

ROAD REVIEW

AUSTRALIAN

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*Linking Australian Science,
Technology and Business*

Green fuel for the future

Australia's biofuel enterprise is about to mature and there are major opportunities, as highlighted in a recent report on a Government commissioned **Advanced Biofuels Study**, which concluded that in the longer term, advanced biofuels produced in Australia could be cost-competitive to non-renewable fuels, reduce Australia's dependence on imported liquid fuels, provide environmental benefits and in a broader picture present a significant opportunity for Australia to create a significant new industry sector.

The recent **Qantas Airbus A330** take-off on a 50-50 blend of biofuel and regular jet fuel attracted some broader attention to the emerging industry which so far has not been much in the public's eye: On the back of the heightened publicity, the Government [announced](#) it would

fund a new feasibility study by **Qantas and Shell Australia** to investigate the long term viability of biofuel feedstock and sustainable production of low carbon alternatives to current aviation fuels in Australia. And earlier in February, it [launched](#) a new \$15 million **Advanced Biofuels Investment Readiness Program**, which will support the deployment of pre-commercial demonstration projects for the production of high energy, drop-in advanced biofuels in

Australia.

Here we provide a broader perspective on the development of biofuels, both in a global and national context. Among other sources, we also draw on articles in *Nature* in June 2011, [published](#) as part of a dedicated 'Outlook' on the rapidly developing global biofuels industry.

The global biofuels industry is in the process of progressing from so called first-generation biofuels to 'advanced' developments, which comprise second and third generations.

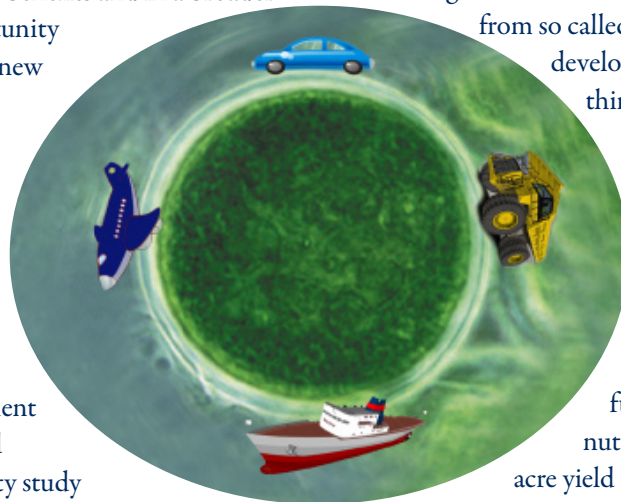
However, the use of terminologies, such as 'advanced biofuels', lack consistency and cause confusion.

A definition, promoted by **Advanced Biofuels USA**, defines advanced biofuels as high-energy

liquid transportation fuels derived from: low nutrient input/high per

acre yield crops; agricultural or forestry waste; or other sustainable biomass feedstocks including algae.

The emphasis of the definition is on sustainability, and in this covers both second and third generation fuels as advanced. The US Energy Independence and Security Act of 2007 puts more emphasis on potential GHG emission reductions (see box). Others restrict the term to the third generational stage, and a definition by the **International Energy**



International Energy Agency Biofuels Technology Roadmap:

"There is considerable debate on how to classify biofuels. Biofuels are commonly divided into first-, second- and third-generation biofuels, but the same fuel might be classified differently depending on whether technology maturity, GHG emission balance or the feedstock is used to guide the distinction. This roadmap uses a definition based on the maturity of a technology, and the terms "conventional" and "advanced" for classification...."

Energy Independence and Security Act of 2007:

"The term 'advanced biofuel' means renewable fuel, other than ethanol derived from corn starch, that has lifecycle greenhouse gas emissions, as determined by the Administrator, after notice and opportunity for comment, that are at least 50 percent less than baseline lifecycle greenhouse gas emissions."

[...continued page 26](#)

It keeps coming...

Continuing the splurge in grants for health and medical research, the government announced in December a further \$114.2 million investment in 159 grants, including 10 Program Grants, 16 Development Grants, 130 Postgraduate Scholarships and 3 Project Grants. This ups the Government's investment in health and medical research in 2011 from the \$673.7 million for 1,140 grants reported in our previous edition to now \$787.9 million for 1,299 research grants.

The awarded program grants, which are to commence in 2013, were selected from 18 applications and will make up 12% of the total funding awarded by the NHMRC this year.

The successful projects include:

- over \$6 million over 5 years for a study that relates to a recent field trial led **Professor Scott O'Neill** from **Monash University** (reported in our previous issue), in which dengue transmitting mosquitoes were infected with *Wolbachia* bacteria and released to control the spread of the dengue virus – the project now seeks to optimise the *Wolbachia* based control strategies.
- over \$12 million for a project at **Baker IDI Heart and Diabetes Institute** led by **Professor David Kaye** to develop approaches to improve outcomes for people suffering from hypertension, heart attack, heart failure & other serious forms of cardiovascular disease (CVD);
- over \$10 million for a project led by **University of Sydney Professor John Simes** to conduct clinical trials research aimed at reducing death and serious disability including through cancer, CVD, diabetes, obesity and neonatal diseases; and
- \$11 million for a project led by **Professor Glenda Halliday** at the **University of New South Wales** which aims to identify the sequence of cellular changes that occur in neurodegenerative disorders, such as

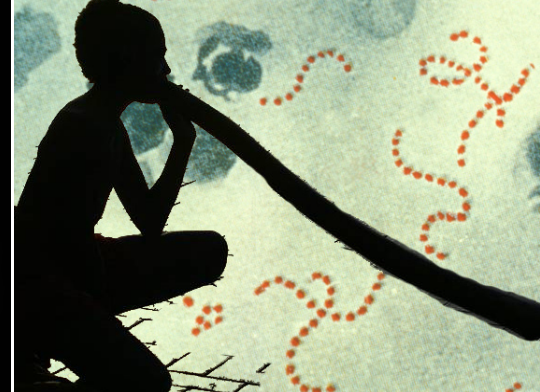
dementia, for targeted interventions.

