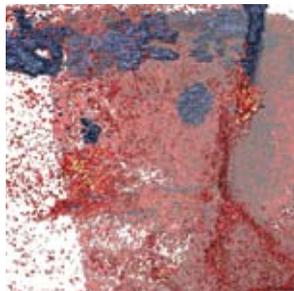




science: securing the future



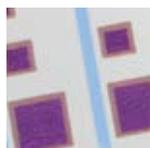
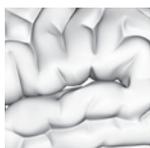
www.csiro.au



> a showcase of CSIRO activity **2008-2009**
Australian Science, Australia's Future

Our purpose states:

By igniting the creative spirit of our people, we deliver great science and innovative solutions for industry, society and the environment.



© CSIRO 2009

This work is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced by any process without prior written permission from CSIRO. Requests and inquiries concerning reproduction and rights should be addressed to: CSIRO Communication General Manager; PO Box 225, Dickson ACT 2602

Welcome



Since I joined CSIRO in January 2009 an economic downturn and tragic bushfires in Victoria have challenged us to respond as a nation. In contributing to these responses, CSIRO has drawn on its key strengths of scale, breadth and multidisciplinary science. The financial crisis has created a renewed focus on the importance of innovation now and in the future, while the bushfires further highlighted the importance of scientific knowledge and information for managing and learning from such tragic occurrences.

It is apparent that today, more so than ever, the global and national challenges we face increasingly require the use of science to understand and provide solutions. CSIRO is responding to this as we focus our activity on the major challenges that matter to Australia and the world.

Our strategy is to bring together the very best scientists to undertake new discovery focused on these challenges, as well as apply all our skills to help our industry partners compete.

We are an organisation with goals and values that go beyond our science. We know we will be successful when our people always go home safely; our collaborators and partners realise lasting value from our science and involvement; our people share a sense of discovery, and we remain a trusted advisor to the people of Australia.

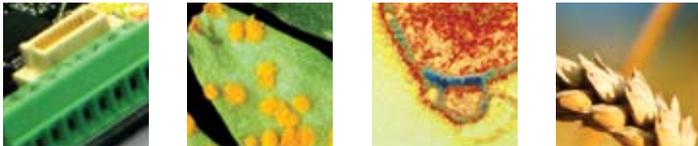
Our performance in 2008-09 has been strong, delivering substantial scientific impact for economic, social and environmental benefit. We reached a record 161 active licenses for our technologies and discoveries. Some of our achievements included imaging research that has brought forward the detection of Alzheimer's disease by 18 months; four carbon dioxide capture plants have been commissioned in Australia and China; we led an acclaimed multidisciplinary research project on water availability in the Murray-Darling Basin, and our longwall mining automation technology is improving health and safety.

These are just some examples of our work and within these pages you will see further highlights across a number of key impact areas that are of major significance to Australia, and also the world. Many of these highlights have been published in top scientific journals during 2008-09, or have resulted in licensing agreements, patents, and scientific breakthroughs. Each of these highlights provides you with a reference for further information so you can discover more about the particular science and its outcomes.

I hope you enjoy reading about some of our recent achievements and view them, as we do, as important steps towards securing the future wellbeing and prosperity of Australia and indeed all humanity.

A handwritten signature in black ink that reads "Megan Clark". The signature is fluid and cursive, written in a professional style.

Dr Megan Clark
CSIRO Chief Executive



contents

- 2 Your CSIRO
- 3 Fast facts

CSIRO in action

- 4 The science of climate change
- 8 Securing our water for future generations
- 12 Improving Australians' health and wellbeing
- 16 Transforming Australia's energy future
- 18 From farm to fork
- 22 Saving the diversity of Australian life
- 26 Safeguarding Australia
- 28 Knowing our oceans, securing our future
- 32 Transforming Australia's minerals industry
- 34 Innovating materials and manufacturing
- 36 Enabling industries through ICT
- 38 Teachings from outer space

Showcases

- 40 Science to better water Australia's 'food basket'
- 41 Man's new best friend – a cow named Dominette
- 42 Front-line defence – the science shield against disease

Talent

- 43 Royal Society honours scientific excellence
- 43 Small-science physicist on the world stage
- 44 Champion of the marine neighbourhood watch
- 44 Faster, smarter, stronger – tomorrow's materials
- 45 Honouring our science

Your CSIRO

CSIRO is Australia's national science agency and we are one of the largest and most diverse research organisations in the world.

We undertake scientific research into practically all aspects of human activity and its interaction with natural and built environments. This scientific embrace includes our air and water, our diverse landscapes, oceans and climate, agriculture, energy, health, space technologies and exploration, manufacturing, materials science, minerals exploration and processing, information and communication technologies, and more.

We seek to make a difference with our research and generate impact for Australia; to apply our knowledge to the creation of jobs, national wealth, a healthy environment and improved living standards for all Australians.

At CSIRO, people are the heart of our organisation and we pride ourselves on recruiting the best talent, where creativity and skill match enthusiasm for science and discovery. Today, we have over 6500 staff, located across 55 sites throughout Australia and overseas.

Our role in Australia's National Innovation System is unique, due to our size, our breadth and depth of capability, and our ability to conduct large-scale, multidisciplinary research focused on tackling the major challenges that matter to Australia's future.

We address these challenges, and opportunities, largely through our National Research Flagships program – one of the largest holistic scientific research programs ever undertaken in Australia. We understand the importance and value of partnering with the community, industry and other research agencies to collaborate with 'the best and brightest' drawn from across both the Australian and international innovation systems.

At CSIRO, we have a proud history of working for Australia. For more than 80 years we have been a trusted source of new and creative ideas that have contributed to Australia's nation-building, that have met some of our greatest technical challenges with practical technologies. These have generated enormous value, not only in the eyes of government and our partners, but also in the eyes of the Australian community. We have worked hard to build this trust and earn the community's confidence. We are proud of our record for science excellence and are committed to our role in sustaining Australia's prosperity and wellbeing.

Fast facts

- > CSIRO stands for Commonwealth Scientific and Industrial Research Organisation.
- > We are an independent statutory authority governed by the *Science and Industry Research Act 1949*.
- > CSIRO ranks in the top one per cent of world scientific institutions in 14 of 22 research fields[^].
- > Our research delivers:
 - integrated solutions to help address major national challenges
 - technologies to transform or create new markets for Australian industry
 - innovative technologies to improve the competitiveness of existing industries
 - advice, information and research to meet specific community needs
 - knowledge-based services to governments and businesses.
- > We are a billion dollar enterprise. In 2008-09 we received Parliamentary appropriation funding of \$668.1m and generated \$634.8m in external revenue.
- > 89 per cent of our total expenditure is directed towards Australia's National Research Priorities.
- > We lead 10 National Research Flagships, the most recent initiated in July 2009, that bring focus and scale to research addressing some of Australia's most important and complex challenges and opportunities.
- > We host three National Research Facilities and manage eight National Biological Collections.
- > The average citation rate for CSIRO's research publications is 12.56*. This is above the Australian average of 10.37 and the world average of 9.43.
- > In the past year, our staff produced more than 4900 publications and 9700 client reports.
- > In 2008-09 we reached a record 161 active licenses for our technologies and discoveries.
- > Our staff provide a wide range of specialised technical and analytical services, ranging from analyses for air pollutants and satellite imaging to fire testing and diagnosis of exotic animal diseases.
- > Each year we typically have over 3000 active research contracts serving small, medium and large businesses as well as the public sector.
- > CSIRO is the single largest participant in the Cooperative Research Centre (CRC) Program, participating in 28 of the 51 centres as at June 2009.
- > We contribute to an average of 700 international collaborations each year in about 70 countries.
- > CSIRO is Australia's leading patenting enterprise, holding over 3710 granted or pending patents.
- > More than 150 spin-off companies have been based on CSIRO generated intellectual property and expertise.
- > Each year over 690,000 students, parents, teachers, and the public participate in a range of CSIRO education and visitor programs; plus we reach a viewing audience in the millions with SCOPE, a children's science television program we jointly produce.
- > At CSIRO, we value integrity of excellent science, trust and respect, initiative to explore, delivering on commitments, and safety and sustainability.

In brief – as at 30 June 2009

Organisation

Total staff	6510
Research Divisions	16
Locations	55
National Research Flagships ¹	10
Total budget 2008-09	\$1302.9m

Research and outputs

Total publications in 2008-09	4961
Total live patents	3710

Partnerships and international

Collaborative projects	55
Partners in flagship collaboration fund	400+
International contracts	565

Education and outreach

Postgraduate students	772
Education program participants ²	450,364
Calls/emails to CSIRO Enquiries ³	33,459
Visitor Centre visitors ⁴	240,462
CSIROpod / CSIROvod internet hits ⁵	258,426

1. The tenth National Research Flagship commenced on 1 July 2009.

2. Includes CSIRO Science Education Centres (390,947), Double Helix members (20,253), Science by Email subscribers (29,560), CREST participants (8355), and Scientists in Schools partnerships (1249).

3. CSIRO Enquiries is CSIRO's central telephone and email contact point.

4. Includes CSIRO Discovery Centre (80,555), Parkes Telescope Visitor Centre (92,369), and The Canberra Deep Space Communication Complex (67,538).

5. CSIROpod and CSIROvod provide the public with podcasts and vodcasts via the Internet.

[^] Based on the Institute for Scientific Information data on total citations of publications as at July 2009.

* Data updated as of 1 May 2009 to cover a 10-year plus two-month period, 1 January 1999 to 28 February 2009.

The science of climate change

Today, climate change poses a serious and urgent threat to our planet. Global warming, greenhouse gases, and human intervention are impacting on our climate with increased speed and consequence.

For Australia, the climate change threat is urgent. We already occupy the driest inhabited continent, with a climate characterised by extremes of flood, fire and drought. In recent years, our vulnerability to the impacts of

climate change has become increasingly clear, demanding a serious and major response.

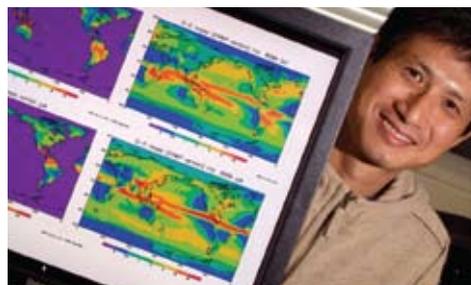
CSIRO is helping the community to understand, respond to and plan for a changing climate by integrating its understanding of climate science with technologies and strategies for mitigation and adaptation.

The future impacts of climate change, for Australia and the world, will depend on what we – humankind – do today.

> Predicting climate and ecosystem cause and effect

Researchers have developed a new theory to explain the global pattern of nitrogen fixation, long recognised as an important process in controlling responses by many ecosystems to global environmental change. In 2008-09, this theory was implemented into the land-surface model component of the Australian Community Climate and Earth System Simulator (ACCESS). This will help scientists better predict the effect of climate change on different ecosystems through the delivery of reliable, timely and accurate forecasts of weather and future climate scenarios spanning decades to centuries.

> *Nature*, 19 June 2008





> Linking world trade and climate

CSIRO and the Australian Bureau of Agricultural and Resource Economics have built a new integrated assessment model called GIAM, which couples global trade with the climate system. Uniquely, the model simulates Australia's trade and economy in detail and, for the first time in this type of model, incorporates a full atmosphere-ocean global climate model. Results from GIAM, which contributed to the Garnaut Climate Change Review, revealed Australia's dual vulnerability to climate change through direct impacts on both our ecosystems and our trade.

> *Report: Assessment of future global scenarios for the Garnaut Climate Change Review: An application of the GIAM framework, October 2008*



> Emissions rising faster since 2000

An international research team including CSIRO has found that human-generated carbon dioxide emissions have been growing four times faster since 2000. The figures, released in September 2008, updated trends in the global carbon budget, including ocean and land sinks, land-use change and fossil fuel combustion. The results show global emissions are tracking above the average of the most carbon-intensive emission scenarios at the high end of the Intergovernmental Panel on Climate Change emission scenarios released in 2000.

> *More at www.csiro.au*

> Developing adaptation strategies for Western Port

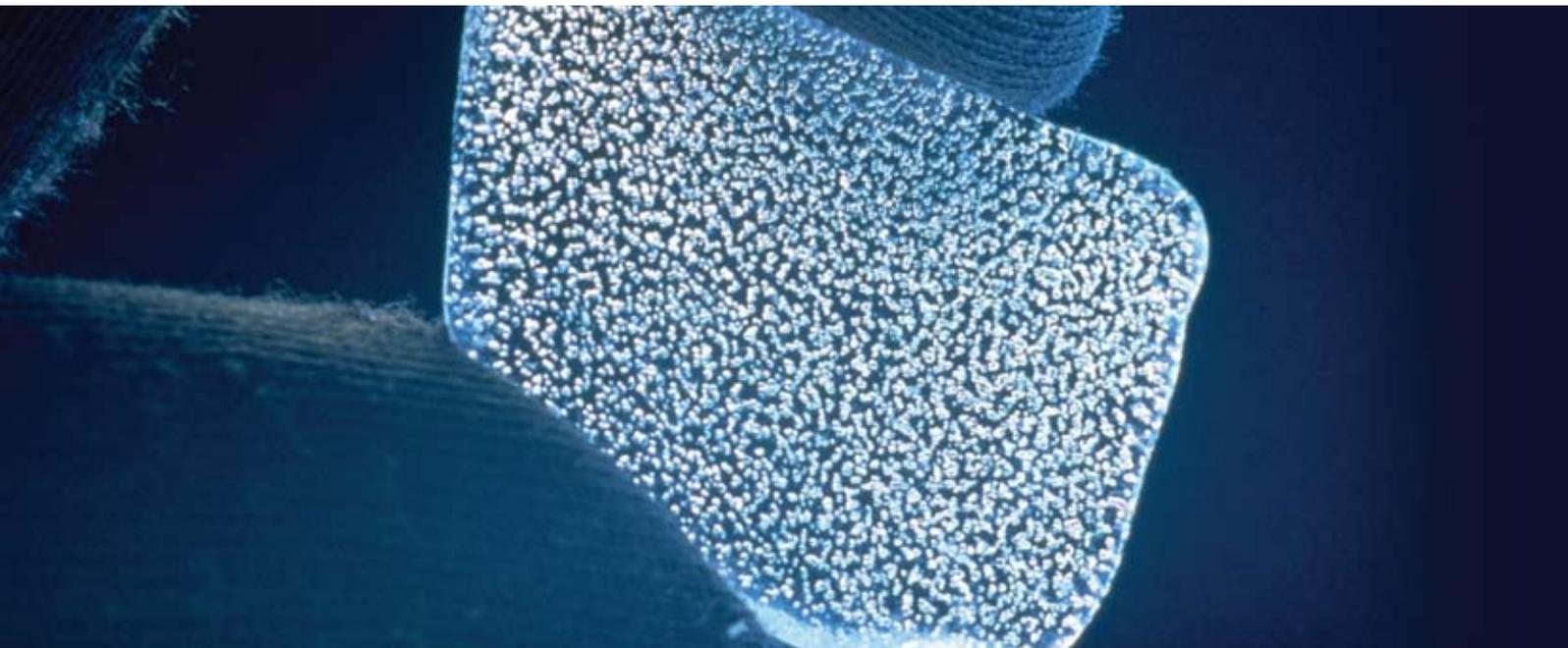
A collaborative project with government and business partners is helping five local governments in the Western Port region, Victoria, to develop climate adaptation strategies based on a vulnerability assessment of the region. As part of the project, CSIRO researchers developed local projections of sea-level rise and storm surge heights and frequency, as well as projected changes to rainfall and temperature. This project won the Victorian Coastal Council's 2009 prize for innovation.

> *Report: Impacts of Climate Change on Settlements in the Western Port Region. People, Property and Places, June 2008*

> Counting success for carbon accounting system

The Australian-developed National Carbon Accounting System (NCAS) is leading the world. At least five years ahead of similar systems elsewhere, it provides Australia with a reliable tool to monitor land-cover change across the continent and thereby measure greenhouse gas emissions and carbon sinks to track progress against international agreements. NCAS was internationally recognised by the Clinton Climate Initiative as a basis for a Global Carbon Monitoring System, and in 2008 received the Sherman Eureka Prize for Environmental Research.

