industrial chemicals and pharmaceuticals.

The researchers want to use the yeast strains *S. cerevisiae* to make isoprenoids, chemicals traditionally used to make pharmaceuticals and food additives, but which can also serve as fuel.

The idea is to give the yeast new functions, so they can consume sucrose from cane sugar and produce isoprenoid products, which can be used to replace or supplement traditional jet fuel, without modifying existing aircraft engines or infrastructure.

Claudia's lab was originally looking at the gut bacteria *E. coli*, which could also be used to produce isoprenoids, but the yeast is now looking more promising.

Other research groups at The University of Queensland and James Cook University are looking to develop aviation fuel from algae and the oilseed tree *Pongamia*, both of which can be grown without competing with traditional food crops for land or water.

The University's sustainable aviation fuel initiative has attracted several backers including Boeing, Virgin Australia, Mackay Sugar, Brisbane-based IOR Energy, and the US-based green energy company Amyris. It is funded by the Queensland State Government.

PHOTO: DR CLAUDIA VICKERS IS LEADING A TEAM LOOKING AT MODIFYING BAKER'S YEAST TO MAKE AVIATION FUEL. CREDIT: AIBN

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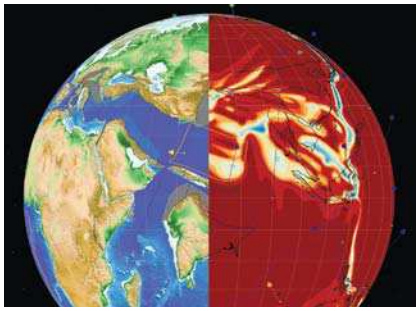

Slide back in time and see the Himalayas form

Researchers in the School of Geosciences at the University of Sydney have developed a computer package that lets scientists record and study the Earth over geological time.

Their GPlates software, which they describe as "Google Earth with a time-slider," contains powerful tools for modelling geological processes. Yet it is simple enough to use in schools or at home, and is freely available. By combining data on continental motion, fossils and sediments, for example, scientists can analyse changes in geography, ocean currents and climate over geological time.

PhD student Sabin Zahirovic used GPlates to better understand the formation of the Himalayas and Tibet. Plate motion models linked to supercomputer simulations suggest that India first ploughed through an arc of islands about 60 million years ago. India slowed down significantly as it finally collided with the Eurasian continent at about 40 million years ago to uplift the vast mountain chains we see today.

"The two-stage collision explains today's observations of surface geology and 3D structure of the sub-surface mantle layer," says Sabin. "It also makes sense of the changes in the speed and direction of India's motion that were affected by the collision."

GPlates Version 1.0, developed in collaboration with Caltech and the Norwegian Geological Survey, is the first interactive tool providing easily visualised yet sophisticated animations. Future releases will allow users to analyse large datasets to investigate relationships between different aspects of the Earth's geology, biology and climate over time.

PHOTO: GPLATES IMAGE SHOWING TOPOGRAPHY (LEFT) AND PREDICTED TEMPERATURE 300 KM BELOW SURFACE (RIGHT) AS INDIA MOVES TOWARDS THE EURASIAN CONTINENT 60MYA. CREDIT: SABIN ZAHIROVIC, EARTHBYTE

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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. More at **www.freshscience.org.au**

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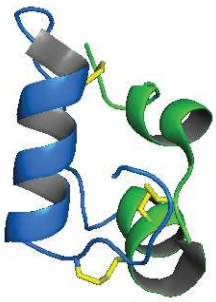
Print your own lasers, lights and TV screens

Imagine printing your own room lighting, lasers, or solar cells from inks you buy at the local newsagent. Jacek Jasieniak and colleagues at CSIRO, the University of Melbourne and the University of Padua in Italy, have developed liquid inks based on quantum dots that can be used to print such devices and in the first demonstration of their technology have produced tiny lasers.

Quantum dots are made of semiconductor material grown as nanometre-sized crystals, around a millionth of a millimetre in diameter. The laser colour they produce can be selectively tuned by varying their size.

PHOTO: JACEK JASIENIAK SPRINKLING QUANTUM DOTS. CREDIT: JACEK JASIENIAK



Insulin that doesn't need a fridge or a needle?

Monash University chemist Bianca van Lierop and her colleagues have successfully strengthened insulin's chemical structure without affecting its activity. Their new insulin won't require refrigeration. The researchers have filed a series of patents with the support of their long term commercial partner ASX-listed Circadian Technologies to start the long process of moving the invention out of the laboratory and into the hands of people with diabetes. At the same time they're using their newly acquired knowledge to develop a form of insulin that can be delivered by pill.