By far the greatest share of funding for Program Grants, over \$17 million over 5 years, will support a project at **Griffith University's Institute for Glycomics** titled *Tropical Disease - immunity, pathogenesis and vaccine development*. According to project leader and current chair of the NHMRC Council, **Professor Michael Good**, the research will develop strategic



While malaria is a tropical disease most common in Africa, but not endemic in Australia, *Streptococcus* bacteria are a common and debilitating infection in the Australian Indigenous population. (Strings in the background depict *Streptococcus pyrogenes* bacteria in a laboratory dish)

Streptococcus pyrogenes shown are from an [image](#) by the Centres for Disease Control and Prevention (public domain)



science initiatives in the field of immunity and vaccine research and use them to test novel vaccines for serious tropical infections, including malaria, worms and also streptococcus, which is particularly common in Australia's Indigenous population.

The project will also test a new malaria vaccine PlasProtect™. As reported in our June-Aug 2011, the vaccine was launched in July 2011 and will be tested in Phase 1 human vaccine trials in 2012. The treatment is expected to produce an immune response that will protect against all known strains of malaria.

► **More information:** www.nhmrc.gov.au

Welcome blockage

In 2012, the **Australian Government** will provide a total of \$1.6 billion in university block grant funding, up by more than \$100 million compared to last year as a result of more generous indexation arrangement. Over the next four years, the new arrangements will provide an extra \$367 million for the six schemes covered by **Research Block Grants (RBG)**.

As in the previous year, the **University of Melbourne** tops



R&D AUSTRALIAN **Elwinmedia**

EDITOR
Dr Gerd Winter
08 8370 2778
editor@elwinmedia.com

DESIGN
Elwinmedia

WWW
www.arldr.com.au

ADVERTISING AND SUBSCRIPTION ENQUIRIES
R&D Review, PO Box 3442, Rundle Mall SA 5000
Phone/Fax 08 8370 2778

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the list of supported institutions, receiving more than \$191 million in total funding. Next in line are the **University of Sydney** (over \$175 million), the **University of New South Wales** (over \$152 million) and **Monash University** (over \$128 million).

The largest post (\$643.5 million) of the funding is consumed by the Research Training Scheme (RTS), which supports students who undertake a research doctorate or research masters degree. The five other supported RBG schemes are:

- \$163.5 million for the Sustainable Research Excellence (SRE) in universities initiative;
- \$339 million for the Joint Research Engagement (JRE), which supports collaboration between universities and the business and non-government research organisations and includes \$1.32 million for a new JRE -Engineering Cadetship scheme.
- \$236.6 million for Australian Postgraduate Awards (APA), which supports the training of higher degree by research students;
- \$21.1 million for International Postgraduate Research Scholarships (IPRS); and
- \$228.7 million for Research Infrastructure Block Grants (RIBG), which helps institutions carrying out research projects that are supported by competitive research grants.

In announcing the funding, the new Minister for Tertiary Education, Skills, Science and Research, **Senator Chris Evans** emphasised the support of the JRE scheme, which he said is specifically designed to encourage and support collaborative research activities between universities and industry.

► [More information:](http://minister.innovation.gov.au) <http://minister.innovation.gov.au>

Leading the pack?

The translation of globally respected research into commercial outcomes has traditionally been a major weakness of the Australian innovation system. And according to the *Australian Innovation System Report 2011*, [reported](#) in the ARDR June-Aug 2011 edition, the nation is still struggling to make the transition into a knowledge based society. Although doing well in adopting new technology, [the report](#) found that Australia produces comparably few new high-end technologies for world markets. Thus Australian innovators were twice as likely to adopt technology than to invent it themselves.

The report also highlighted networking and collaboration as the “most significant flaw in the Australian Innovation System”. Only 4.4% of innovation-active businesses worked with publicly funded research organisations, and only 2.4% with universities, the report found, emphasising the poor interaction between industry and research organisations.

However, a [new report](#) by the **Milken Institute**, an

independent economics firm, depicts a more positive picture of the Australian innovation performance. The *Milken Institute Innovation Report* was prepared for global company **General Electrics** (GE), which on the same day in January also released its *GE Global Innovation Barometer 2011*, the second in a series of annual innovation and technology surveys of top business executives.

The Milken report examined a series of innovation indicators including University-Industry Collaboration in R&D, Venture Capital Deals, Gross Expenditures on R&D, High-Tech Exports, Utility Patents, education in the STEM subjects, and the general business environment. Ranked against the top 100 countries in the *World Economic Forum's Global Competitiveness Report 2011-2012*, Australia was found to perform “extremely well”, leading in five, and above average in two, of seven indicators. Thus it was, for example, found leading in its generation of utility patents or ‘patents for invention’, despite the Innovation Systems Report having noted a comparably low rate of patenting in Australia, ranked just 18th in the OECD.

However, while Australia does not place in the top 10 on any one of the indicators, it performs well across the board, the Milken report states.

It comments favourably on Australia’s “well-developed innovation policy document, *Powering Ideas: An Innovation Agenda for the 21st Century*, which it regularly reviews and assesses, making adjustments as needed.” Yet, it also notes

a discrepancy between its results and the perception among Australian top executives evaluated in the GE innovation survey. Thus, 66% of Australian survey respondents did not think the governments support for innovation was efficiently organised. And only 64% of respondents thought it was easy for companies to partner with universities. This is a surprising result, the Milken report states, given the strong Government support in this area, which includes the almost \$3.5 billion in funding so far committed under the Cooperative Research Centre program, and its finding that Australia is actually a leader in facilitating collaboration between industry and university sectors.

In a Government statement, Acting Minister for Innovation and Industry **Senator Chris Evans** described the report as “broadly consistent” with the *Innovation Systems Report*. But he also noted that “the levels of university-industry interaction and of venture capital deals are still well below the Gillard Government’s expectations.”

The Government hopes to further stimulate collaborative activities with its \$249 million Industrial Transformation Research program announced in December 2011.