> *More at www.csiro.au*



> Two 'new' greenhouse gases growing

An international research team led by scientists from the University of California and CSIRO has identified two new greenhouse gases growing quickly in the atmosphere. Using observations from sites including the Cape Grim Baseline Air Pollution Station in Tasmania, scientists identified increasing concentrations of the powerful greenhouse gases nitrogen trifluoride and sulfur hexafluoride, which are used in industrial processes, partly as alternatives to other harmful greenhouse gases. This discovery is significant for the revision of the Kyoto Protocol in December 2009.

> *Journal of Geophysical Research*, 12 March 2009



> Southern Ocean resistant to changing winds

Scientists have found no evidence that intensifying winds in the Southern Ocean are affecting ocean currents or the rise of deep water (and therefore the ocean's ability to absorb carbon dioxide). The Southern Ocean slows the rate of greenhouse warming by removing carbon dioxide from the atmosphere and storing it in the ocean. This work refutes previous studies suggesting the Southern Ocean carbon sink is now 'saturated' and no longer able to keep pace with increasing concentrations of atmospheric carbon dioxide.

> *Nature Geoscience*, 23 November 2008





> Methane on the rise again

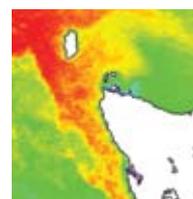
After eight years of near-zero growth in atmospheric methane concentrations, levels rose again in 2007 and 2008. CSIRO research with international partners suggests the increase was due to wetland sources in the high-latitude Northern Hemisphere and tropics, following rapid Arctic and tropical climate changes. Methane is also emitted from rice fields, cattle, coal mines, natural gas and other sources which, over the past decade, have been balanced by natural processes.

> *Geophysical Research Letters*, November 2008

> Study guides fishing industry's climate response

Scientists have found that changing ocean conditions due to climate change present both threats and opportunities for Australia's \$2.2 billion wild and farmed fisheries. South-east fisheries are most likely to be affected by changes in water temperature; northern fisheries by changes in rainfall; and western fisheries by changes in the Leeuwin Current. Each change results in regional shifts in the location and abundance of wild fish stocks.

> *Report: Implication of climate change for Australian fisheries and aquaculture*, August 2008



> Super-sized and slushy

New research involving CSIRO indicates that the amount of frozen organic carbon locked away in the world's permafrost regions – a potential added source of atmospheric carbon dioxide and methane – is double previous estimates. These permafrost soils are fast becoming vulnerable to degradation from rising temperatures, and any melting could see large quantities of carbon dioxide and methane released. Exposure of these previously stable stores could further increase global temperatures by the end of the century.

> *BioSciences*, September 2008

Securing our water for future generations



Water is central to human life – environmentally, biologically, economically, and socially. The sustainable management of water resources is therefore vital, and it is a challenge facing many around the world.

For Australia, as one of the driest continents, efficient and sustainable water use is a critically important issue. As demand for water increases, the climate changes and storage sites reach capacity, we must look to new strategies that reduce demand, increase efficiency of use, recycle wastewater and allow water to be traded.

CSIRO is doing the research to provide a better understanding of our environmental systems to secure the future sustainability of our valuable water resources. Our science is informing the decisions on where and how to best invest in these strategies and is providing enabling technologies.

> Modelling the future of Australia's food basket



CSIRO researchers have led the most comprehensive and technically challenging water-modelling project ever undertaken in Australia and possibly the world. The Murray-Darling Basin Sustainable Yields Project provides the world's first rigorous assessment of the potential impacts of climate change on surface water and groundwater availability across a major river basin. It is providing governments and industry with an unprecedented level of water information to guide future resource planning, management and investment.

> Report: *Water Availability in the Murray-Darling Basin: A report from CSIRO to the Australian Government, October 2008* • Read a full profile on page 40



> Support for sustainability decisions

The water industry is looking for more sustainable ways to provide water and sewerage services to new urban developments. CSIRO and partners have developed an award-winning, innovative sustainability-assessment framework that compares alternative options, such as wastewater and stormwater recycling, third pipe systems and rainwater tanks, with traditional centralised servicing. Use of the framework justifies sustainability decisions by demonstrating better environmental, social and fiscal outcomes for alternative servicing options.

> *Environmental Engineering Science, 23 April 2009*



> Guidelines for recycled water

Using recycled water is a viable option to reduce water shortages. Recycling water through managed aquifer recharge (MAR) is emerging as an innovative and environmentally friendly treatment option. CSIRO scientists have led the development of the national guidelines for MAR. These guidelines comprise a risk management framework and specific guidance on managing the health risks and the environmental risks associated with the use of recycled water.

> *More at www.csiro.au*



> Great Barrier Reef protection

Two years of integrated and collaborative research in Queensland's Tully-Murray Basin have paved the way for improved water quality in the Great Barrier Reef World Heritage Area. Combining environmental and socioeconomic research, CSIRO scientists, in partnership with local landholders, traditional owners, and local government and industries, identified management actions that can improve water quality. These results have been incorporated into water quality improvement plans across the Great Barrier Reef, helping to ensure the long-term survival of this world-famous Australian icon.

> *Report: Tully Water Quality Improvement Plan, March 2009*



> Tool to contain farm toxins

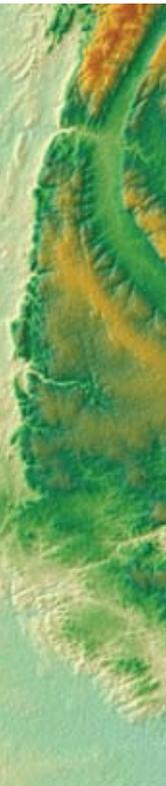
A simple screening tool that predicts the potential for the off-site migration of pesticides into surface or groundwater is helping Tasmanian industry and natural resource managers to better protect the state's river catchments. The PIRI-Tas tool also assesses the risk to different species based on the toxicity of pesticides (including herbicides, insecticides and fungicides) to a range of aquatic organisms. PIRI was first developed by CSIRO in 1998 and in 2008 was customised and tailored to Tasmanian conditions. It is used by organisations nationally and internationally.

> Licensed to Department of Primary Industry and Water, Tasmania

> From mine site to national park

CSIRO-led research is helping the Ranger mine in northern Australia plan and implement rehabilitation strategies to protect the environment. The area is to become part of the Kakadu National Park when the mine closes in 2021. A key component is an integrated water-management and environmental-protection strategy. Treated water from the mine is passed through a constructed wetland, where plants and microbes reduce residual metals and nutrients to environmentally acceptable levels before the cleaned water runs back into the landscape.

> Process, June 2009

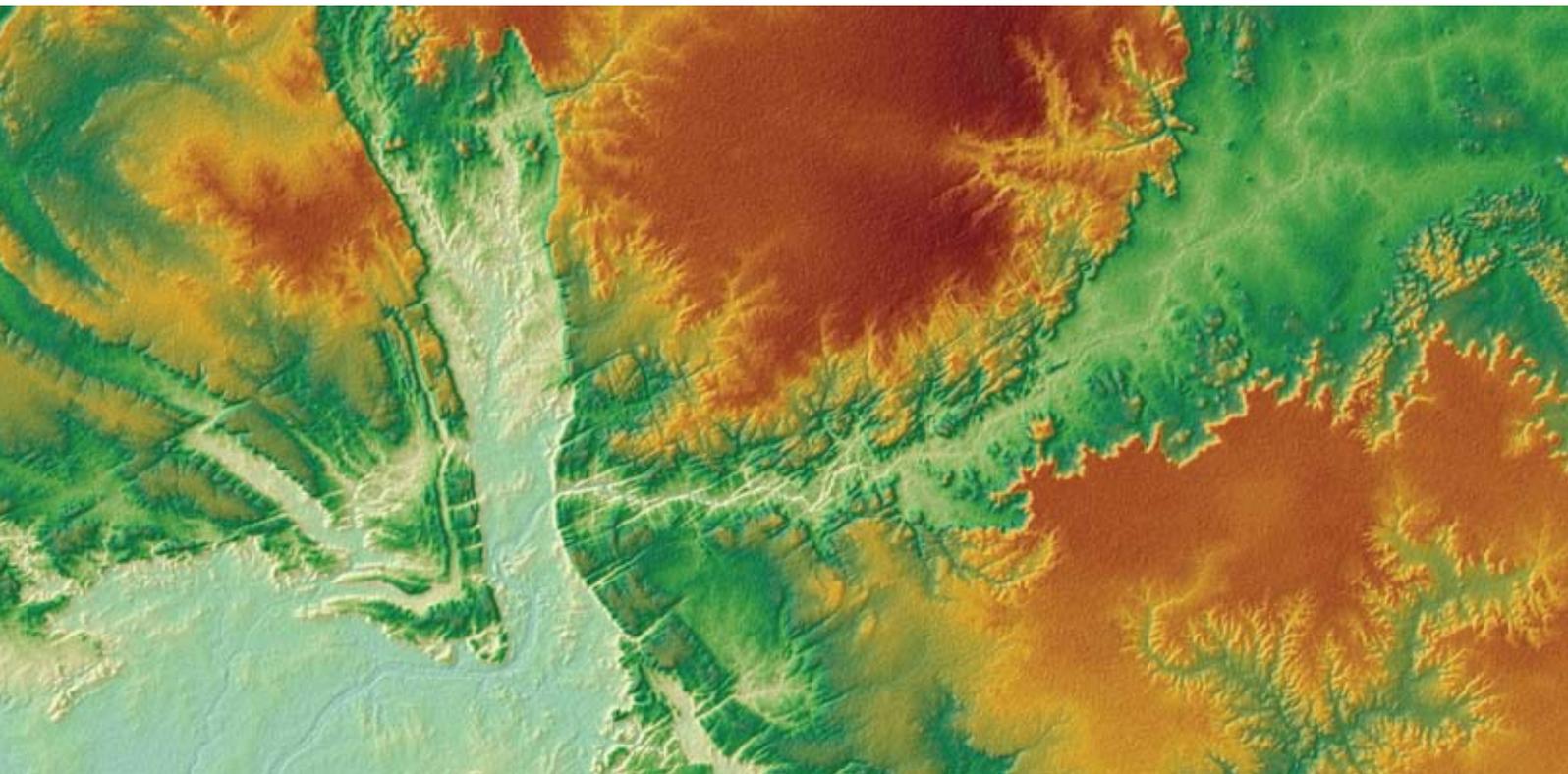


> Turning stormwater into drinking water

Urban stormwater, usually left to flow down our gutters, can be treated to produce water of drinking standard. The Aquifer Storage Transfer and Recovery project in Adelaide, involving CSIRO, pumps stormwater into aquifers, allows it to be 'polished' as it moves through, then recovers it from another part of the aquifer. The approach is less expensive than other water supply options, such as desalination, and has a low carbon footprint.

> More at www.csiro.au





> Australia's topography close-up

CSIRO, with assistance from government and university bodies, has built a three-dimensional computer model of Australia's ground surface topography at an unprecedented fine scale. The new one-second digital elevation model (DEM), based on data collected by NASA, provides data at nearly 10-times finer resolution than the previous Australia-wide model. It shows landforms with clarity and detail that will improve our understanding of Australia's landscape and ability to manage Australia's natural resources.

> Licensed to Geoscience Australia

> Water conservation saves energy

Water conservation can play an important role in reducing greenhouse gas emissions. A CSIRO and Water Services Association Australia study demonstrated that influencing the way water is used has a much greater impact on energy consumption than simple consideration of the energy used in supplying urban water services. A 15 per cent reduction in residential hot water use, or an equivalent increase in the efficiency of hot water production, would offset all energy used by water utilities in 2006-07.

> Report: *Energy use in the provision and consumption of urban water in Australia and New Zealand*, 10 November 2008

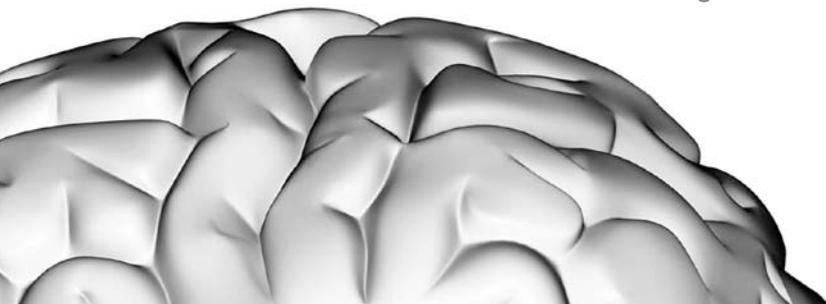
Improving Australians' health and wellbeing

Chronic diseases are a growing cost on the health and wellbeing of people and healthcare systems around the world. This, together with ageing populations, requires innovative healthcare solutions to prevent or delay such diseases, to improve people's health and contain escalating healthcare costs.

For Australia, the protection and maintenance of public health is imperative to our prosperity in terms of social and economic wellbeing, workforce participation and productivity.

CSIRO is contributing strongly to improving the health and wellbeing of Australians through

research into the prevention, early detection, and better treatment of diseases and other degenerative conditions. In fact, each year we invest more than \$150 million in health-related research across fields such as nutrition, disease prevention, biomedical devices and implants, medical imaging and information processing.

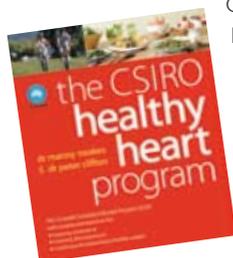


> Coming to grips with Alzheimer's

CSIRO research is breaking through Alzheimer's disease. Scientists have developed a new system to screen for compounds that can inhibit one of the processes that takes place during the disease's progression. New brain-image processing software is also giving clinicians a powerful new procedure with improved reliability and accuracy for detecting the disease's early stages. And in a world-first, CSIRO scientists have determined the structure of small oligomers of beta-amyloid, a protein that builds up in the brain in the form of plaques, and considered one of the links to how Alzheimer's develops.

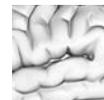
> *Journal of Alzheimer's Disease, November 2008; Provisional patent filed*

> Heart health for all Australians



Cardiovascular disease kills one Australian almost every 10 minutes. In September 2008, CSIRO released its publication *The CSIRO Healthy Heart Program* to help Australians lower their risk to this disease. Developed by the same team as the highly successful *CSIRO Total Wellbeing Diet* books, the Healthy Heart Program provides a complete eating and exercise plan aimed at reducing risk factors for cardiovascular and related diseases, such as diabetes.

> *The CSIRO Healthy Heart Program, published by Penguin Group (Australia)*



> Clearer vision in sight

Through the Vision CRC, CSIRO and partners have developed two novel technologies that have the potential to revolutionise vision correction. The first is an implantable contact lens that corrects refractive errors including myopia, hyperopia and astigmatism. The second is a synthetic crystalline lens replacement designed to restore an aged eye's ability to near focus – the process called accommodation, which the eye performs during close-work activities such as reading. A spin-out company is now commercialising these technologies.

> Spin-out company: *Adventus Technology Inc*



> New wound sealant

CSIRO scientists have developed a new tissue sealant that could be used to heal wounds after common surgeries such as blood vessel repair and tumour removal. The sealant, known as PhotoSeal™, uses naturally occurring proteins, including the blood protein fibrinogen or gelatin, as easy-to-use, minimally invasive wound closure and repair devices.

> *International PCT Patent No. WO 2009/021287*



> Frog poison may unravel brain mysteries

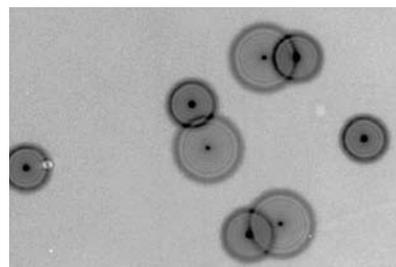
CSIRO has completed the first synthesis of histrionicotoxin 285A – a compound found in the protected 'poison arrow' frog from South America (*Dendrobates histrionicus*). As a defence mechanism, these frogs secrete a cocktail of alkaloids through their skins, including histrionicotoxin 285A. The molecule could improve the understanding of neurological disorders, including Alzheimer's disease, but is only now available for biological evaluation.

> *Organic Letters, 4 September 2008*

> Molecular ruler for made-to-measure pharmaceuticals

CSIRO has patented an improved microscopy technique for measuring the shapes and sizes of proteins, which could help scientists create new pharmaceuticals that better match their targets. Called Differential Aberration Correction (DAC) microscopy, the new technique measures distances at the molecular level in two and three dimensions using conventional fluorescence microscopy. It allows scientists to measure proteins in solution, which is how they exist in nature, instead of using coated or crystallised proteins as with other techniques.