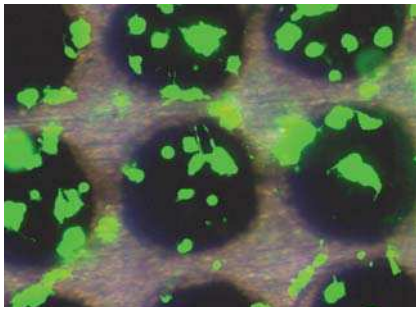
PHOTO: THE TERTIARY STRUCTURE OF HUMAN INSULIN. CREDIT: BIANCA VAN LIEROP

Cling wrap captures CO_2

High tech cling wraps that 'sieve out' carbon dioxide from waste gases can help save the world, says Melbourne University chemical engineer, Colin Scholes who developed the technology. The membranes can be fitted to existing chimneys where they capture CO_2 for removal and storage.

Not only are the new membranes efficient, they are also relatively cheap to produce. They are already being tested on brown coal power stations in Victoria's La Trobe Valley, Colin says. "We are hoping these membranes will cut emissions from power stations by up to 90 per cent."

PHOTO: COLIN SCHOLES OPERATES A TEST RIG FOR HIS CARBON CAPTURE MEMBRANE. CREDIT: C02 CRC

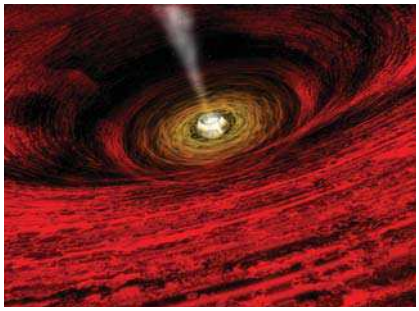


Electric plastics: Better bionic eyes and ears

A UNSW biomedical engineer has developed conductive bioplastics which will transform the performance of bionic devices such as the cochlear ear and the proposed bionic eye. "These plastics will lead to smaller devices that use safer smaller currents and that encourage nerve interaction," says Rylie Green. "And we can attach natural proteins to them which will aid the survival of damaged and diseased nerves."

The plastics are already being tested in prototype bionic eyes and she hopes they will find application in bionic ears, robotic limbs—wherever researchers are attempting to integrate electronics with the human body.

PHOTO: NEURAL CELLS GROWING ON THE CONDUCTING BIOPLASTIC ELECTRODES. CREDIT: RYLIE GREEN



How do black holes eat?

Australian Astronomical Observatory researcher David Floyd has been able to use galaxies as cosmic telescopes to observed matter falling into a super-massive black hole. It's the first time scientists have been able to probe so close to a super-massive black hole, a region inaccessible to telescopes until now. The research makes use of a technique known as gravitational microlensing, where the bright light from a quasar passes near or through another galaxy on its way to Earth. The intervening galaxy acts like a lens, enlarging and splitting the image of the quasar into several components, each of which can be analysed.

PHOTO: ARTIST'S IMPRESSION OF MATERIAL FALLING ONTO A BLACK HOLE. THE MATERIAL IS COMPRESSED, HEATING IT AND CAUSING IT TO SHINE. CREDIT: APRIL HOPART, NASA/CHANDRA X-RAY CENTER (CXC)

Bacteria munch up alumina impurities

Previously unknown species of naturally-occurring bacteria have the potential to save the alumina and aluminium industries millions of dollars while helping to reduce their impact on the environment, microbiologist Naomi McSweeney has found in a collaborative project between Alcoa of Australia, CSIRO and the University of Western Australia.

The bacteria can successfully break down and remove sodium oxalate, an organic impurity produced during the refining of low-grade bauxite into alumina. At a typical refinery, sodium oxalate forms by the tonne during the production of alumina. It can affect the colour and the quality of the final product.

PHOTO: NAOMI MCSWEENEY INVESTIGATING BACTERIA FOUND AT AN ALUMINA REFINERY. CREDIT: DAMIEN SMIT

Ultrasound puts water back in the Murray Darling

By applying the right amount of ultrasound during processing, Jianhua (Jason) Du and researchers from the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE) have been able to squeeze a considerable amount of fresh water from mining waste. The technique also reduces waste bulk, which could save mining companies millions of dollars.

As good as an atomic clock

Even tiny delays across the internet introduce data errors. So University of Melbourne engineer Julien Ridoux and colleagues have invented a free, new, software clock that is accurate to within a millionth of a second.

Nano-sand to improve lotions and cosmetics

Nasrin Ghouchi-Eskandar from the University of South Australia's Ian Wark Research Institute and fellow researchers have invented and patented a new technology for delivering cosmetics and drugs through the skin. They use nanoparticles of silica (essentially sand) to create longer lasting cosmetics and creams that control the delivery of drugs.