► [More information:](http://minister.innovation.gov.au) <http://minister.innovation.gov.au>



Revitalised wisdom

The **Australian Government** will revamp the **Prime Minister's Science, Engineering and Innovation Council (PMSEIC)**, its peak science body, to receive more timely independent scientific policy advice on existing and emerging issues. To this end, it will reduce the size of the council, which in future will meet three times a year. To provide longer term advice, looking five to 30 years ahead, the council will be able to refer issues to the **Australian Council of Learned Academies (ACoLA)** to undertake in depth, interdisciplinary research and report to Government through Chief Scientist **Professor Ian Chubb**.

This research will be supported with \$1.95 million. The Government also announced that Professor Chubb will consult

with business, universities, state chief scientists and other stakeholders on council projects and priorities, including technology, health and

communications issues that have implications across Government. A priority of the new Council will be the Chief Scientist's report on the Health of Australian Science. The PMSEIC's revised membership will include:

- the Prime Minister (chair);
- the Minister for Tertiary Education, Skills, Science and Research (alternate chair);
- the Minister for Industry and Innovation;
- other Ministers at invitation;
- the Chief Scientist;
- the CEO of the **Australian Research Council**;
- the CEO of the **National Health and Medical Research Council**; and
- the following six individual standing members:
 - **Dr Megan Clark**;
 - **Dr Cathy Foley**;
 - **Dr Ben Greene**;
 - **Professor Robert Saint**;
 - **Professor Fiona Stanley**; and
 - **Professor Graeme Turner**.

In April, the Government further announced a \$10 million over three years [funding grant](#), which will support research projects by ACoLA and the Learned Academies under the **ARC Linkage Learned Academies Special Projects** funding scheme.

► [More information](http://minister.innovation.gov.au): <http://minister.innovation.gov.au>

Clean help for the ailing

Australian manufacturing is living through difficult times. In a

high dollar environment, industries will have to become more productive and efficient to stay competitive, while there is a strong push for cleaner production processes.

The **Australian Government** has recently released components of its **Clean Energy Future** package designed to assist businesses to undertake these transitions. The \$800 million **Clean Technology Investment Program** will provide grants to help manufacturers invest in new plant and equipment

that will cut energy costs or reduce their green house gas emissions. In addition, it launched a \$200 million **Clean Technology Food and Foundries Investment Program**.

To make the grant programs more attractive for small and medium-sized firms, the Government has decided that manufacturers with turnovers of less than



\$100 million and requesting funding under \$500,000 will now only have to match the grants on a dollar for dollar basis, while all other grants under \$10 million will require applicants to contribute \$2 for every \$1 from the public purse.

For grants of \$10 million or more, applicants will be expected to make a co-contribution of at least \$3 for each \$1 of Government support.

► [More information](http://www.ausindustry.gov.au): www.ausindustry.gov.au

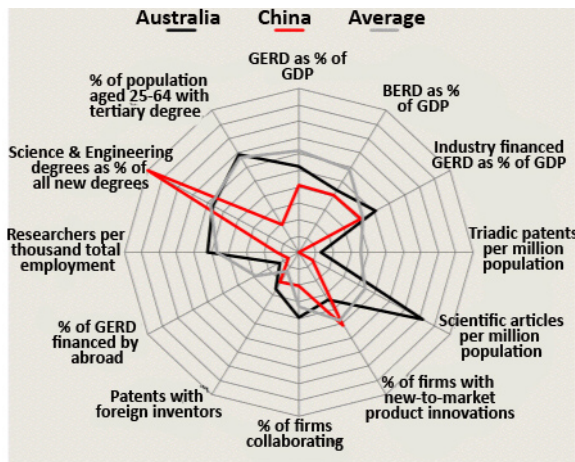
Evolving relations

A new report *Science and Research Collaboration between Australia and China* [provides](#) a different perspective of the Australian Innovation System – focussing on its partnership with China, it puts Australia into the context of the global science, research and innovation system with its limited number of dominating countries. These include the US, UK, China, Germany, France and Japan and also some smaller but highly innovative countries such as the Netherlands and Switzerland, which excel in certain areas such as patenting.

Australia is not considered a major global player but with just 0.3% of the world's population it still ranks among the top twenty nations in areas including research expenditure, research, research workforce, patent registrations and research publications. Over 30 years ago, in 1980, Australia signed a treaty on science cooperation with China with a focus on aid and development. Since then China has ascended to become Australia's major trading partner, and a major participant in the global science, research and innovation system, in which international collaboration is of increasing importance.

Accordingly, the China-Australia relationship in science and research has matured to mutually beneficial collaborations, while at the same time links in trade have become stronger with China now being Australia's major trading partner.

The context of the Australia-China science and research cooperation is characterised by the great differences in the population, economical and political settings of both countries as well as the synergies in challenges and opportunities both countries face in the future.



Gross expenditure on R&D (GERD) per gross domestic product (GDP) of both Australia (2.21) and China (1.45) is still less than the OECD average, and both are closing the gap, while China is also catching up with Australia. However, when GERD is measured on a per capita basis, Australia actually outperforms the OECD average, and still spends around ten times that of China, despite China, on the back of 20% of the world's population, now being ranked third in the world in GERD overall.

Both countries have also improved their output of research publications, with China having the momentum and scope for further large improvements.

Between 1981 and 2009, Australia increased its share of world publications from 2.4% in 1981 to more than 3% in 2009, and on a per capita basis led in 2009 the top ten ranked nations with 1.7 publications per thousand population (although their relative impact is lower than that of some other countries). Over the same period China increased its share of world publications from just 0.3% to 9.9%, which still amounts to only 0.08 publications per thousand population.

Australia and China are closely linked by trade and share some similar policy challenges such as issues related to the environment, economy and the healthcare systems in the face of ageing populations, and this could be conducive to research collaborations. In addition, Australia and China both tend not to specialise in the same research areas, relative to the rest of the world. Thus complementary strengths may provide further incentives for collaborative relationships, such as in agriculture and energy.