> *Journal of Microscopy, November 2008; Provisional patent filed*



> Weight loss mentor

A novel approach to providing overweight people with personalised diet and lifestyle information has been developed by CSIRO and its partners. The Weight Management Mentor uses mobile phone technology to poll the participant at key times, requesting information on their diet, activity and other lifestyle and wellbeing indicators. This information is then used to profile the participant and provide them with personalised support and information.

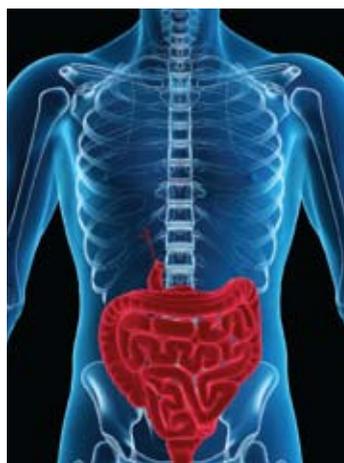
> Agreement with Verdant Health; Provisional patent filed



> Progress for bowel cancer tests

A novel biomarker panel that can differentiate colorectal adenoma (benign) and carcinoma (malignant) tissues from normal colon epithelium has been identified by CSIRO and its partners. These biomarkers move us closer to an improved diagnostic test for bowel cancer. If the markers can also be reliably detected in infected stool or blood samples, the team's commercial partnership with Clinical Genomics Pty Ltd could open the way to the development and global marketing of an improved diagnostic test for early stage colorectal cancer.

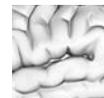
> Three International PCT patent applications filed



> Bowel cancer screening

Research by the Adelaide Colorectal Cancer Collaborative, of which CSIRO is a member, is expected to lead to a nine per cent increase in the uptake of bowel cancer screening. A 2007 population study showed that screening rates could be increased by sending eligible recipients a letter inviting them to a free bowel cancer screen. Based on this research, the Australian Government incorporated an advanced notification letter as an integral part of its screening process in July 2008.

> *Journal of Medical Screening*, June 2007



> Maths test a close shave

CSIRO has developed maths-based imaging technology to track hair growth and removal on different parts of the body. CSIRO's image analysis specialists, who develop software to automatically analyse images, worked with UK personal-care products company Reckitt Benckiser to create technology for objectively testing hair-removal products. The software automatically finds and measures straight lines in an image captured using a flatbed scanner. It can detect hairs that people struggle to see and is not confused by wrinkles, scars or moles.

> *Skin Research and Technology, November 2008*



> Data for healthier children

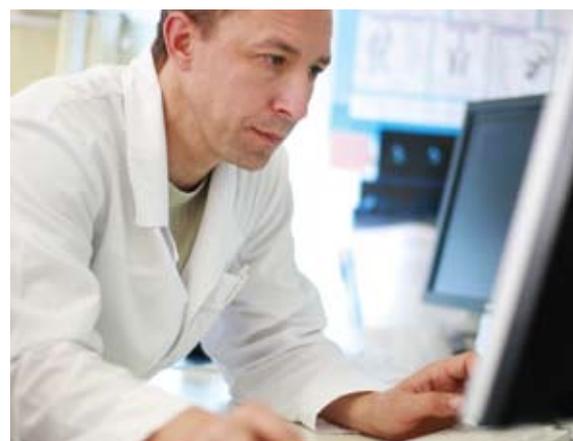
Researchers from CSIRO and the University of South Australia have undertaken the most comprehensive survey ever of Australian children's diet and activity patterns. It now provides the evidence needed to develop programs that promote good nutrition and healthy lifestyles. CSIRO, with the Australian Government, has also developed an easy-to-read guide for parents of four-year-olds to help develop life-long healthy habits. The booklet will be distributed with this age group's immunisation schedule.

> *Get Set 4 Life, published by the Australian Government*

> Secure health data analysis

Software developed by CSIRO researchers is providing a single, secure access point to healthcare data stored in multiple databases. The Health Data Integration (HDI) tools create virtual data repositories for large-scale research and analysis without breaching patient confidentiality. HDI technologies will contribute to an improved and more cost-effective analysis of public health data by helping medical authorities better understand and manage complex disease issues.

> *Licensed to 12 organisations*



Transforming Australia's energy future

Global warming is threatening all aspects of life. Ongoing human activity has increased the intensity of greenhouse gas emissions to the atmosphere, with electricity production and transport two of the biggest sources. New energy solutions are needed now to mitigate their impact on an already changing climate.

Australia is a nation of rich solar, coal and gas resources and we need to utilise these along with innovative renewable technologies in a clean and efficient way to secure our energy future.

CSIRO is developing clean, affordable energy and transport technologies. We are working to halve greenhouse gas emissions and to double the efficiency of Australia's new energy-generation technologies. Our research is strengthening, for example, Australia's capacity and capability to embrace a future hydrogen economy.



> Harnessing the sun for green power



CSIRO's National Solar Energy Centre is using mirrors to collect the sun's energy and transform solar power into

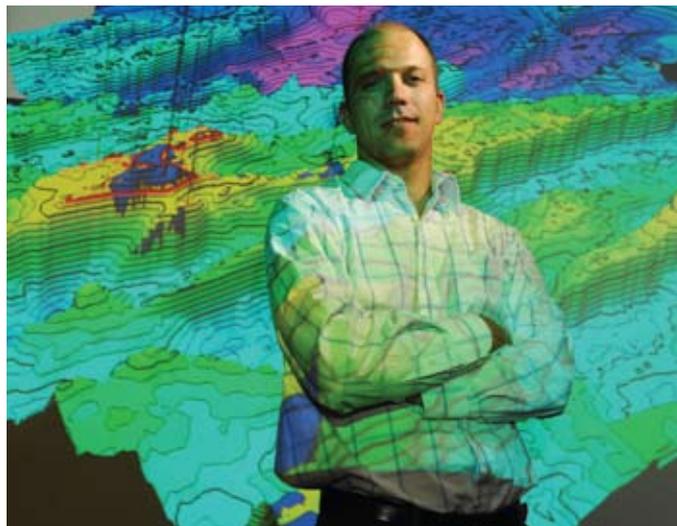
a gas that can be stored and transported. Researchers have just completed a \$7 million facility upgrade and will soon establish a new state-of-the-art solar thermal array on-site as part of the Australian Solar Institute. The new facility will allow CSIRO to work towards making solar thermal power competitive in the future low-emission energy mix.

> More at www.csiro.au

> Battery to reduce global transport emissions

CSIRO's UltraBattery technology is set to have a global impact on greenhouse gas emissions thanks to an international commercialisation agreement with Japanese and US manufacturers. The agreement will see the production and distribution of the UltraBattery in Japan, North America, Mexico and Canada. Combining a supercapacitor and lead acid battery in a single unit, the UltraBattery delivers low-cost, long-life, high-performance power and offers a solution for future energy storage needs.

> Licensed to Furukawa
Battery Company (Japan)



> IPETS signposts trapped oil and gas

The Integrated Predictive Evaluation of Traps and Seals (IPETS) project has developed knowledge, tools and workflows along with practical case studies to investigate factors that control how oil and gas are trapped underground. Understanding this is critical for discovering hydrocarbons and deciding where to drill. The research has reduced exploration risk, improved Australia's oil and gas prospectivity and could potentially save the petroleum industry tens of millions to hundreds of millions of dollars.

> *Journal of Structural Geology, March 2009*



> Fuel for thought

Securing access to affordable and sustainable fuel underpins Australia's economy and our way of life. Through the Future Fuels Forum, CSIRO brought together Australia's transport stakeholders to identify plausible scenarios for sustainable transport to 2050. Released in July 2008, the resulting report *Fuel for thought* made a significant impact resulting in its modelling approach being made available to the Garnaut Review.

> *Report: Fuel for thought – the future of transport fuels: challenges and opportunities, June 2008*



> Capturing carbon to clean up coal use

Two weeks out from the 2008 Olympics, CSIRO and its Chinese partners launched a post-combustion capture (PCC) pilot plant in Beijing that strips carbon dioxide from power station flue gases. In Australia, coal is the primary fuel for 80 per cent of Australia's electricity supply – it is what turns the lights on in most homes – but it also contributes substantially to the country's greenhouse gas emissions. CSIRO is establishing similar PCC pilot plants in NSW and Victoria as another part of the effort to stem climate change.

> *More at www.csiro.au*

> Fracture tips show the way

Hydraulic fractures are used to increase production from oil, gas and geothermal wells. Understanding the physical processes that occur at fracture tips is critical for deciding how to place hydraulic fractures to best stimulate wells. CSIRO research has experimentally confirmed a theoretical formula that predicts crack tip behaviour. This formulation is now being used in commercial software to design hydraulic fracture stimulation of coal seam methane and petroleum reservoirs, and advance the potential for clean energy from geothermal resources.

> *Journal of the Mechanics and Physics of Solids, August 2008*

From the farm to the fork

The provision of safe, healthy food and agricultural products is central to the social and economic wellbeing of all countries. But, in a carbon-constrained world, addressing agricultural productivity and food security becomes increasingly challenging.

One of Australia's greatest natural advantages is its ability to efficiently produce clean, healthy foods. This is the underlying value of Australian farm exports, but it also benefits Australian consumers who expect healthy, high-quality food products.

CSIRO continues to enhance Australia's food production systems through an integrated 'farm-to-fork' approach – from growing fresh produce to developing novel value-added food products. We are developing innovative processing technologies and improving food satisfaction and choice. We are improving the quality and yield of Australian crops and are positively influencing livestock, aquaculture and fishery industries.

> Saving the world's wheat



CSIRO scientists and partners have found the key to overcoming three major cereal diseases

through the discovery of a wheat gene sequence known as Lr34 transporter protein. This resistance gene is the first of its kind to be found in a commercial crop. Lr34 is capable of delivering broad-spectrum control of leaf rust, stripe rust and powdery mildew diseases which, in epidemic years, cost wheat growers worldwide in excess of A\$7.8 billion.

> *Science*, 20 February 2009



> Unlocking the bovine genome

The most comprehensive sequencing of the cow genome has provided new understanding of the relationship between the form and function of an animal and its genetic code. CSIRO played a leading role in the international consortium of 300 scientists from 25 countries that spent the past six years sequencing, assembling and analysing the genome. The results will accelerate genetic improvement in the dairy and beef industries, leading to increased productivity and potentially a reduced environmental footprint.

> *Science*, 24 April 2009 • Read a full profile on page 41



> New genomic tool for sheep industry

CSIRO scientists played a lead role in the International Sheep Genomics Consortium, which produced a new genomic tool to fast-track genetic gain in sheep. Launched in the US in January 2009, the Ovine SNP50 BeadChip is allowing researchers worldwide to pinpoint the small genetic differences that produce a variety of commercially important traits in sheep – such as improved growth rates, higher fertility, parasite resistance and healthier meat products.

> *Licensed to Illumina Inc (USA)*



> CottASSIST: best practice cotton-management tools

In 2009, cotton growers gained free access to a set of online tools that promote and support the adoption of best practice in cotton crop management as well as access to new research findings. Developed by CSIRO and the Cotton Catchment Communities CRC, CottASSIST helps cotton growers assess their crop's progress and assists with complex decision-making so that crops can be grown more efficiently.

> *Free license through Cotton Catchment Communities CRC*

> Stem cells transform livestock breeding

In a world-first, lambs have been born at a CSIRO research station from natural matings where a surrogate ram delivered the sperm of a donor ram from a different breed. The breakthrough, which uses germ cell transplantation or stem cell technology, aims to increase the productivity of Australia's livestock industries.

> *Biology of Reproduction*, June 2009



> Diet: the new frontier

CSIRO scientists are helping NASA to understand the dangerous effects of space radiation on human DNA, and why some people are more vulnerable to radiation than others. The team is looking to diet as a way to minimise the effects of high radiation exposure. It has found that diet can provide molecules that have the ability to quench the free oxidated radicals generated by radiation and, as a result, reduce one of the major health hazards associated with space travel.

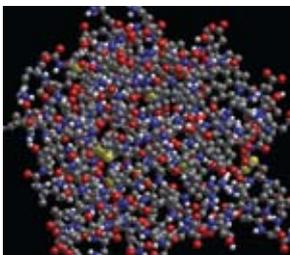
> *Nature Protocols, May 2009*



> Pressure on healthier foods and juices

Scientists have been putting pressure, literally, on foods to extend their shelf life, and a new Melbourne food manufacturing facility is now taking the results to the market. CSIRO's High Pressure Processing Unit, the technology behind the pressure, is improving the way fruit juices and food products are processed. When subjected to pressures of about 6000 times standard atmospheric pressure, juices and foods can be preserved without heat and without changes to their original freshness, flavour, colour, texture or nutritional value.

> Commercialised through Preshafood Ltd



> Sourcing waste for valuable bioactives

A new generation of clean and 'green' separations technology – MIPs (Molecular Imprinted Polymers) – is being developed by a research collaboration, which includes CSIRO, to capture valuable molecules from food waste without the need of solvents. These biologically active molecules are an integral and natural part of plant and animal products. The MIPs will facilitate a cleaner extraction for their use in the functional food and ingredients industries.

> More at www.csiro.au

> Deal signed for GI Analyser

A worldwide licensing agreement was signed in 2009 between CSIRO and an Australian company to commercialise an 'artificial gut'. The GI and RS Analyser is a world-first, automated instrument that predicts glycaemic index (GI) and resistant starch (RS) in foods. Developed by CSIRO, it works by mimicking the human digestion process. The instrument will give the food industry an accurate way to test the functional properties and potential human health benefits of new foods in a quicker and more cost-effective way.

> Licensed to Stadvis Pty Ltd (Australia)



> Not all water is equal

CSIRO and Mars Australia Ltd have undertaken carbon and water footprinting assessments to help improve sustainability strategies. New methodology was developed and applied for water footprinting looking at a product's whole life cycle – from farm to consumer. It accounts for the water source, not just total water usage, and provides more understanding of a food's environmental impact and water stress.

> Commercialised through Mars Australia Ltd

Saving the diversity of Australian life



Over the past 50 years humans have changed ecosystems more rapidly and extensively than at any comparable time in human history. The result has been a substantial reduction in the diversity of life – the biological matrix that eventually underpins everyone’s long-term economic, environmental and social health.

Australia’s landscape has changed, is changing and will continue to change. Particular protection against damaging change is needed to ensure the survival of natural assets.

CSIRO is a central agency for tackling landscape issues such as rising greenhouse gas emissions and reduced biodiversity. Our research is aimed at reducing the carbon footprint of Australia’s land uses while improving the productivity of sectors like agriculture. We are also committed to developing land-use systems that will halt or reverse biodiversity decline.

> Bound in life and death



CSIRO scientists have been studying the relationship in natural systems between organisms that cause diseases and their plant hosts. Their work underscores the value of research on the ecology and evolution of plants and their pathogens as models for understanding co-evolution in other biological systems. Co-evolution occurs when a change in one organism triggers changes in another. This provides insight into the durability of resistance in agricultural systems and ways of understanding biological control of weeds, and the conservation and restoration of ecosystems in natural environments.

> *Science*, 8 May 2009



> Species: move them or lose them

Current conservation practices may not be enough to avert species losses in the face of projected climate changes. Research by ecology experts from CSIRO and universities around the world have discovered that moving plant and animal species to sites where they do not naturally occur may be the only option to save them from rapid climate change. The work provides a decision framework for policy makers to identify low-risk 'havens' where assisted colonisation may be an option.

> *Science*, 18 July 2008



> Missing link sounds biodiversity alarm

Evolutionary biologists have argued that the three different forms of crimson rosella arose through 'ring speciation'. The theory is that a species that spreads to new areas may eventually join back up with itself, forming a ring. But a team, including CSIRO, conducting genetic and geographic research on rosellas has found no clear link. Scientists believe the evidence for the ring has been lost through climatic or environmental changes. This has important implications for research into how climate change may affect Australia's biodiversity.

> *Proceedings of the Royal Society B*, 30 July 2008



> Science aids conservation investment

Conservation funds are often limited, so it is essential to prioritise funding allocations to maximise the benefit. Previous research identified a set of global priority areas for mammal conservation that acknowledged the potential for conflict between conservation and agriculture. As part of an international collaboration, CSIRO scientists incorporated social, economic and environmental objectives into the analysis and achieved the same biodiversity outcomes while reducing the costs to and conflicts with human agriculture by up to 50 per cent.