Aussie lizard reveals cancer secrets

A compound that encourages the growth of blood vessels in pregnant three-toed skinks may provide important information on the origins and treatment of cancer in humans. Zoologist Bridget Murphy from the University of Sydney, discovered the protein, which is pivotal to the development of the lizard placenta.

Joint reversal eases arthritis

A shoulder-joint implant, with the ball and socket on the opposite bones from nature, can significantly improve the quality of life of patients with severe arthritis and tendon tears, says medical engineer David Ackland from the University of Melbourne. Testing shows that the new implant stabilises the joint and increases the range of movement of arthritic shoulders.

Add fertiliser to fight weeds

Feeding weeds fertiliser sounds like exactly the wrong thing, but Jennifer Firn of CSIRO Sustainable Ecosystems has been doing just that to control African lovegrass, an invasive species of rangelands in every Australian state. Her method works by making the weed tastier to grazing animals.

Waste is a waste

A biotechnologist from the South Australian Research and Development Institute has taken using "everything but the pig's squeal" to new lengths. See Andrew Ward's story on page 3.

Silk microchip for rapid medical testing

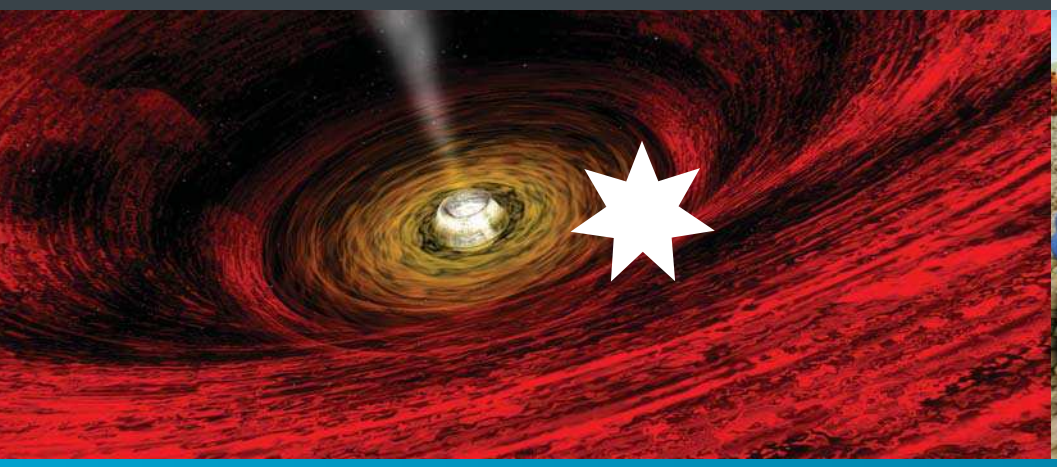
Silk could provide a sophisticated new way of monitoring health, Peter Domachuk, a physicist from the University of Sydney, has found. He and his colleagues have created microchips for diagnostic blood tests using silk fibres. And in the lab they've demonstrated that these microchips can measure oxygen using haemoglobin embedded in the silk.

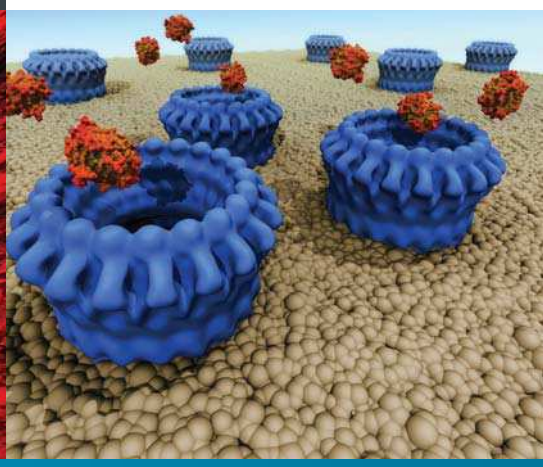
Wind—the key factor for dangerous bushfire weather

Wind speed plays a bigger role than temperature in creating dangerous conditions for bushfires, says Andrew Dowdy a physicist from the Bureau of Meteorology. His work with the Bushfire Cooperative Research Centre has led to new possibilities for predicting bushfire conditions based on the weather.

Measuring the climate on ice

Young Tasmanian electrical engineer Natalia Galin has turned US technology into a robust helicopter-borne radar system that can accurately measure the thickness of snow on polar sea ice. Her work will improve NASA's satellite measurements of what's happening to the Antarctic sea ice, and will contribute to more accurate climate models.





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