It is noteworthy and a reflection of the strength of the partnership in key research areas, that between 1996 and 2009 the number of joint publications rose 20 fold, compared with the 12 fold increase of China-US collaborations. Only Singapore has been more engaged with China as a research partner. China and Australia are both in each other's top ten list of collaborators in

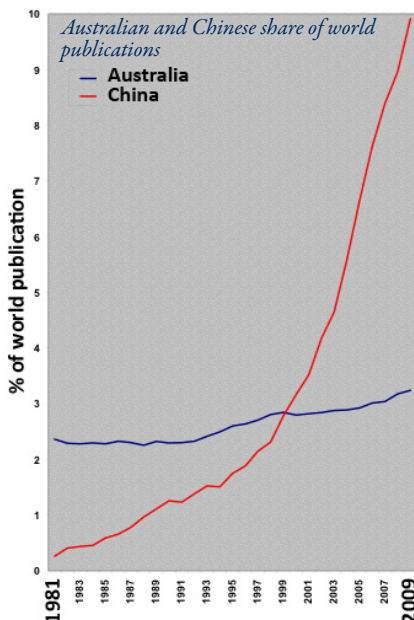


Figure: adapted from *Science and Research Collaboration between Australia and China report*

more than half of Australia's imports are manufactured goods, with small household and, increasingly, high technology items topping the imports from China's strongly developed manufacturing industry.

The science and research systems of both countries also differ greatly in scale, investment and organisation. Notably, there is a marked difference in the role Government plays in directing their respective systems. Thus the Chinese Government, guided by its *15-year Medium to Long Term Plan for the Development of Science and Technology* from 2006, plays a much more central role in directing the country's complex web of sub-systems and research organisations. And importantly, the control by the government also stretches across the commercial sector, as enterprises are often still state owned.

But both countries share an emphasis on building innovation systems to boost prosperity and meet specific challenges, and this is paralleled by increased investments in R&D compared to other leading countries.

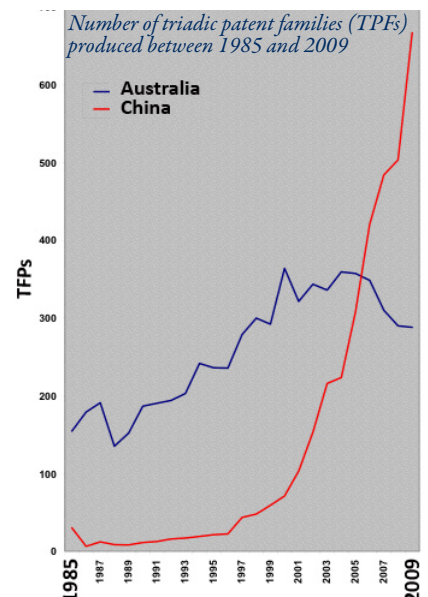


Figure: adapted from *Science and Research Collaboration between Australia and China report*

joint research publications, with Australia sixth on China's and China now third on Australia's list. They also share their major collaboration partners as both list the US, UK, Japan, Germany, Canada and France among their top ten collaboration partners.

A key characteristic of the successful collaborations in science and research have been an investment in long-term relationships, the report states, also highlighting the importance of today's students maintaining relationships into the future.

However, the pool of more engaged collaboration partners is still quite exclusive, with the **CSIRO** and six universities in Australia and the **Chinese Academy of Sciences (CAS)** and ten universities in China accounting for more than half of the joint publications over the past decade, but the basis of cooperation is set to broaden as it moves from individual or organisational arrangements to more formal government-to-government collaboration and joint funding. An example for this is the new **Australia-China Science and Research Fund**, which was announced in 2011 to provide over three financial years support for joint projects in areas of strategic priority.

An important characteristic of the Australia-China relationship is, though, that collaborations are predominantly based on science and research rather than development and commercialisation. The report puts this down to Australia's overall poor performance in commercialising new discoveries.

There are exceptions, which are often based on Chinese alumni returning from Australian universities to China where they launch successful businesses. A well known example is **Suntech Power Holdings Co Ltd**, which was founded by a **University of New South Wales** alumnus, and has recently entered a collaboration with **Swinburne University** on a \$130 million **Victoria-Suntech Advanced Solar Facility** (see also 'Plasmonic Record' in Science & Technology)

In both countries business (in China often state-owned) is by far the largest contributor to GERD. And as China's GERD is rapidly increasing, there is an innovative expansion of China's commercial sector that is also reflected in the output of triadic patent families (TPFs), an indicator of innovation and commercial value. According to the report, the commercial output of both China and Australia is lagging their academic output, but China is redressing the situation with an accelerated growth in TPFs since 2000.

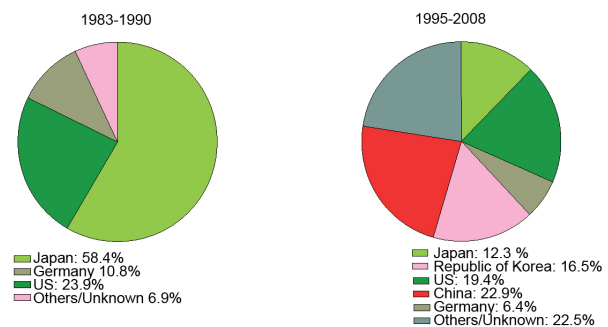
By contrast, over the same period, Australia's output, while per capita much higher than China's, has fallen over the past decade, both in total numbers and as a share of global TPFs.

► [More information: http://minister.innovation.gov.au](http://minister.innovation.gov.au)

...Chinese patenting frenzy

The global financial crisis had not only direct economic consequences but also saw in its wake a decline of 3.9% in intellectual property filings in 2009.