> *Proceedings of the National Academy of Sciences*, 12 August 2008

> Revegetating Australia for good

Land and water degradation resulting from land clearing is a global problem. Effective restoration techniques are essential to reduce the damage and improve the environment. CSIRO scientists and collaborators have explained how sourcing genetically diverse seed for revegetation, even if not sourced locally, will ensure that restored flora populations across Australia have ample genetic diversity to respond to changing environments.

> *Evolutionary Applications*, November 2008

> Crops yet to feel fewer bees

The worldwide decline in bees and other pollinators is not, at this stage, limiting global crop yields, according to a collaborative study. However, there are warning signs. Demand for pollinators is growing and some crops are suffering. While most crop yields grew between 1961 and 2006, more research is needed because the interaction between yields and pollination is complex. A surprise finding has been a global increase in pollinator-dependent crops, particularly in developing countries, despite the pollinator decline, which could see future problems emerge.

> *Current Biology*, 11 November 2008



> Indigenous carbon offsets

Research has found carbon offsets could be generated through Indigenous land management practices, including fire management in savannas, reforestation of cleared lands and grazing land management. Initial research by CSIRO found that many Indigenous jobs could also be created to manage carbon-emission offsets in regional and remote Australia. The report has prompted the Australian Government to recommend more research in this area.

> *Report: Land management for emissions offsets on Indigenous lands, 2008*

> National resources account

Australia's natural resources have long been a major driver of the nation's economic prosperity. CSIRO research has analysed patterns of resource use over a 30-year period, resulting in a new environmental reporting system. This expands conventional state of the environment reporting to include resource use consumption, providing policy makers with a better understanding of how best to sustainably manage natural resources.

> *Journal of Industrial Ecology*, 22 December 2008

> Soil fingerprint helps carbon detectives

CSIRO has developed a new technique for measuring carbon in soils. Using mid-infrared (MIR) spectroscopy, scientists can generate a spectrum of any soil, similar to a fingerprint. This indicates soil composition including the quantity of various minerals and the different forms of organic carbon. When combined with existing soil carbon models, the MIR technique will help predict the carbon status of Australian soils and their potential role in national and global carbon budgets. CSIRO is now providing technical leadership for the Federal Government's \$20 million program to assess Australia's soil carbon potential to help combat climate change.

> *Australian Journal of Soil Research*, 2007





> Living Australia online

CSIRO is in a partnership with government, museums and universities to develop the Atlas of Living Australia (ALA). ALA will simplify access to data on the distribution, biology and identification of all Australian species and support decision-making on biosecurity, global change management and conservation issues. The first public ALA tool gives users a portal through which to explore the distribution of Australian species. The Australian Government showed further support of the ALA with increased funding in the 2009 Budget.

> More at www.dla.org.au



> Applause for ladybird reference

A 'big' book on a 'small' creature was recognised in 2008 with a prestigious Whitley Award Commendation. Written by CSIRO's ladybird beetle specialist Dr Adam Ślipiński, *Australian Ladybird Beetles (Coleoptera: Coccinellidae): their Biology and Classification*, provides a fascinating insight into Australia's large group of ladybirds. It is an ideal reference, especially for people working in biocontrol or natural resource management. The book reviews all 57 Australian Coccinellidae-family genera, looks at the 260 described species and details some new genera and species.

> *Australian Ladybird Beetles (Coleoptera: Coccinellidae): their Biology and Classification, 2007, published by Australian Biological Resources Study*

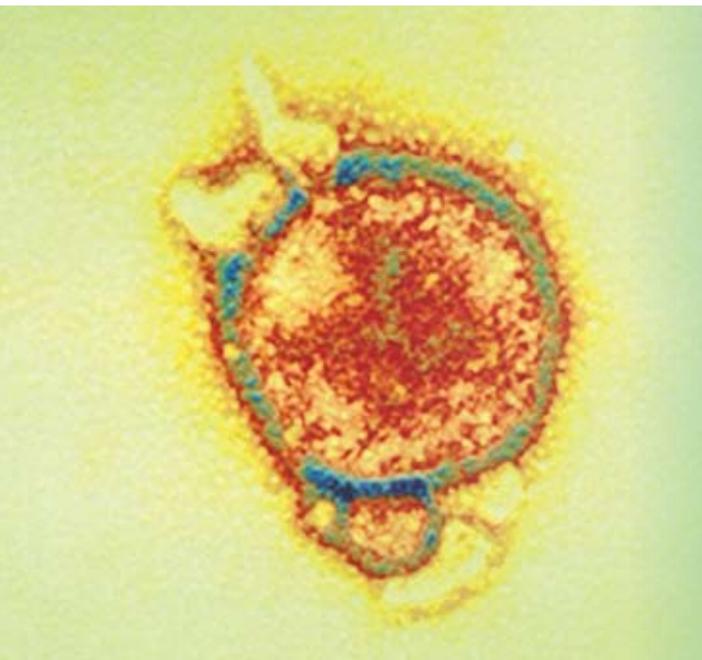


> Not all biochar is created equal

Biochar is attracting attention for its potential to improve soil quality and as a carbon reversal process, by converting biomass carbon to stable charcoal. However, not all biochars are the same. By varying the feedstock and the temperature at which it is burned, it may be possible to produce 'designer biochars' that can be used for a specific purpose. CSIRO collaborated with an international research team to review biochar's credentials and has developed a research program, involving partner organisations across Australia, to help clarify biochar's use.

> Report: *Biochar, climate change and soil : A review to guide future research, February 2009*

Safeguarding Australia



The world is now characterised by the widespread and rapid movements of people, digitally coded data, goods and services, and exotic biological agents. With this has come increased risk to national security.

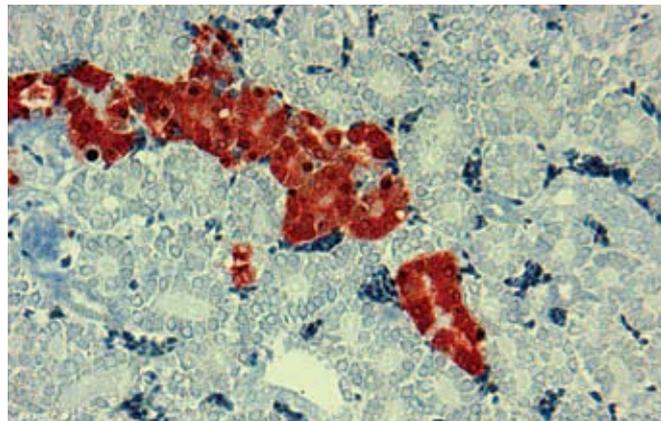
Australia is vulnerable to such risks because of its linear infrastructure and vast coastline borders. We must be capable of anticipating and tackling critical threats to society, the economy and the environment.

CSIRO is working towards a safer and more secure society through the development of world-first security technologies as well as national security technology partnerships. We are also the key national provider of science to help Australia reduce the impact of biological invaders and to manage the risk of emerging and future security threats.

> Novel viruses found

Scientists at CSIRO's Australian Animal Health Laboratory have used cutting-edge technology to identify and characterise two new viruses in northern Australia – Middle Point orbivirus in cattle and Stretch Lagoon orbivirus in mosquitoes. This research is important because future disease epidemics are more likely to be caused by new or emerging disease agents rather than the 'classical' diseases. By characterising novel viruses collected in the field and designing diagnostic tests, CSIRO is preparing for diseases of the future

> *General Virology, June 2009*

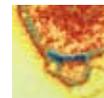


> New human bird flu vaccine

CSIRO scientists, working to protect Australia's poultry industry from the deadly H5N1 Avian Influenza (bird flu), have played a key role in the development of a new vaccine, which will be used in the event of a human bird flu pandemic. Called Panvax®, the new vaccine – registered by CSL Ltd – will be a frontline 'vaccine-in-waiting' for the Australian population should a pandemic occur.

> *More at www.csiro.au*





> Fighting deadly Hendra virus



CSIRO scientists have discovered how the deadly Hendra virus spreads from infected horses to

people and other horses. As a result, the guidelines for people dealing with sick horses have been amended. CSIRO's work will help to develop a field test to accurately diagnose the virus in horses before obvious clinical symptoms develop. There have been 11 outbreaks of Hendra since it was first identified in horses by CSIRO in 1994, and three deaths from six human cases (as at 30 June 2009).

> More at www.csiro.au

> CSIRO RNAi phenomenon subject of new book

In response to the global interest in CSIRO's discovery of RNA interference (RNAi), the renowned scientific publisher CABI (the Centre for Agriculture and Biosciences International) invited two CSIRO scientists, Dr Chris Helliwell and Dr Tim Doran, to write a book. CSIRO has been using RNAi technology in plants for more than a decade to prevent disease infection and is currently using the technique to develop chickens resistant to bird flu. Published in December 2008, the book will be translated into various languages.

> *RNA Interference: Methods for Plants and Animals*, December 2008, published by CABI



> Rabbits fight back naturally

Australian rabbits have survived myxomatosis and rabbit haemorrhagic disease (RHD) (also known as calicivirus). Now it appears some rabbits in cool, high-rainfall areas carry a benign virus that gives them immunity to RHD. Since RHD is not as effective in these areas, scientists suspected that a non-lethal calicivirus was out there; now they have found it. This new virus does not cause disease in rabbits and thus possibly functions as a natural vaccine, protecting rabbits from the lethal calicivirus.

> *Virology*, February 2009

> Bioremediation to clean-up atrazine

Scientists have developed an enzyme that breaks down atrazine in irrigation run-off water. Atrazine is a widely used herbicide that can leave lasting residues. The enzyme was successfully trialled in a holding dam filled with atrazine-contaminated run-off. It removed more than 90 per cent of the herbicide in less than four hours. The CSIRO team is now focusing on improving the production and application of the enzyme.

> *Provisional patent filed*

> CSIRO's strengthened regional role

In 2008, CSIRO's Australian Animal Health Laboratory (AAHL) received global recognition for its efforts to control infectious animal diseases in south-east Asia by being made a Collaborating Centre for Laboratory Capacity Building by the World Organisation for Animal Health. AAHL is the only laboratory in the world to receive this designation. It will help AAHL to continue to work with Australia's neighbouring countries to better control and eradicate infectious animal diseases, in turn reducing the threat to Australia's livestock industries.

> More at www.csiro.au • Read a full profile of AAHL on page 42



Knowing our oceans

– securing our future

Australia's territory is half ocean, giving us one of the largest marine estates in the world. Despite this, our oceans are poorly understood and relatively unappreciated.

But this largely unexplored domain provides enormous opportunities for Australia to generate enduring social, environmental and economic wealth for today and tomorrow.

CSIRO research is providing leadership in understanding ocean systems, processes and technologies. We take a whole-of-system approach to marine science, focusing on national challenges where oceans play a central role.

We continue to push the boundaries of ocean-based research, and are discovering new ways to deliver benefits to the economy, while ensuring we meet community expectations for the ocean's sustainable management.

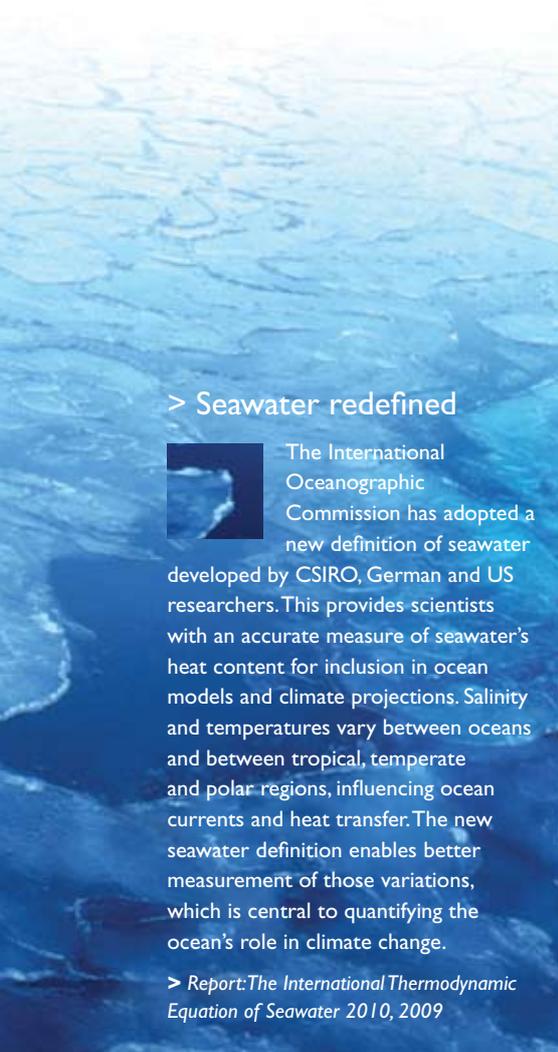


> Prawn fishery a world leader

A bio-economic model developed by CSIRO with fisheries industry, management and research partners has led to international acclaim for Australia's Northern Prawn Fishery (NPF). A report by the United Nations Food and Agriculture Organization praises the NPF for its equitable, responsive and measurable management. The bio-economic model placed the fishery among the first major fisheries in the world to fully embrace economic efficiency and environmental sustainability in an operational system.

> Report: *Global study of shrimp fisheries, 2008* (FAO report)





> Seawater redefined



The International Oceanographic Commission has adopted a new definition of seawater

developed by CSIRO, German and US researchers. This provides scientists with an accurate measure of seawater's heat content for inclusion in ocean models and climate projections. Salinity and temperatures vary between oceans and between tropical, temperate and polar regions, influencing ocean currents and heat transfer. The new seawater definition enables better measurement of those variations, which is central to quantifying the ocean's role in climate change.

> Report: *The International Thermodynamic Equation of Seawater 2010, 2009*

> Oil search accuracy improved

CSIRO's proven technology for detecting and mapping buried mineral deposits is being applied to oil and gas exploration beneath the ocean. The controlled source electromagnetic (CSEM) method distinguishes between reservoirs deep beneath the seafloor containing economic concentrations of hydrocarbons and those that are full of salt water. CSIRO's OCEANMAG gives industry greater confidence in the CSEM data. Subsequent savings in the costs of petroleum exploration have a flow-on effect to the economy, and this project represents savings that conservatively run into the millions of dollars.

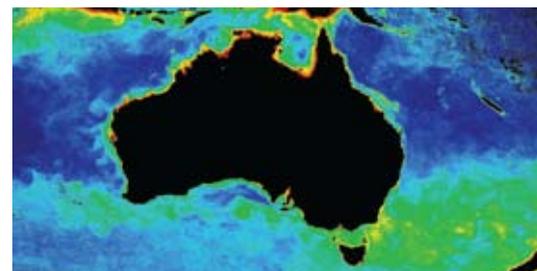
> *International PCT Patent No. WO 2009/062236 A1*



> New approach to marine monitoring

CSIRO and the Australian Department of Environment, Water, Heritage and the Arts have developed a new approach to marine environmental monitoring. This approach is now being applied to Commonwealth marine waters to develop a suite of marine indicators of ecosystem health that explicitly monitor the impact of identified threats on defined ecological assets. This will contribute to future state of the environment reporting.

> Report: *Ecological indicators for the Exclusive Economic Zone waters of the South West Marine Region, August 2008*



> Survey aids Kimberley gas decision

CSIRO and the Australian Institute of Marine Science designed and conducted an extensive marine environmental survey in the remote Kimberley region. The results provided the Western Australian Government with a research basis for its assessment of potential sites to process natural gas along the Kimberley coastline. The study was undertaken through the Western Australian Marine Science Institution.

> Report: *Benthic habitat surveys of potential LNG hub locations in the Kimberley region, October 2008*



> Seals dive deep for data

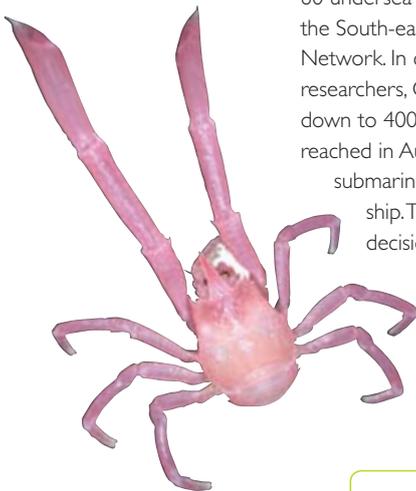
Elephant and Weddell seals are helping scientists overcome a blind spot in their ability to detect change in Southern Ocean circulation, as well as sea ice production and its influence on global climate. University of Tasmania and CSIRO scientists, with international colleagues, fitted elephant seals with special oceanographic sensors. The sensors have delivered a 30-fold increase in observations recorded in some previously data-sparse parts of the Southern Ocean, while providing critical environmental information relevant to seal health and food systems.