However, as a report *World Intellectual Property Indicators 2011* from the **World Intellectual Property Organisation** has recently [revealed](#), despite the ongoing economic turmoil there was a strong rebound in 2010, led by the US and China. Globally, patent and trade mark filing grew by 7.2% and 11.8%



Contribution of individual countries to the total volume of patent filings

figure: adapted for publication from World Intellectual Property Organisation report World Intellectual Property Indicators 2011

respectively, outstripping the 5.1% growth in gross domestic product. And the US and China accounted for around 80% of the patent filings.

The US, after two years of almost zero growth, recorded

a 7.5% increase and the largest number of filings. But it is China, which also overtook Japan to become the world's second largest economy measured against GDP, where

growth was most pronounced. China's patent office filed more than 391,000 patent applications, continuing a decade of dramatic increases in which annual growth averaged 22.6%.

In 2010, China also accounted for three-fifths of the 11.8% global growth in trade mark filings.

► [More information: www.wipo.int](http://www.wipo.int)

...together facing the wind

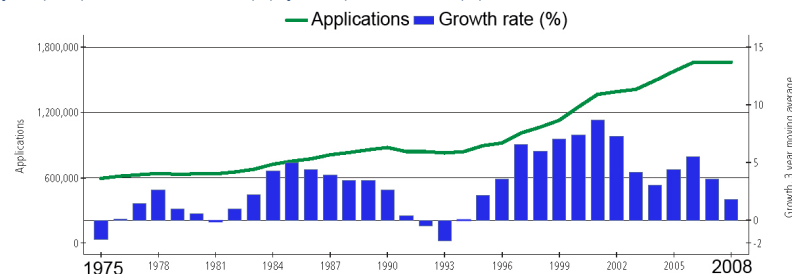
Food production will be the focus of three projects selected in the first round of the **Australia-India Strategic Research Fund (AISRF) Grand Challenge Fund**, which was set up to support research that can deliver practical and innovative solutions to some of the major challenges both countries share.

The fund is a component of the \$64 million **Australia-India Strategic Research Fund**, which has supported more than 90 projects since its inception in 2006, and represents Australia's largest bilateral fund.

Each of the projects will receive around \$3 million from the Australian arm of the AISRF, while the **Government of India**

Growth in patent filings worldwide

figure: adapted for publication from World Intellectual Property Organisation report World Intellectual Property Indicators 2011



will support the participation by Indian teams. The successful projects include:

- a collaboration between the **University of Queensland** (*Professor Gimme Walter*) and **Tamil Nadu Agricultural University** (TNAU) aimed at protecting grain harvests from insect threats;
- a collaboration between the **University of Melbourne** (*Adjunct Professor Derek Russell*) and **International Centre for Genetic Engineering and Biotechnology** in India that is developing crop plants which remove their own major biotic constraints; and
- a project between the **Australian Centre for Plant Functional Genomics** (*Dr Tim Sutton*) and the **International Crops Research Institute for the Semi-Arid Tropics** (ICRISAT) in India applying new genomic approaches for enhancing stress tolerance in chickpea.



Indian meal moth larva, a major threat to wheat harvest

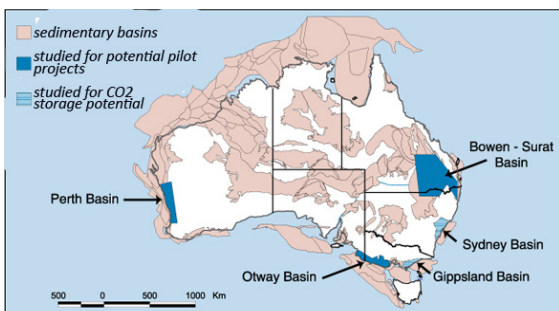
► **More information:** <http://minister.innovation.gov.au>

Difficult injections

The road ahead for developers of competitive industries based on emerging green technologies is spiked with challenges, despite the already significant investment. According to estimates by the **Climate Institute**, clean energy projects are now worth \$31 billion. Still, the limited funds available for large-scale projects continues to present a major issue in realising existing potential in many areas of renewable energies.

This also relates to the surprise announcement by the **Australian Government** in February that it would **reopen** the shortlist for Round 1 of the **Solar Flagships Program**, after the selected **Moree Solar Farm** consortium was unable to meet the funding conditions associated with the offered Government grant. Question marks also arose about the \$1.2 billion 250 megawatt **Solar Dawn** project, the only solar thermal project deemed viable by the Flagships Council – the project has now until 30 June to reach financial close.

Carbon capture and storage potential in Australia

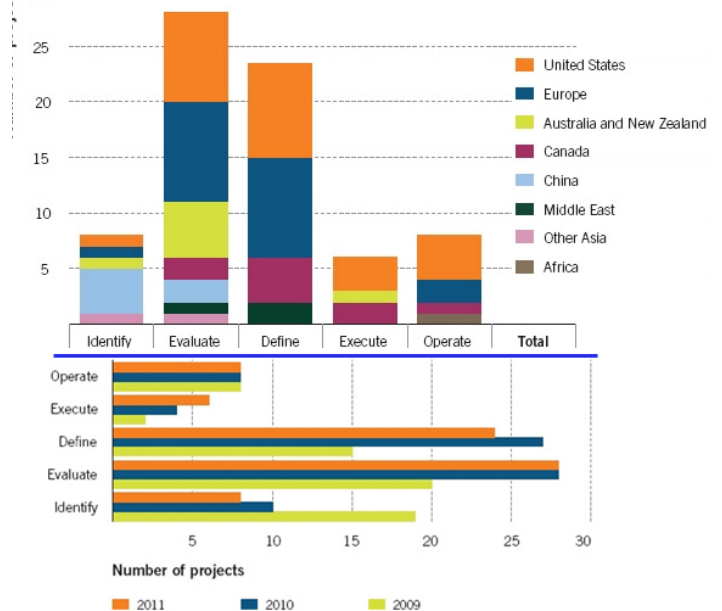


development of geothermal (reviewed in our previous issue) and carbon capture and storage technologies (CCS).