> *Proceedings of the National Academy of Sciences, 12 August 2008*

> Voyages brimming with discovery

Working with museums and using the Marine National Facility Research Vessel *Southern Surveyor*, CSIRO discovered 274 new marine species and 80 undersea mountains in a project to monitor the South-east Commonwealth Marine Reserve Network. In collaboration with American researchers, CSIRO also sampled flora and fauna down to 4000 metres – deeper than previously reached in Australian waters – using a robotic submarine deployed from an American ship. This research informs government decisions about the location, size, design and effectiveness of marine reserve areas, and the deep-sea impacts of climate change.

> *More at www.csiro.au*



> Tuna fishery A–Z

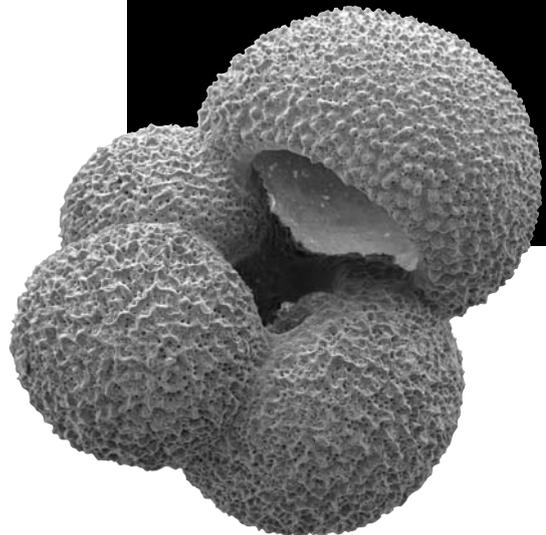
A study of ocean ecosystems dominated by the top predators broadbill swordfish, yellowfin and bigeye tuna, and striped marlin has provided knowledge and management tools for Australia's Eastern Tuna and Billfish Fishery. A research voyage described the oceanography and seabed topography of key fishing grounds, tested acoustic techniques for estimating prey biomass, and identified key feeding sites and distinct bio-regions. Models have been developed for testing the impacts of fishing patterns and climate change on target and bycatch species.

> *Report: Determining the ecological effects of longline fishing in the Eastern Tuna and Billfish Fishery, March 2009.*

> Evidence mounts on ocean acidification

Scientists from the Antarctic Climate and Ecosystems CRC and CSIRO published the first field evidence of a link between ocean acidification and a decrease in the shell-making ability of forams – microscopic marine animals at the base of the food chain. University of New South Wales and CSIRO researchers have also found that the 'tipping point' of ocean acidification – when carbonate levels are too low for some plankton to build and maintain shells – may be reached much earlier than previously predicted.

> *Nature Geoscience, 8 March 2009; Proceedings of the National Academy of Science, 11 November 2008*





> Jellyfish joyride

Scientists have called for urgent action to address the problem of large increases in jellyfish numbers, which they say are the result of human activities. Researchers from CSIRO, the University of Queensland and overseas believe the current 'jellyfish joyride' is caused by a combination of over-fishing, climate change and nutrients from fertilisers and sewage. A picture is now emerging of more severe and frequent jellyfish outbreaks worldwide.

> *Trends in Ecology and Evolution*, 6 June 2009



> Aerial whale count

CSIRO statisticians working with the Australian Antarctic Division have conducted the first fixed-wing aerial survey of minke whales in the Antarctic. This technique overcomes the limitations of traditional surveys from research vessels that cannot penetrate the pack ice where the whales may be, preventing accurate counts. The observers flew transects in a plane fitted with video, infrared and still cameras. This project is helping reinforce Australia's global leadership in non-lethal whale research.

> *Report: An aerial survey for Antarctic minke whales in sea ice off East Antarctica: A pilot study*, June 2009

> Ultimate guide to sharks and rays

Spookfish, numbfish, stingarees, fiddler rays and cookie-cutter sharks are just some of the 322 shark, ray and chimaerid species – collectively known as Chondrichthyans – illustrated in the new edition of *Sharks and Rays of Australia*. This definitive reference by CSIRO's Dr Peter Last and Dr John Stevens catalogues a rich seam of Australia's unique marine biodiversity, including 29 species discovered and 100 species named and formally described since the first edition was produced in 1994.

> *Sharks and Rays of Australia – Second Edition*, 2009, published by CSIRO Publishing

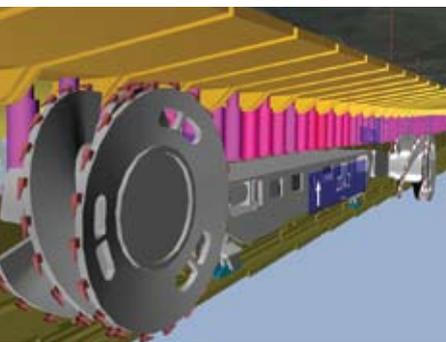


Transforming Australia's minerals industry

The mining industry is central to the Australian economy. Over the past 20 years it has contributed \$500 billion, but the future of this industry is far from assured. New deposits are not being found fast enough to replace those being extracted. Also many of Australia's deposits have declining grades, with an associated increase in waste rock, tailings, greenhouse gas emissions, and water and energy consumption.

Australia's challenge is to remain competitive in the global minerals market despite these hurdles.

CSIRO is committed to sustaining Australia's competitive edge through the development of new technologies and processes. We are integrating advanced technologies for next-generation tools and solutions to locate new mineral resources, and to deliver safer and more efficient mining, clean processing and value-added mineral products.



> World's miners adopt CSIRO innovation

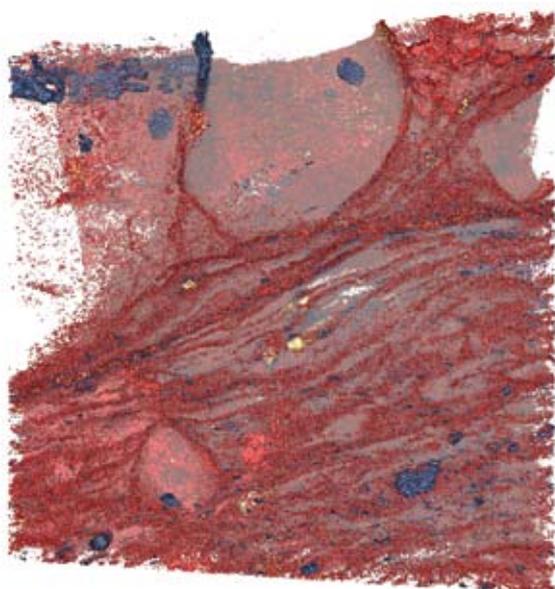
Over the next five years, about \$2 billion is expected to be returned to CSIRO through the licensing of its longwall mining automation technology. Underground longwall coal mining involves large machines cutting into the coalface. Automation of some of the processes increases mine productivity and moves miners away from hazardous, noisy and dusty environments. CSIRO leads the world in this technology and has signed non-exclusive worldwide licensing agreements with all of the world's major longwall mining equipment manufacturers.

> Licensed to Joy Australasia, Inbye Mining Services, Eickhoff Australia, Bucyrus Australia and the ZZM-KOPEX Group

> Safety lift for coal mines

Mine control-room operators have to deal with large, sometimes overwhelming amounts of information from numerous sources. But with CSIRO-developed Nexsys™, information is integrated, analysed and converted into information that provides operators with real-time risk-management and decision support, including automatic triggering of response plans in the advent of hazardous conditions arising. This new safety tool is expected to generate export sales and improve safety in the global mining community.

> Licensed to Mining Logic Solutions

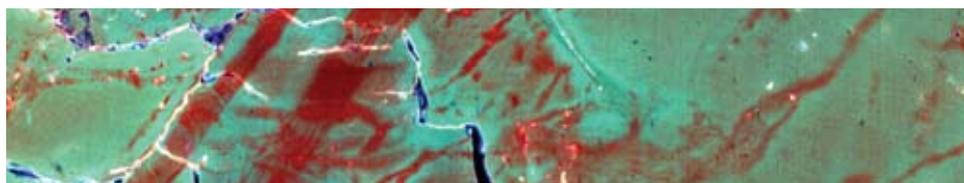
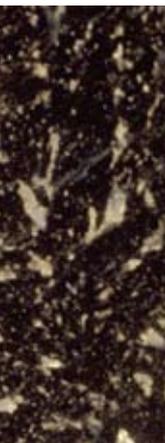


> Fresh clues to ore formation



For the first time, scientists have discovered the presence of a natural deep-earth pump that is a basic element in the formation of ore deposits and earthquakes. The discovery includes the first direct observation of fluid movement about 15 kilometres below the surface. The scientists propose that the 'granular fluid pump' is a self-sustaining process, where pores open and close allowing fluid and gas to be pumped out.

> *Nature, 18 June 2009*



> Ultra-trace elements brought into the light

A new microanalysis technique that quantifies light emission generated in a scanning electron microscope is allowing researchers to detect trace element levels that were previously unobtainable. Developed by CSIRO researchers, the technique, when applied to the mineral scheelite, allowed the interpretation of ultra-trace elements, providing important insights into the formation of gold deposits. This new technique allows researchers to analyse minerals to better understand a range of mineral growth and geoscience problems.

> *Microscopy and Microanalysis, June 2009*



> 'Green' slag processing

CSIRO is developing a novel dry granulation method for turning the molten slag produced during iron and steel making into a resource. The method will turn slag into a feedstock for the cement industry, while also saving up to three billion litres of water a year in Australia, and save waste heat for re-use in industrial processes. It has the potential to reduce annual greenhouse gas emissions from Australia's iron and steel and cement industries by up to 1.8 million tonnes.

> *International PCT Patent No. PCT/AU2009/000834 and PCT/AU2009/000835*

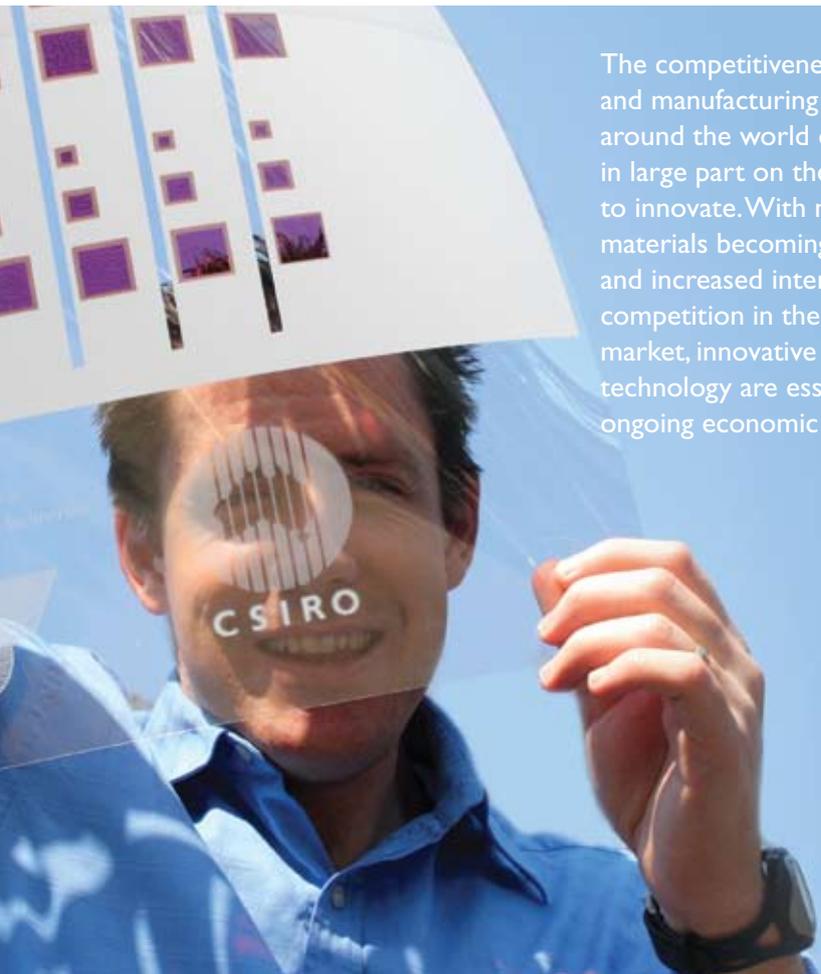


> Models measure coal options

CSIRO researchers have developed a mathematical and physical model to assess how dried brown coal could be used to fire Victorian power stations. With 70 per cent less water than currently used brown coal, dried brown coal has the potential to reduce carbon dioxide emissions when burnt to generate electricity. The mathematical model determined how furnace operations need to be changed to use dried coal, while a scaled-down cold model of the furnace is being used to validate the mathematical findings.

> *Process, June 2009*

Innovating materials & manufacturing

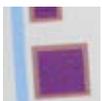


The competitiveness of materials and manufacturing sectors around the world depends in large part on their ability to innovate. With natural materials becoming more scarce and increased international competition in the manufacturing market, innovative science and technology are essential for ongoing economic sustainability.

Australia has a recognised track record in materials innovation and development, and manufacturing technologies, and needs to maintain this effort.

CSIRO is helping to secure Australia's global competitiveness by continuing to develop innovative materials technologies and processes that will transform existing industries and build future manufacturing opportunities. Such technology growth will support employment and deliver economic and social benefits by contributing to technical solutions across the energy, water, climate, health, security and environment sectors.

> Next generation solar cells



The discovery of molecules that deliver benchmark performance in high power conversion efficiencies is set to advance

Australia's solar industry. Developed by CSIRO and partners in the Victorian Organic Solar Cell Consortium, these flexible plastic solar cells are cheaper and more efficient to produce, and can be installed over large areas such as rooftops. The technology has the potential to replace silicon in the next generation of solar collectors.

> More at www.csiro.au

> Faster, safer, stronger welding

Tiny welding technology developed by CSIRO through the CRC for Welded Structures, has been transferred to an Australian manufacturer. The new welding tips are 50 per cent faster, last five times as long and use 50 per cent less energy and gases as conventional welding tips. Health and safety risks are also reduced with lower spatter and fume levels. Estimates of 27 per cent improved productivity gains have already been recorded by Australian manufacturers.

> Licensed to MIGfast Pty Ltd





> Safe, clean, fire-proofing

Researchers are taking building safety to a higher level with the development of a tough materials-coating system that is fire and acid-resistant. Known as HIPS – hybrid inorganic polymer system – the coating contains a ceramic-like inorganic polymer that can withstand temperatures over 1000°C. As water-based products, HIPS coatings are free of volatile organic compounds, do not burn or produce heat, and do not release smoke or toxic chemicals at temperatures up to 1200°C. This emerging class of engineering materials has the potential to transform the building products industry.

> Patent applications filed in Australia and USA



> Yarns for functional fabrics

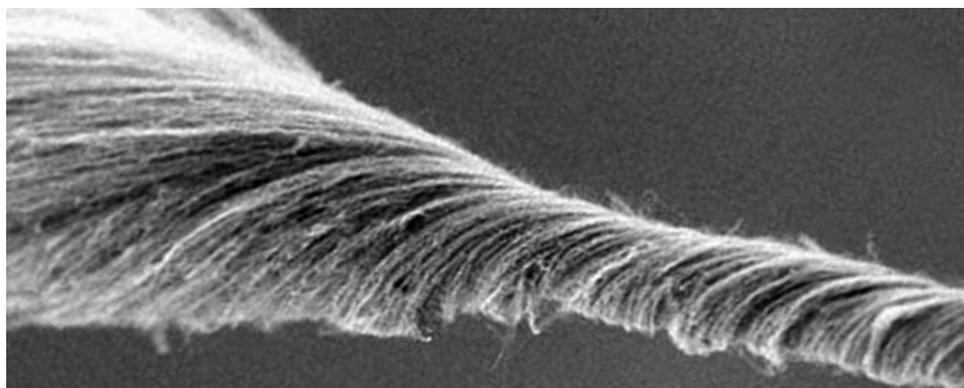
Carbon nanotube yarns are now stronger and more electrically conductive following CSIRO's advances in dry spinning of carbon nanotube yarn. These advances will enable the production of futuristic products, such as strong, light and flexible 'smart' clothing, and a new generation of manufactured devices and instruments. The property improvements to carbon nanotube yarns will increase the opportunities for Australian manufacturers to develop products in new value-add industries.