There are significant research efforts underway, including **CSIRO's** post-combustion capture (PCC) project aimed at using a liquid, such as ammonia, to capture CO₂ from power station flue gases. CSIRO is currently involved in a pilot of the technology with China's **Huaneng Group**, and has recently reported findings from its two pilots in Australia (see *Captive*

progress with caveats in 'Rural and Resources'). However, similar to the geothermal energy industry, the specific challenge for CCS options is to demonstrate the entire chain at commercial scale. This includes CO₂ capture at major industrial sources, including power plants, which is then compressed, transported and finally injected into suitable storage sites.

Enhanced oil recovery (EOR) systems, in which CO₂ is injected into oil reservoirs to increase the recovery of crude oil, are more matured and attractive options in some countries, such as the US. According to the **most recent** Status Report by the **Global CCS Institute**, five of eight currently operating projects use EOR, thus benefitting from generating revenue through enhanced oil recovery. The technology is not without environmental challenges, though, because of the potential contamination of ground water with toxic metals and salt.



The figure shows current large-scale integrated CCS projects by country and lifecycle, as reported in the Global CCS Institute THE GLOBAL STATUS OF CCS: 2011 report figure adapted from the Global CCS Institute THE GLOBAL STATUS OF CCS: 2011 report

In Australia there is limited potential for EOR, but the country's overall theoretical storage capacity, including in saline aquifers, is very large, although the major challenge remains the identification of potential sites close enough to power plants. There is also a need to address broader concerns such as long-term leakage. The use of options such as onshore sites in depleted gas fields – projects in the Netherlands and Germany, for example – faced stiff opposition at many levels due to such concerns.

The **CO2CRC Otway Project** in south western Victoria is currently investigating the scope for injecting tens of thousands of tonnes of CO₂ under geologically well constrained research conditions. In December last year, a paper in the journal *PNAS** described the science behind the project, which used a natural source of carbon dioxide to inject, store and monitor over 65,000 tonnes of CO₂-rich gas, two kilometres underground in a depleted natural gas reservoir. According to

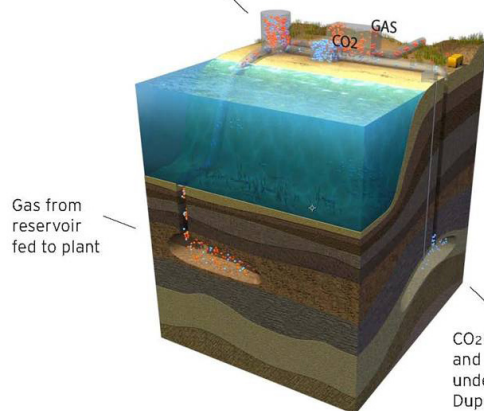
Raising the monies required to get major projects off the ground presents also a major obstacle for the

the international team led by **CSIRO** researcher *Dr Charles Jenkins*, the project [confirmed](#) that storage in depleted gas fields can be safe and effective, and in a populated area can be conducted together with all stakeholders. The authors conclude that these structures could store globally significant amounts of carbon dioxide.

Alternative options are emerging, though, such as emissions abatement through the large scale production of algae, a technology currently being investigated by a venture between **James Cook University** and **MDB Energy** in an *Algae for Biological Carbon Capture and Sequestration* project (see lead story).



CO₂ is separated from natural gas



Gas from reservoir fed to plant

CO₂ is compressed and injected 2.5km underground into Dupuy Formation

As detailed in the Global CCS Institute's report, global progress by the industry has been "measured" during 2011 (see figure), with eight large-scale integrated projects (LSIPs)* in operation and a further six under construction. Together, the projects

would have a total CO₂ storage capacity of 33 million tonnes per year (mtpa). Since the institute's 2010 report, 11 LSIPs were put on hold or cancelled, most commonly

because they were deemed uneconomic in their current form and policy environment.

Substantial,

timely and stable policy support, including a carbon price signal, is needed for CCS to be demonstrated and then deployed, the report states.

All eight projects in operation are part of an established industrial process, with six in natural gas processing. By comparison, power generation projects have significant additional costs and risks, which are not supported by electricity markets. Hence, no commercial scale clean-coal plant using CCS is to date in operation, although there are two power projects in the construction phase – the US **Kemper County** project and the Canadian **Boundary Dam** project – both using EOR for generating revenue.

In the US, there is now also a first project storing CO₂ in deep saline formations in construction stage.

The eight LSIPs in operation are located in the US (4), Europe (2), Canada (1) and Africa (1). Australia has one project at the construction or 'Execute' stage, the **Gorgon Carbon Dioxide Injection Project**, which is connected to the **Gorgon gas project** in Western Australia. Six further projects are at earlier stages of development.

Last year, the **Collie South West Hub** south west of Perth was selected for a \$52 million grant under the \$1.68 **Carbon Capture Storage Flagships Program** to move the project, aimed at capturing around 2.5 million tonnes of CO₂ per year, into the next phase including a detailed storage viability study (see also ARDR June-Aug 2011). The CCS Flagships Program, is a major component of the expanded \$5 billion Clean Energy Initiative (CEI), despite the significant dent it received in the 2011-2012 Budget with the Government's decision to reduce or defer the program's funds by \$420.9 million over five years – although \$60.9 million were redirected to establish the **National CO₂ Infrastructure Plan**, an important support measure for CCS industry development. The legislative steps are also well advanced in Australia by international standards, after the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* was amended

in 2008 to provide major low emission project developers with more legislative certainty.

But the high costs associated with LSIPs remains a major headache for developers, and ultimately for politicians set on meeting carbon reduction targets.

In February, **National Low Emissions Coal Council** chairman *Dick Wells* [said](#) in an ABC interview that the technology would probably not be commercially viable until the 2030s unless Government provided more financial support, as the coal industry would not invest the billions required for establishing clean-coal plants.

Looking at the targets of CCS technology, which globally could reduce carbon emissions by 20% and supply a quarter of Australia's electricity by 2050, Mr Wells said to the ABC: "It is a really critical stage for the deployment of these technologies, but if we don't start to get some big projects to be put into place in the 2020s, the role of CCS in actually meeting those sorts of targets in 2050 won't be achieved."

In February, the **Australian and Victorian Governments** jointly [announced](#) they would invest \$100 million into the \$1 billion plus **CarbonNet** CCS project, the second project



selected for funding under the CCS Flagships program. The funding will support feasibility work to demonstrate low emission brown coal electricity generation in the region, which the governments hope will help sustain the brown coal industry in the Latrobe Valley – still a source of 95% of the state’s electricity.

The CarbonNet project is managed by the Victorian **Department of Primary Industries** and will capture carbon emissions from power plants, industrial processes and new coal-based industries and store it in geological basins. If successful, it would be one of the world’s first industrial-scale, multi-user foundation CCS networks, integrating multiple CCS projects and proponents across the entire CCS value chain within the next ten years. Initially sized to capture 1.2 mtpa before 2020, it could be upscaled to support over 20 mtpa.

The Commonwealth has also awarded the Victorian Government an offshore tenement for CO₂ storage site exploration in the Gippsland Basin, one of the most promising storage sites in the country.

***LSIPS are projects not less than 800,000 (400,000) mtpa for a coal-based power plant (other emission-intensive industrial facilities including natural gas-based power generation).**

Finally valued acceleration

After almost a year of uncertainty about the future of one of Australia’s most prestigious research facilities, the **Australian and Victorian Governments** reached an agreement that will secure the immediate future of the **Australian Synchrotron**. Under the deal, the Commonwealth will contribute \$69 million towards the Synchrotron’s operation, with an additional \$26 million provided by the Victorian Government. New Zealand has also given an in-principle commitment to contribute to the operational funding of the Synchrotron over the next four years.

Both, Victoria and the Commonwealth have been ardent supporters of the project, and contributed substantially to its establishment and operation (since 2006, \$207 million and \$114 million, respectively). However, the new Victorian Government failed to set aside any support for the facility’s ongoing operation in its May 2011 Budget and the Australian Government refused to, as previous Innovation Minister **Senator Kim Carr** put it, ‘bail out’ the state. The continuing squabble over funding raised doubts in the research community about the continued commitment of Australia’s political establishment towards one of the nation’s key research infrastructures.

Officially opened in 2007, the Synchrotron answered a pressing infrastructure need for the Australian research community, as access to synchrotron science has become crucial for high calibre experiments within a broad range of research fields.

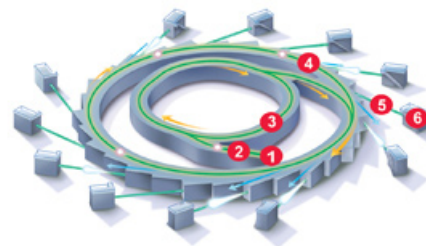
The **Australian Academy of Science** had already highlighted an emerging infrastructure bottleneck in 1989 in a report *A Requirement for Australian Research: Access to*

“Big Science” Facilities, and in 1992 the **Australian National Beamline Facility (ANBF)** was established at the **Photon Factory** in Japan. However, in 1993 the **Australian Science and Technology Council (ASTEC)** recommended that Australia build its own synchrotron, with a feasibility study completed in 1997. While researchers gained access to synchrotrons overseas, through the 1995 Australian Synchrotron Research Program (ASRP), the need for access closer to home persisted.



Australian Synchrotron scheme

- 1 Electron gun
- 2 Linear accelerator (linac)
- 3 Booster ring
- 4 Storage ring
- 5 Beamline
- 6 Endstation



In 2001 the Victorian Government took on the multi-million project, which quickly developed into a broad collaborative funding partnership for the establishment of a national research facility.

Since opening in 2007, the value of the national infrastructure has become apparent, each year hosting more than 3000 researchers conducting about 500 experiments.

A joint statement by the new Australian Science and Research Minister **Senator Chris Evans** and his Victorian counterpart, Innovation Minister **Louise Asher**, pointed out that the synchrotron light beams, generated through kinetic energy of electrons accelerated close to the speed of light, have contributed to a broad breadth of applications ranging from the development of anti-malarials to an energy efficient high-temperature superconductor that could be used in motors, generators and transformers.

► **More information:** <http://minister.innovation.gov.au/chrisevans>

Long time coming

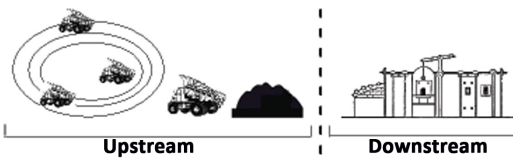
Two major reforms, covered in detail in recent issues, will now pass into law:

- The *Intellectual Property Laws Amendment (Raising the Bar) Act 2012* aims to [raise the standards](#) for Australian patents in accordance with legislation of major trading partners. While many parts of the legislation will come into effect in a year’s time, key features of the



legislation, providing exemptions for researchers and regulatory use, apply immediately.

- The **Minerals Resource Rent Tax (MRRT)** was [passed by the Senate](#) in March, and will come into effect on 1 July 2012. It will apply only to iron ore and coal projects in Australia and impose an effective tax rate of 22.5% to net profits on upstream mining operations. Only



Upstream Downstream
Taxing point for the MRRT as indicated by dashed line.

realised profits, typically at the point of sale of the resource, are taxed, but not the value added in downstream

activities. While the tax may apply to resources subject to State and Territory royalties, the scheme credits for royalties paid. Losses can be carried forward to later years and uplifted at the long term bond rate plus 7%. The value of a miner's existing projects at 1 May 2010 will be recognised in the form of an allowance for the decline in value of the assets over their effective lives. Small miners with group mining profits of less than \$75 million will not pay any mining tax.

Profits down the wire (-less)

The **CSIRO** has been again successful in the settlement of litigations in the US concerning its wireless local area network (WLAN) technology. According to the agency, the outcome will earn the agency proceeds of around \$220 million. In its first round of litigation, completed in 2009, CSIRO had reached agreement with 14 companies – including Hewlett-Packard, Intel, Toshiba, Microsoft and Nintendo – which had adopted the patented invention as industry standard in their devices without paying the research agency any royalties. Crucial to this was a case won in the **US Federal Court** against Japanese **Buffalo Technologies** in June 2007,

In total, CSIRO now has licencing agreements with 23

companies representing around 90% of the industry, with total revenue earned from this technology totalling now more than \$430 million.