> Carbon, 27 May 2009

> Imaging world-first

CSIRO has developed the world's first terahertz imaging system based on a high temperature superconducting Josephson detector. The system operates at 77 Kelvin (liquid nitrogen temperature equivalent to -196 °C) and can be used to image subsurface structures for a variety of applications, including security to detect concealed weapons or substances, and health for the imaging of tumours beneath the skin.

> Patent No. 6514774 (USA) and 2357917 (UK); German patent application filed



> Old tyres a new resource

Each year about one billion tyres are discarded around the world, with most ending up in landfill. As part of an Advanced Manufacturing CRC project, CSIRO is collaborating with VRTEK Operations to develop new technologies designed to reduce waste tyres to devulcanised and activated high-quality rubber powders that can be used to manufacture new rubber products. CSIRO and VRTEK recently succeeded in segmenting tyres into specific pieces using a cutting mechanism built to VRTEK's design.

> Patent (VRTEK)

> Partnership cast for success

CSIRO technology has helped transform an Australian manufacturer into an international technology exporter. Aluminium-casting machines made by o.d.t. Engineering Pty Ltd now incorporate CSIRO's patented pouring system and ingot mould design, which improve ingot quality and increase casting productivity by almost 20 per cent. The high performance technology resulted in o.d.t. securing a contract in 2009 to supply six casting machines to an international aluminium producer. The research was funded entirely through the CAST CRC.

> Licensed to o.d.t. Engineering Pty Ltd

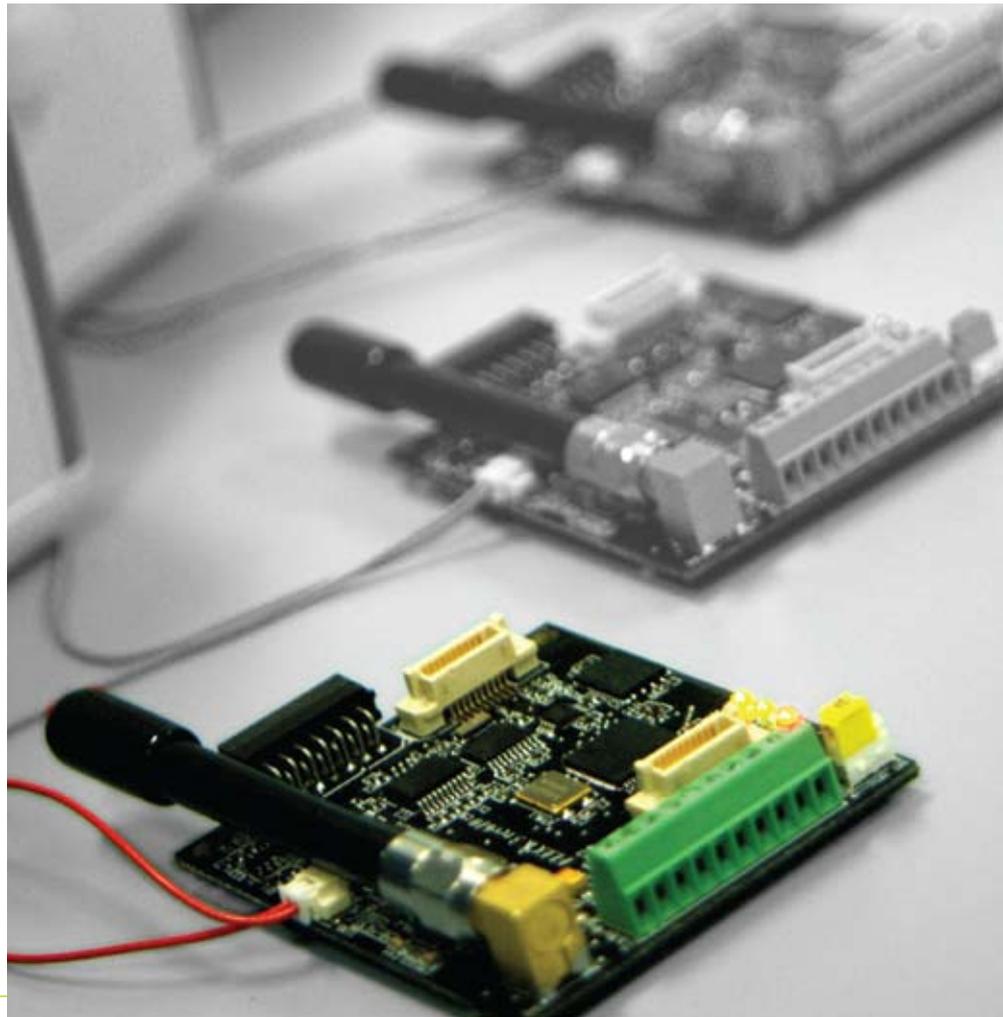


Enabling industries through ICT

We live in an increasingly fast-paced and information-rich world. Individuals and businesses want immediate and virtual access to information. The need to collect, manage and use information is unique to no one.

Almost all sectors of the Australian economy are underpinned by information and communication technologies. Innovative ICT research provides opportunities for improving productivity and transforming industries.

CSIRO is providing innovative ICT solutions to deliver enhanced services across industry sectors including health, the environment, energy, agriculture, security and mining. We are developing the enabling technologies and systems that are relevant to Australia and have the potential to lead to globally adopted solutions.



> Environment super sensors



An Australian SME is now manufacturing CSIRO's patented smart wireless sensor network technology, FLECK™. These sensor nodes gather environmental data independently, then cooperate to wirelessly send the data to a database. The nodes use little power; are solar capable and have a range of about one kilometre.

FLECK™ is now helping monitor the quality of Brisbane's drinking water. CSIRO, with project partner Seqwater, has deployed about 50 floating nodes in the Wivenhoe and Somerset Dams plus 70 microclimate stations throughout the catchment.

> Manufactured by The Powercom Group, 2009

> Software strengthens security response

Sophisticated analysis technology jointly developed by CSIRO and Boeing has been licensed to an Australian SME to develop software for protecting Australia's security with a whole-of-situation analysis capability. Designed to address the need for solutions to 'needle-in-a-haystack' problems, the software enables counter-terrorism agencies to analyse, crosslink and query huge datasets.

> Licensed to Semantic Sciences, November 2008



> Emergency bottlenecks prevention

The Australian e-Health Research Centre (AEHRC) has created software that predicts how many patients will turn up at hospital emergency departments, their expected medical needs and the number of hospital admissions. Developed in collaboration with clinical staff, the Patient Admission Prediction Tool allows on-the-ground staff to see what the patient load will be like in the next hour, for the rest of the day, into next week and even on holidays with varying dates, such as Easter.

> More at www.csiro.au



> A major ICT research collaboration with China

Joining forces with the Beijing University of Posts and Telecommunications, CSIRO is leading a major research collaboration with China – the Australia-China Research Centre for Wireless Communications launched in March 2009. This will put both countries at the forefront of research into future wireless communications technologies, including next-generation mobile networks.

CSIRO's reputation in wireless technologies stems from pioneering work in high-speed wireless local area networks (WLANs). This patented technology is now used in almost every wireless LAN around the world.

> More at www.csiro.au

> CSIRO e-health centre goes national

The Australian e-Health Research Centre (AEHRC) – a joint venture between CSIRO and the Queensland Government – went national in July 2008 after securing \$20 million in funds from the Federal and Queensland governments. Centre nodes are now in Queensland, South Australia and Victoria. Established in 2003, the AEHRC has become a leading facility in information and communication technologies that help health research providers improve the quality and safety of healthcare delivery. The AEHRC focuses on developing applied e-health solutions that are actively adopted by the health system.

> More at www.csiro.au

> Global health toolkit

Researchers have developed software that can process medical data 10 times faster than other classifiers. Called Snorocket™, it is standardising descriptions of patient symptoms, treatments and outcomes in electronic health records around the world. The software, developed by CSIRO through the Australian e-Health Research Centre, has been included in the International Health Terminology Standards Development Organisation's (IHTSDO) new workbench for classifying medical information. It will soon be used by IHTSDO member organisations, including Australia's National E-Health Transition Authority.

> Released by IHTSDO, February 2009

Teachings from outerspace

Much can be learned from the universe – our past, our present, our future. Scientists around the world are utilising satellites, spacecraft and telescopes to explore outer space and better understand the intricacies of our solar system and beyond.

Astronomy is among Australia's highest-performing areas of research, as measured by

international citations. CSIRO underpins this by operating a world-class National Research Facility for radio astronomy, supported by leading-edge technical innovation and high-quality astrophysical research.

Over the next five years CSIRO will contribute answers to key science questions of 21st century astrophysics and physics, including the formation of the first stars, the origin of cosmic magnetism, the nature of dark energy and the most stringent tests of general relativity.

> Upgrade turns data stream into a torrent

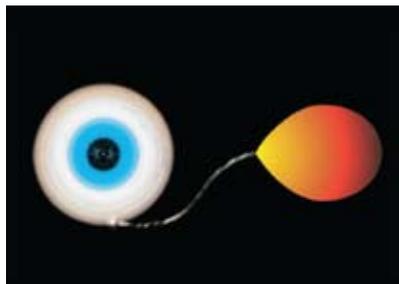
A seven-year, \$12 million upgrade of CSIRO's Australia Telescope Compact Array radio telescope has resulted in an instrument that is four times more sensitive to the faint signals of the universe and better able to detect cosmic objects travelling at a wider range of velocities. The Compact Array Broadband Backend upgrade has 'opened the taps', allowing 80 times more data to flow from the antennas to the rest of the system. It can be compared to moving the universe from dial-up to broadband.

> More at www.csiro.au

> Pulsar precision refined

Researchers have used six radio telescopes from the Australian Long Baseline Array, operated by CSIRO, to obtain the most accurate pulsar distance determination to date. The newly determined distance (156.3 +/- 1.3 pc, where 1 pc is 3.0856×10^{13} km or about 3.26 light years) to a rapidly rotating pulsar (named PSR J0437-4715) and its nearby white dwarf star companion, allows researchers to probe general relativistic effects and has enabled high-precision tests of a possible time variability of Newton's gravitational constant.

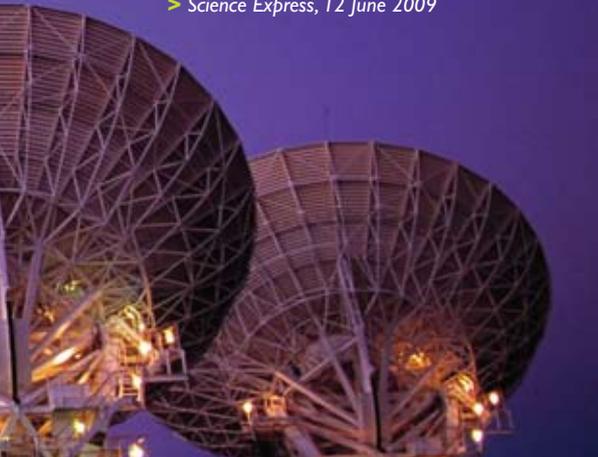
> *The Astrophysical Journal*, 20 September 2008



> Star caught in a spin

Using telescopes in the USA and the Netherlands, and CSIRO's Parkes Radio Telescope, researchers have witnessed a star being transformed into an object that spins at almost 600 times a second. Named PSR J1023+0038 and pictured above, the object is a millisecond pulsar, a condensed star about the size of a major city, which lies 4000 light-years from Earth.

> *Science Express*, 12 June 2009



> Still strong after 20 years

CSIRO's Australia Telescope Compact Array celebrated its 20th anniversary in September 2008 and continues to be one of the world's leading radio astronomy instruments. It is ranked the second most productive radio telescope in the world, as determined by the number of refereed papers generated and the total number of citations of refereed papers. The telescope operates 24 hours a day, 365 days a year and is used for more than 100 different observing projects each year.

> *Astronomische Nachrichten*, July 2008



> Next-generation radio telescope

The future of radio astronomy lies with the Square Kilometre Array (SKA), a next-generation telescope that will be located in either Australia or southern Africa. CSIRO is leading the development of the Australian Square Kilometre Array Pathfinder (ASKAP), a SKA precursor radio telescope being built in Western Australia. ASKAP will help astronomers to answer fundamental questions about the creation and early evolution of our universe and to test theories of cosmic magnetism and relativity.

> *Experimental Astronomy*, 28 October 2008

> New benchmark for star velocity spread

CSIRO's Mopra and Compact Array facilities have been used to discover water maser emission from a highly evolved star named OH 009.1-0.4 that lies in our galaxy. The emission has a velocity spread of 400 kilometres per second, which is the highest spread yet seen. It seems likely that this high-velocity emission, or 'water fountain', is in the form of jets along the star's rotation axis. These jets then collide with a dense wind that the star has ejected during the previous million years of its existence.

> *Monthly Notices of the Royal Astronomical Society*, March 2009

> Around the world in 80 telescopes

In early 2009, CSIRO telescopes initiated an almost non-stop, 33-hour observing marathon tracking three quasars as they rose and set with the rotation of the Earth. This unprecedented and extraordinary feat of international collaboration involved 17 telescopes and 28 data networks around the world, and marked the official start to the International Year of Astronomy. CSIRO's Parkes Radio Telescope also joined the global 24-hour webcast 'Around the World in 80 Telescopes', providing a snapshot of 'telescope life'.

> More at www.csiro.au

Science to better water Australia's 'food basket'

– The Murray-Darling Basin Sustainable Yields Project

Imagine the enormity of assessing in detail an area one-seventh the size of Australia – over one million square kilometres – to determine the condition of one of Australia's most important river basins. CSIRO was given this challenge by the Council of Australian Governments (COAG) in November 2006, to lead the Murray-Darling Basin Sustainable Yields Project.



The Murray-Darling Basin is often referred to as Australia's 'food basket'. It generates over 40 per cent of the gross value of Australian agricultural production, and over 60 per cent of all irrigation water in the country is used there.

At the start of the 21st century, it was clear the Murray-Darling was in trouble. The effects of prolonged drought, increased land development and associated water use, and the spectre

of climate change were causing a serious loss of water security for communities and the environment. To ensure the region's ongoing health, a whole-of-basin water assessment was required.

In late 2008, CSIRO presented to the Australian Government its report* on what has become the most comprehensive and technically challenging water-modelling project ever undertaken in Australia and possibly the world. It was certainly the single largest project ever undertaken in CSIRO's history.

The Murray-Darling Basin Sustainable Yields Project team conducted a complete assessment of all available water within the Basin, including an examination of assumptions about water availability in light of likely changes in climate, catchment development and groundwater extraction to 2030.

The team had to come to grips with over 40 individual jurisdictional water models and develop new surface and groundwater models to cover the entire

Basin. By linking these 70 models, the team generated a single super-model that, for the first time, allowed the flows and fate of water to be assessed from one end of the Basin to the other under different scenarios. Estimates for 2030 were provided for a range of possible climate scenarios, ranging from dry to wet.

The sheer size and importance of the project required the collaboration of more than 170 people (including 60 CSIRO researchers) and more than 15 organisations from government, industry and the then Murray-Darling Basin Commission.

The project's results are now informing water policy at both national and state level, in particular the development of the Murray-Darling Basin Plan. Its approaches and methods are also being used in three follow-on assessments in northern Australia, south-west Western Australia and Tasmania. CSIRO is leading these initiatives with its partners.

** Full report: Water Availability in the Murray-Darling Basin, October 2008.*

Award winning science

In 2008, the Murray-Darling Basin Sustainable Yields Project team was awarded the CSIRO Chairman's Medal – honouring the very best in CSIRO research. The award recognises the team's success in increasing the knowledge which is fundamental to the sustainable management of one of Australia's most important regions, the Murray-Darling Basin.

Man's new best friend – a cow named Dominette

–The Bovine Genome Sequencing Project

Ever since cattle were first domesticated farmers have been looking for ways to breed higher-performing animals. However, without a thorough understanding of the genetic make-up of cattle, and the role different genes play in influencing production traits, farmers have been working somewhat in the dark.

But now, following groundbreaking research* by an international consortium of scientists, the cow genome has been sequenced. This genetic map provides far greater understanding of the relationship between the form and function of an animal and its genetic code. The research is likely to have a profound impact on livestock industries around the world and, in turn, help scientists interpret the human genome sequence.

CSIRO scientists were among the 300 researchers from 25 countries involved in the six-year Bovine Genome Sequencing Project designed to sequence, annotate and analyse the genome (genetic make-up) of a female Hereford cow called LI Dominette.

The project concluded that the cow genome consists of 2.9 billion DNA base pairs, containing a minimum of 22,000 genes. Small differences in DNA sequences of individuals can affect how genes function and this can mean the difference between a highly productive animal and a poor performer.

By being able to identify these genes, far more sophisticated breeding programs can be implemented to produce livestock suited to particular markets or environments. There can also be overarching gains. For example, by selecting animals for feed efficiency, it may be possible to decrease the beef industry's environmental 'footprint'.

One of the surprises from the research was the discovery that cattle have far more in common genetically with humans than mice or rats have with



humans. Of the 22,000 genes in the cow genome, 80 per cent are shared with humans. This suggests that cattle may make better subjects for studying human health than the traditional rodent models.

Another important finding was that cattle have significant rearrangements in many of their immune genes and presumably an enhanced natural ability to defend themselves against disease. Exploring these findings should help medical researchers gain insight into the human genome and develop improved ways to treat and prevent disease.

Using the complete genome sequence from LI Dominette as a framework, scientists also undertook comparative sequencing for six additional breeds to look for genetic differences. The resulting bovine HapMap – a literal map of genetic diversity among different cattle populations – has allowed the development of gene chips that help identify animals with higher-value commercial traits. This could lead, for example, to cattle breeds with higher meat and milk production, improved resistance to parasites, improved fertility and increased feed efficiency.

The cow genome project data is expected to underpin livestock research for many decades. There is enormous potential for new avenues for research and industry application. CSIRO is well positioned to utilise this data through its extensive bioinformatics capabilities and access to databases containing the growth characteristics of large numbers of production animals.

As the genomes of more species are sequenced, scientists will better understand the function and evolutionary processes that act on genomes. This is sure to unlock new understanding and strategies to treat and prevent disease in humans and animals.

Funding for the Bovine Genome Sequencing Project was provided by: CSIRO; AgResearch Ltd; Agritech Investments Ltd; Dairy Insight Inc; Genome Canada; Kleberg Foundation; National Human Genome Research Institute; National, Texas and South Dakota Beef Check-off Funds; State of Texas; US Department of Agriculture.

* Research published in two papers in *Science*, 24 April 2009: *The genome sequence of taurine cattle: a window to ruminant biology and evolution*, and *Genome-Wide Survey of SNP Variation Uncovers the Genetic Structure of Cattle Breeds*.

Front-line defence – the science shield against disease

– The Australian Animal Health Laboratory

Newly emerging and exotic animal diseases pose a constant threat both to human health and to Australia's livestock industries. The ability to investigate such diseases, and quickly develop diagnostic tools and methods to limit their spread is crucial for the protection of the Australian community, economy, and environment.

To this end, CSIRO is the nation's front-line defence force, and science is its weapon – in particular the sophisticated research capabilities housed at the Australian Animal Health Laboratory (AAHL) in Geelong, Victoria.

AAHL is a national centre of excellence in disease diagnosis, research and policy advice in animal health. It plays a vital role in maintaining Australia's capability to quickly diagnose exotic and emerging diseases that threaten Australia's livestock, aquaculture species, wildlife and people. Through AAHL, CSIRO provides an advanced risk-management capability for managing and containing disease outbreaks of national and international concern.

In 2009, CSIRO scientists at AAHL made a major breakthrough in better understanding how the deadly Hendra virus spreads among horses and to humans. This groundbreaking research defined the actual period,

AAHL is a World Organisation for Animal Health (OIE) Reference Laboratory for:

- avian influenza • Hendra and Nipah virus diseases • Newcastle disease • bluetongue disease • epizootic haematopoietic necrosis virus • yellowhead disease.

Plus an OIE Collaborating Centre for:

- new and emerging diseases
- laboratory capacity building.

And also a:

- World Health Organisation Collaborating Centre for severe acute respiratory syndrome (SARS)
- National Reference Laboratory for rabies and brucella.



following the first signs of disease, when infected horses are most likely to infect other horses and people.

The threat of Hendra virus is now likely to be considered or recognised earlier in sick horses, allowing confinement strategies to be implemented sooner while corroborating tests are carried out. This testing also uses CSIRO research that has quickened the time it takes to diagnose the virus.

2009 also saw the rapid, global outbreak of H1N1 influenza – swine flu. Even before the virus appeared in Australia, scientists at AAHL were developing typing serum for human influenza for diagnostic purposes, as well as capability for diagnostic tests in animals.

CSIRO scientists continue to investigate the H1N1 virus, including helping partners working on vaccines, studying the biology of the virus as it develops in humans and the impact of antivirals, plus looking at the potential impact of H1N1 on Australia's pig industry.

Regarded as one of the most sophisticated laboratories in the world, AAHL's capabilities were further strengthened in July 2008 with the

opening of the Diagnostic Emergency Response Laboratory (DERL), within AAHL's high bio-containment facility.

DERL is a specialised laboratory capable of processing more samples, faster. In the event of a large-scale animal disease outbreak, DERL becomes an assembly line for samples, enabling staff to perform diagnostic tests on up to 10,000 samples a day within maximum biosecurity. During 'routine mode', DERL facilitates the development and validation of tests for predictive biomodelling activities. DERL adds considerably to AAHL's already world-class reputation.

Every day, scientists at AAHL are protecting Australia from real and potential animal disease threats. Their knowledge and expertise is also helping neighbouring countries and others to deal with emergency animal diseases. This support not only reduces the disease risks to those countries, but strengthens Australian biosecurity through better threat-assessment and management.

AAHL is funded by the Australian Government, via CSIRO and the Department of Agriculture, Fisheries and Forestry.



Royal Society honours scientific excellence

– Dr Jeff Ellis, Research Program Leader

In May 2009, biologist Jeff Ellis was elected as a Fellow of the Royal Society. The appointment recognised his world-leading research that identified for the first time the two key genes that determine whether plants are infected by crop diseases caused by rust fungi.

Rust fungi are a major threat to world food security, causing devastating crop losses. In epidemic years the value of lost harvests worldwide can be almost A\$7.8 billion.

Jeff and his team used gene transfer technology to unravel fundamental aspects of plant biology in the model flax/flax rust system. They identified how rust pathogens cause disease in plants and how resistant plants recognise the rust virus and trigger a defence response. Flax is a non-food plant grown for linseed and for fibre used to produce linen and has been used to study the interaction between plants and their rust pathogens for more than 50 years.

This research is a major step forward in understanding the interactions of plants and pathogens and ultimately in improving disease and pest resistance in food crops.

Jeff is now working towards translating the discoveries from the model system into protecting wheat from wheat rust, and delivering this information to Australian wheat breeders for the development of new rust-resistant varieties. This could have a profound impact on improving rust resistance and crop yields for the grains industry.

Jeff's appointment to the Royal Society is an acknowledgement of the international significance of the work he and his team perform in Australia. He joins a distinguished 'club' of Australian Fellows including Suzanne Cory, Jim Peacock and Sir Gustav Nossal, and world-renowned figures such as Charles Darwin and Sir Joseph Banks.

Founded in 1660, the Royal Society is the national academy of science for the United Kingdom and the Commonwealth, and is the world's oldest scientific academy.



Small-science physicist on the world stage

– Dr Amanda Barnard, Research Scientist

Is there anything this young physicist cannot do? Amanda Barnard has won seven national and international awards in the past year alone, confirming her status as an internationally recognised physicist and author.

The most significant of her recent awards was the International Union of Pure and Applied Physics 2009 Young Scientist Prize in Computational Physics. This award acknowledged Amanda as a world leader in nanomorphology – the study of the structures, shapes and crystal structures of materials at the nanoscale.

Amanda has made substantial contributions to the field of nanoscience, in particular to how nanoparticles interact with the environment and how environmental changes may affect their stability. Using supercomputer simulations, Amanda's research focuses on enabling scientists to understand how these tiny artificial pieces of matter interact with natural ecosystems.

Understanding the stability of nanoparticles is important because scientists need to

know that what they have created in the laboratory remains the same in the environment. This is of central importance for environmental impacts, but also for the ultimate performance of devices.

Consumers who buy products containing nanoparticles want to know how they will work under different conditions, when exposed to moisture, light or air; for example. Such devices and end-uses currently range from wound dressings and cosmetics, to nanotech electronics and fuel catalysts in cars for improving fuel performance and lowering emissions.

Amanda is also looking from nature back to the laboratory, studying naturally occurring particles as they are often highly stable. Amanda's goal is to replicate this natural stability in the laboratory.

In addition to this work, and as part of a global initiative, Amanda is also looking at how diamond nanoparticles can add value to chemotherapeutic delivery systems and assist medical imaging using light imaging in cells. Amanda is the sole Australian involved in this research. To date, trials have shown that 20 times less drugs are needed in treatment programs when combined with nanoparticles, providing far better health outcomes for patients.

Amanda's work has earned her invitations to contribute publications on predicting and preventing the risks and hazards associated with nanomaterials, as well as to contribute her time to international committees and symposiums that debate these issues.



Champion of the marine neighbourhood watch

– Dr Beth Fulton, Office of the Chief Executive Science Leader

In May 2009, on a trip to see whale sharks at Western Australia's Ningaloo Reef, CSIRO Science Leader Beth Fulton came face to face with an enormous potato cod.

Captivated by its sausage-shaped lips, steam-shovel mouth and disdainful eyes, Beth thought she was looking at the most amazing creature she had ever seen. The potato cod was less impressed, despite its encounter with a human whose work influences the management of marine ecosystems across the world.

Beth was at Ningaloo to talk to local workers and residents about research to support sustainable development, tourism and management of the region.

The research team led by Beth uses video-game technology to build ecosystem models that simulate marine biology, physics and geology, human activities, and their inter-connections.

The models test potential management actions, helping governments, industry and the community respond to pressures of urbanisation and climate change, and competing uses such as tourism, shipping and resource extraction.

Beth's Atlantis computer model was the first in the world to give equal attention to the biophysical and human aspects of fishery ecosystems. It has been applied to more than 17 regions in Australia, the United States, South Africa and Europe.

With an international team, Beth used the Atlantis and Ecosim models to analyse ecosystem recovery in 31 fisheries worldwide. Steps taken to curb

overfishing were succeeding in five of the 10 large marine ecosystems examined.

Beth and her colleagues also developed InVitro, a model tailored for several ecosystems. The version developed for Ningaloo Marine Park embraces the physical structure, ecosystem features and human use of the area, as well as regional economics and potential global events such as terrorism.

Beth's position as an Office of the Chief Executive Science Leader provides scope for developing the next generation of models. These will consider the effects of evolution and biodiversity shifts on marine systems in the face of changing human uses and climate.



Faster, smarter, stronger – tomorrow's materials

– Dr Kostya Ostrikov, Office of the Chief Executive Science Leader

It's amazing there's any time left in the day for physicist and CSIRO Science Leader, Kostya Ostrikov. In his first year with CSIRO alone, he published 49 scientific papers and one sole-authored book. This averages out to almost one publication a week – an extraordinary effort in any scientific circle.

It is the area of plasma nanoscience that has Kostya so captivated; discovering the unique properties and diverse applications of these ultra-tiny (microscopic) pieces of matter, or ionised gases. Kostya is regarded as an international pioneer in this field. It was he who determined how to control various plasma characteristics to precisely position their building blocks and, in turn,

create self-organising nanostructures – something that had eluded researchers for some time. This, and Kostya's exceptional career to date, saw him appointed as an Office of the Chief Executive Science Leader at CSIRO in 2008.

So what is plasma nanoscience? Research in this field looks at the effect ionised gases – plasmas – have on the properties, assembly and self-organisation of micro and nanoscale objects. It is a new and rapidly expanding research area at the cutting edge of many scientific disciplines, including physics, nanoscience and nanotechnology, surface science, materials science, structural chemistry, astrophysics, life sciences, and more.

The current manufacture of nanoscale devices – such as computer microchips,

biosensors and communication devices – is mostly process-specific and suffers from cost-inefficient 'trial and error' practices with limited controls. Plasma nanoscience on the other hand provides greater control and is significantly faster.

Kostya's research aims to further explore plasma nanoscience and develop a radically new predictive approach and specific techniques to create self-organising, intricate nanostructures that will lead to the development of next-generation materials, nanodevices and sensors.

The outcomes of Kostya's research are expected to revolutionise CSIRO's – and the world's – capabilities for nanoscale synthesis and will have wide scientific, technological and commercial benefits.

OCE Science Leaders Scheme

CSIRO's Office of the Chief Executive Science Leaders Scheme attracts high-performing early to mid-career scientists from across the globe. It provides them with the resources and freedom of research direction to deliver outstanding scientific impacts that contribute to CSIRO's ability to provide for Australia's prosperity and wellbeing.

Honouring our science

– CSIRO medals and awards

At CSIRO, our staff are the organisation's heart and soul. Their talent, vision and commitment to solving problems and exploring opportunities are key to our success. Foremost, it is our staff who are working every day to thread the importance of scientific endeavour into the fabric of Australian society. Each year we honour the tremendous efforts our people put into achieving this goal with the awarding of CSIRO medals and awards.

The CSIRO Chairman's Medal

The Murray-Darling Basin Sustainable Yields Project Team

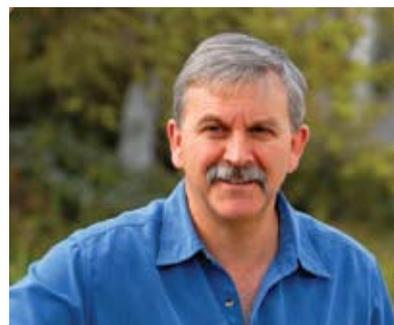
(Water for a Healthy Country Flagship, Land and Water and Marine and Atmospheric Research)

For research that has delivered the most comprehensive and complex whole-of-basin water assessment ever undertaken in Australia.

Commonly regarded as Australia's food basket, the Murray-Darling Basin generates over 40 percent of the gross value of Australia's irrigated agricultural production.

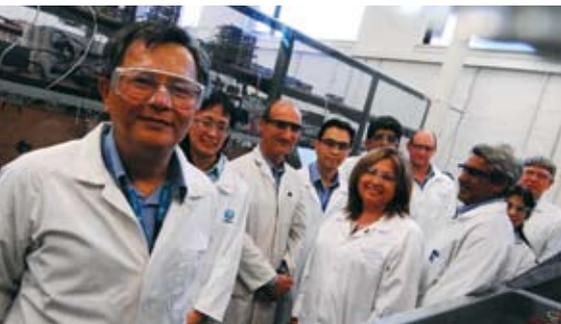
Dr Tom Hatton and his team undertook the most comprehensive and complex whole-of-basin water assessment ever undertaken in Australia.

This knowledge will be fundamental to the future sustainable management of one of Australia's most important agricultural regions.



The Team (Seminal and significant contributors):
 Dr Tom Hatton (Team Leader), Mr Mark Alcorn, Ms Jenet Austin, Ms Kate Austin, Dr Brian Barnett, Mrs Janice Bathols, Mr Heinz Buettikofer, Dr Francis Chiew, Mr Peter Cook, Dr Richard Cresswell, Dr Russell Crosbie, Ms Sue Cuddy, Dr Carl Daamen, Mr Andrew Davidson, Mr Phillip Davies, Ms Rose Davis, Mr Trevor Dowling, Dr Ray Evans, Mr Richard Evans, Ms Kathryn Farry, Ms Dianne Flett, Mr Andrew Freebairn, Dr Andrew Frost, Mr Simon Gallant, Dr Juan Pablo Guerschman, Ms Rachael Gilmore, Dr Anthony Goode, Mr Paul Harding, Mr Mick Hartcher, Dr Peter Hill, Ms Linda Holz, Dr Donna Hughes, Mr Craig Johansen, Dr Phillip Jordan, Mr Durga Kandel, Mr Scott Keyworth, Dr Mac Kirby, Dr Dewi Kirono, Dr David Lemon, Ms Nicola Logan, Mr Yi Lui, Mr Mohammed Mainuddin, Dr Nick Marsh, Mr Steve Marvanek, Mr James McCallum, Mr Craig McKay, Mr Geoff McLeod, Ms Linda Merrin, Dr Brad Neal, Mr Steve Page, Dr Zahra Paydar, Mr Jorge Pena-Arancibia, Mr Jean-Michel Perraud, Dr Geoff Podger, Dr David Post, Dr Nick Potter, Dr Ian Prosser, Mr Bai Qifeng, Mr Arthur Read, Dr Stuart Richardson, Dr Tony Sheedy, Mr Garry Swan, Mr Jin Teng, Dr Albert Van Dijk, Dr Jai Vaze, Dr Neil Viney, Mr Jamie Vleeshouwer, Dr Vic Waclawik, Dr Q J Wang, Dr Glen Walker, Dr Wendy Welsh, Mr Paul Wettein, Dr Ang Yang, Dr Bill Young and Dr Lu Zhang.

The CSIRO Medal for Research Achievement



The UltraBattery Project Team (Energy Technology and Energy Transformed Flagship)

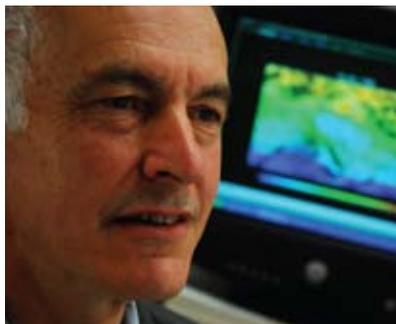
For innovative research resulting in the invention and development of the UltraBattery – an advanced hybrid energy storage device for automotive and renewable storage applications.

A hybrid energy storage device, the UltraBattery represents a truly revolutionary step-change for the automotive industry.

Dr Lan T Lam and his team combined supercapacitor and lead-acid battery technologies to develop this revolutionary new storage system. It is 70 per cent less expensive than current hybrid electric vehicle (HEV) battery systems, lasts four times longer, charges and discharges energy at a faster rate and has 50 per cent more power than existing systems.

The roll out of the UltraBattery could lead to greater uptake of HEVs and significantly reduce carbon emissions globally from the transport sector.

The Team: Dr Lan Lam (Team Leader), Mr Nigel Haigh, Mr Owen Lim, Ms Rosalie Louey, Ms Hilkat Ozgun, Mr Christopher Phyland, Dr David Rand, Mr David Vella and Ms Lan Vu.



The CSIRO Climate Model Development Team (Marine and Atmospheric Research)

For developing one of the world's top coupled ocean-atmosphere climate models and for making significant national and international contributions to the science of climate change and to national and international assessments.

Dr Hal Gordon and his team developed one of the world's top coupled ocean-atmosphere climate models.

The CSIRO climate model has become the mainstay of CSIRO climate research and is instrumental in keeping CSIRO and Australian expertise at the forefront of international research on climate and climate change.

The Team: Dr Hal Gordon (Team Leader), Mr Mark Collier, Mr Martin Dix, Ms Tracey Elliott, Dr Tony Hirst, Ms Eva Kowalczyk, Dr Richard Matear, Dr John McGregor, Dr Siobhan O'Farrell, Dr Steven Phipps, Dr Leon Rotstajn, Dr Ian Watterson and Dr Steve Wilson.



The Hydrodec Process Team (Energy Technology)

For the development of the Hydrodec process that simultaneously regenerates the electrical properties of degraded transformer oils and destroys any organochlorine contaminants.

A team led by Dr Greg Duffy and Dr Chris Fookes developed a process which has the potential to save hundreds of millions of dollars on the treatment, disposal and import of transformer oils for industry each year while reducing environmental contaminants.

The Hydrodec process is the only technology available in the world that both removes contaminants, like organochlorine contaminants, and regenerates the electrical properties of transformer oil leaving it as good as, if not superior to, the original oil.

The Team: Dr Chris Fookes, Dr Greg Duffy (Team Leaders), Mr Roger Bolling, Dr Cameron Briggs, Mr Ian Campbell, Mr Martin Chensee, Dr Narendra Dave, Mr Ken Davis, Mr Stuart Day, Mr Cihan Dokumcu, Mr Harro Drexler, Dr Alf Ekstrom, Ms Karen Hanselmann, Mr Barry Jones, Ms Leonore Ryan, Dr Sunil Sharma, Ms Cherie Walters, Mr Steve Weir, Mr Joe Wong and Mr Ken Wong.

The CSIRO Medal for Business Excellence



The TiRO Transaction Team

(Light Metals Flagship, Minerals, Commercialisation and Legal)

For seminal contribution to establishing an Australian titanium industry.

Titanium is stronger than steel and weighs 40 per cent less. It is also a resource with which Australia is naturally imbued and developing a Titanium industry in Australia would add billions of dollars to the economy.

The TiRO team led by Dr Raj Rajakumar successfully engaged a commercial partner to invest the technology, with the goal of developing a titanium pilot manufacturing plant in Australia.

This significant achievement represents the first major step towards a Titanium industry in Australia.

The Team: Dr Raj Rajakumar (Team Leader), Ms Kiara Bechta-Metti, Dr Christian Doblin, Dr Chris Goodes, Dr Alan Manzoori, Mr Andreas Monch, Ms Lynda O'Brien, Ms Julie Pulford, Mr John Shaw, Dr Grant Wellwood and Ms Tania Wong.



The Underground Coal Gasification Team

(Energy Technology, Exploration and Mining, Legal and Business Services)

For technology transfer to support the commercial development of an environmentally responsible underground coal gasification industry in Australia.

Underground Coal Gasification will expand Australia's usable coal resources by enabling its users to access coal resources previously seen as uneconomical to explore.

A multidisciplinary team successfully created a unique energy generating process – Underground Coal Gasification – that is leading to the commercial development of a new environmentally responsible energy generation industry in Australia.

The Team: Ms Anna Littleboy (Team Leader), Dr Deepak Adhikary, Dr Andrew Beath, Ms Kiara Bechta-Metti, Ms Jan Bingley, Mr Max Cozijn, Dr Stuart Craig, Dr Narendra Dave, Dr Thong Do, Mr Alex Eastwood, Mr Stephen Fraser, Dr Deliana Gabeva, Dr Cliff Mallett, Mr Rusty Mark, Mr Tim McLennan, Dr Renate Sliwa, Dr Andrew Wilkins, Ms Tania Wong and Dr John Wright.

The CSIRO Medal for Lifetime Achievement



Dr John K Wright
(Energy Transformed Flagship)

For raising the profile of CSIRO's commitment to energy research and development, and taking a leading role in the development of Australia's energy future.

Through his research and leadership, Dr John Wright has forged an exemplary path for CSIRO as a leading organisation worldwide that is committed to developing new technologies to enhance Australia's energy future.

The John Philip Award for the Promotion of Excellence in Young Scientists



Dr James Tickner
(Minerals)

For the development of novel computer modelling and experimental techniques in the field of radiation instrumentation and their application in the minerals and security industries.

Dr James Tickner works in the field of radiation instrumentation – that is, coming up with novel ways of using radiation to solve practical measurement and imaging problems in industry. Ionising radiation – X-rays, gamma-rays and neutrons – can penetrate deeply inside many materials and reveal an enormous amount of detail and information about the objects being examined.

James combines expertise in nuclear physics, computer modelling and experimental work to create new ways of solving challenging industrial problems.

Image details

The following information provides credit and caption details for the images used throughout this publication. Image details begin from the top left corner of each page and move clockwise.

1: CSIRO Chief Executive, Dr Megan Clark.
Credit: CSIRO

4-5: Clouds. Credit: iStockphoto.com

CSIRO research contributed to the Garnaut Climate Change Review. Credit: CSIRO

Adapting Western Port to climate change calls for changes to infrastructure. Credit: Greg Hunt, Western Port Greenhouse Alliance

Human-generated carbon dioxide emissions are growing four times faster since 2000. Credit: CSIRO

Dr Ying Ping Wang's team is simulating and predicting the interactions between climate change and terrestrial ecosystems. Credit: CSIRO

6-7: Tiny bubbles of air enclosed in a sliver of Antarctic ice. Credit: CSIRO

Sea surface temperature image indicating increased warming on Tasmania's east coast. Credit: CSIRO

Ocean changes due to climate change present both threats and opportunities for Australia's fisheries. Credit: Graham Blight

Frozen soil sediments in Siberia.
Credit: Edward AG Schuur

Scientists have found no evidence of a change in ocean current strength. Credit: Steve Rintoul

8-9: Mouth of the River Murray.
Credit: Fancy Films (on cover)

Queensland's new Currumbin Ecovillage provides houses with recycled water. Credit: Dept. Environment & Resource Management, QLD

CSIRO research is helping to protect the Great Barrier Reef. Credit: Marie Davies

Simon Higginson and Dr Elise Bekele sample groundwater. Credit: CSIRO

10-11: A wetland filter is helping extract metals and nutrients from treated waste water at the Ranger mine. Credit: Brad Sherman, CSIRO

Katherine Gorge and the Katherine River pictured using DEM. Credit: John Gallant, CSIRO (on cover)

Water conservation can play an important role in reducing greenhouse emissions.
Credit: iStockphoto.com

Treated urban stormwater can produce water of drinking standard. Credit: CSIRO

12-13: Science is revolutionising vision correction.
Credit: iStockphoto.com

Microspheres used to test DAC microscopy are one-thousandth the width of a hair. Credit: CSIRO

The 'poison arrow' frog. Credit: Arachnokulture, courtesy of Thomas Villegas

The CSIRO Healthy Heart Program. Credit: Penguin

CSIRO is investigating Alzheimer's disease.
Credit: iStockphoto.com

14-15: CSIRO's Dipak Bhandari with the Weight Management Mentor. Credit: CSIRO

CSIRO is contributing to the health of Australian children. Credit: iStockphoto.com

HDI tools are providing secure, large-scale research and analysis. Credit: iStockphoto.com

Biomarkers are a step closer to an improved bowel cancer diagnostic test. Credit: iStockphoto.com

16-17: Solar panels at the National Solar Energy Centre in Newcastle. Credit: CSIRO

Laurent Langhi showing software results predicting trap integrity as applied to the Timor Sea. Credit: CSIRO

The *Fuel for thought* report identifies options for Australia's transport fuel future. Credit: CSIRO

Researcher, Rosalie Louey, prepares UltraBattery components. Credit: CSIRO

18-19: Scientists have found the key to overcoming three major cereal diseases.
Credit: iStockphoto.com (on cover)

Unlocking the cow genome has provided valuable information. Credit: iStockphoto.com

Research is providing information that could improve Australia's livestock industries productivity.
Credit: iStockphoto.com

CottASSIST supports Cotton managers monitor their crops. Credit: CSIRO

20-21: Research is looking at the dangerous effects of space radiation on human DNA.
Credit: NASA/courtesy of nasaimages.org

Preshafruit juices. Credit: Design and photography by Design By Pidgeon

A concept of the GI and RS Analyser.
Credit: Stadvis Pty Ltd

Molecule beta-LG. Credit: Monash University Centre for Green Chemistry

22-23: A plant and its pathogen.
Credit: Carl Davies, CSIRO (on cover)

Plants and animals may need to be moved to protect them from climate change.
Credit: Sue McIntyre, CSIRO

Crimson rosella. Credit: Mathew Berg, Deakin University

Research is helping maximise mammal conservation investment. Credit: iStockphoto.com

24-25: There is no evidence yet that pollinator decline is affecting crop yields. Credit: iStockphoto.com

Atlas of Living Australia is linking Australian biological collections information.
Credit: David McClenaghan, CSIRO

The Australian ladybird, *Australoneda burgeoisi*.
Credit: J McDonald

Carbon offsets could be derived from Indigenous land management. Credit: Adam Leidloff, CSIRO

26-27: An artificially coloured electron micrograph of the deadly Hendra virus. Credit: CSIRO

RNA Interference: Methods for Plant & Animals.
Credit: Courtesy of CABI

Some rabbits carry a benign virus that gives them immunity to calicivirus. Credit: iStockphoto.com

Examining agar dishes for bacterial colonies as part of the bioremediation project.
Credit: David McClenaghan, CSIRO

A new bird flu vaccine has been developed for human use. Credit: Dr John Bingham, CSIRO

28-29: This instrument measures temperature and salinity in the ocean. Credit: CSIRO

New technologies and CSIRO processes are providing new approaches for monitoring Australia's marine ecosystems. Credit: CSIRO

OCEANMAG. Credit: Phil Schmidt, CSIRO

The Kimberley coastline. Credit: CSIRO

Australia's Northern Prawn Fishery is recognised as a world leader. Credit: Austral Fisheries

30-31: Elephant seals are assisting researchers gather data. Credit: Mike Fedak, St Andrews University

Jellyfish clogging fishing nets in Japan.
Credit: Y Taniguchi

Jellyfish. Credit: Karen Gowlett-Holmes, CSIRO

Orectolobidae reticulatus – one of the illustrations in *Sharks and Rays of Australia*. Credit: Roger Swainston

Ocean acidification is affecting microscopic marine animals called forams. Credit: Antarctic Climate and Ecosystems CRC

Uroptychus raymondi – one of the new marine species discovered. Credit: Karen Gowlett-Holmes, CSIRO.

32-33: Olivine-sulphide ore. Credit: CSIRO

A rock sample of less than 1 mm that was deformed in the earth's middle crust. Porosity highlighted in red.
Credit: Dr Florian Füsseis, University of WA (on cover)

A cathodoluminescence species map of a scheelite grain. Credit: Colin MacRae and Nick Wilson, CSIRO

Dr Dongsheng Xie and Mr Bernie Washington with CSIRO's pilot-scale dry granulation rig.
Credit: Mark Fergus

CSIRO leads the world in longwall mining automation technology. Credit: CSIRO

34-35: Dr Scott Watkins with a sample of flexible plastic solar cells. Credit: Tracey Nicholls, CSIRO
HIPS coatings withstand heat up to 1000 degrees.
Credit: Lawrence Cheng, CSIRO

Advances in dry spinning is producing improved carbon nanotube yarn. Credit: Dr CD Tran

New technologies are turning old tyres into new rubber products. Credit: iStockphoto.com

36-37: FLECK™ nodes. Credit: Sam West, CSIRO

Hospital trials show PAPT vastly improves successful prediction of patient loads. Credit: CSIRO

The Australia-China Research Centre for Wireless Communications is a major research collaboration with China. Credit: iStockphoto.com

38-39: Five of the six 22 metre antennas of the Australia Telescope Compact Array. Credit: CSIRO

Material from distended 'normal' star (right) streams onto accretion disk (white and blue) surrounding neutron star (left). Credit: Bill Saxton, NRAO/AUI/NSF

Artist's impression of ASKAP antennas.
Credit: Swinburne Astronomy Productions.
Design data provided by CSIRO

40: Monoman Creek, an anabranch of the River Murray. Credit: Ian Overton, CSIRO

41: LI Dominette 01449. Credit: Michael MacNeil, United States Department of Agriculture

42: CSIRO's Australian Animal Health Laboratory.
Credit: CSIRO

43: Dr Jeff Ellis. Credit: CSIRO

Dr Amanda Barnard. Credit: CSIRO

44: Dr Beth Fulton. Credit: CSIRO

Dr Kostya Ostrikov. Credit: CSIRO

45: Dr Tom Hatton. Credit: Fancy Films

46: Members of the UltraBattery Project Team.
Credit: Fancy Films

Dr Hal Gordon. Credit: Fancy Films

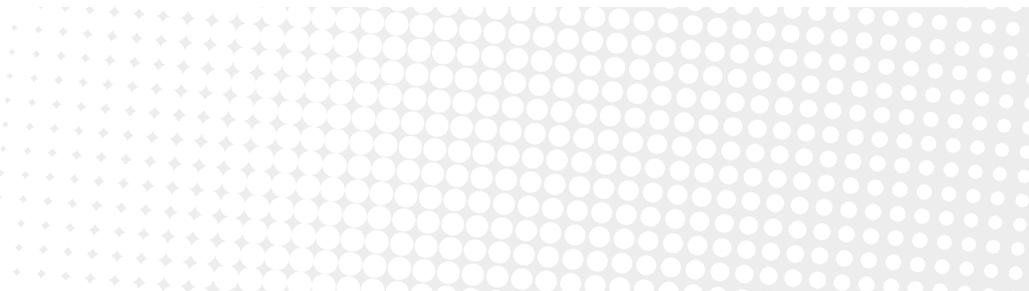
Dr Greg Duffy. Credit: Fancy Films

47: Dr Raj Rajakumar. Credit: Fancy Films

Members of the Underground Coal Gasification Team. Credit: Fancy Films

48: Dr John KWright. Credit: Fancy Films

Dr James Tickner. Credit: Fancy Films



Contact Us

Phone: 1300 363 400
+61 3 9545 2176

Email: enquiries@csiro.au

Web: www.csiro.au

Your CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.