CSIRO's lucrative technology, which links two or more devices using a wireless distribution

method, was invented in the 1990s by **Dr John O'Sullivan** and coworkers **Dr Terry Percival**, **Diet Ostry**, **Graham Daniels** and **John Deane** in the process of their work in radioastronomy. The scientists, at the time working with the **CSIRO ICT Centre** (then called CSIRO Division of Radiophysics), were able to overcome a main problem of wireless networking, called reverberation, where the radio waves from the outgoing signal



bounce around the surrounding environment causing an echo that distorts the signal.

Using complex mathematics known as 'fast Fourier', Dr O'Sullivan and colleagues developed a solution that is now part of some 3 billion devices around the world, and potentially will be in five billion devices by the time the patent expires in 2013.

► **More information:** <http://minister.innovation.gov.au>

Sun spots down under

The Australian Solar Institute (ASI) will provide close to \$12 million for ten solar power technology projects under the third round of its grants program, focussing on concentrating solar power (CSP) storage and hybrid technologies, as well as CSP pilot demonstration projects. The leveraged value of the selected projects is more than \$33 million. Major funded projects include:

- **RayGen Resources Pty Ltd** and partners receive \$1.75 million to demonstrate the world's first pre-commercial pilot of a central receiver CSP system that uses photovoltaic energy conversion. The company will also receive \$1 million in funding from the Victorian Government, as was [announced](#) in April.
- **Solar Systems Pty Ltd** and partners receive \$2.00 million for a project in which a thin layer of Germanium is deposited on a Silicon wafer to develop, fabricate, and test novel next-generation multiple-junction solar cells used in the evolving utility scale concentrating photovoltaic (CPV) solar power station industry;
- **Chromasun Pty Ltd** and partners receive \$3.46 million to develop and establish an Australian pilot manufacturing capability for the Chromasun Micro-Concentrator concentrating solar thermal product.
- **CSIRO** and partners receive \$1.56 million for research on syngas, a product that will increase the efficiency of solar hybrid fossil fuels. The project will also formulate a **Solar Fuels Roadmap** for Australia. Established by the **Australian Government** in 2009 with \$150 million, ASI is managing a number of solar energy programs to which it has committed close to \$90 million.

Three major grants of \$5 million each went to projects from institutions involved in setting up ASI. They include:

- the **Process and Characterisation Solar Research Facility** at the **Australian National University**, the **University of New South Wales** and **CSIRO**;
- the **Solar Thermal Research Hub** at the **CSIRO Energy Centre**;
- and the **University of New South Wales' Solar Industrial Research Facility** – Australia's first photovoltaic demonstration and pilot manufacturing facility.

ASI also supports research with international partners, including through the **US–Australia Solar Energy Collaboration** (USASEC).

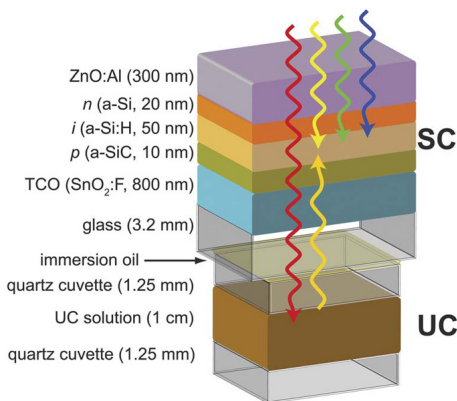
In addition, ASI announced its commitment of a total of \$2.3 million to five projects under the **Australia-Germany Collaborative Solar R&D Program**.

Breaking through the limit

Recently, ASI [announced](#) an early advance in one of the projects it is funding: A collaboration between the **University of Sydney** and the German **Helmholtz Centre for Materials and Energy** published in *Energy & Environmental Science* the development of a so called 'photochemical upconversion' technology, through which lower energy photons that may

fall below the energy threshold of all but the most expensive solar cells could be used for electricity production.

The efficiency of 'single energy threshold' solar cells are limited to a maximum of around 30% of unconcentrated energy from the sun. But this is not the only constraint



A cartoon of a solar cell (SC)/upconversion (UC) device. Low energy (shown in red) photons pass through the cell and excite dye molecules in the upconversion unit, which subsequently returns photons of a shorter wavelength (yellow).

for solar to become more competitive – the other is material cost. **Associate Professor Tim Schmidt**, one of the study leaders, is working on hydrogenated amorphous silicon that can be used as a very thin film, potentially reducing material cost. The trade-off is the material's high optical threshold and hence low efficiency.

The upconversion could potentially improve this as it combines lower-energy photons to photons of higher energy that can pass the threshold to be converted to electricity.

The authors see this as superior to other approaches to overcome the single threshold paradigm, as it does not require a costly re-engineering of solar cell architecture.

► **More information:** www.australiansolarinstitute.com.au

...and a short German perspective

Germany is often referred to as a frontrunner of renewable energies. That is certainly true if considered purely on the basis of how renewable energy technologies have been adopted, particularly in the residential realm.

According to figures provided by Professor Andrew Blakers, director of the Centre for Sustainable Energy Systems at the ANU, Germany installed about 5000 megawatts of photovoltaic (PV) solar generated electricity in 2010.

Per capita this is around 4 times more than Australia, which installed only about 200 megawatts of PV in 2010, despite Germany having only around 60% of the sunshine in populated areas. In Germany, solar PV alone provides around 3% of total electricity.

German research in renewable energy is world leading and it is also true that the industry, particularly the solar manufacturing industry, has developed rapidly, backed by generous Government support and feed-in tariffs.



But is the gloss beginning to come off?

As Government subsidies to the industry have recently been wound back, the German solar industry has hit extremely difficult times. After a string of insolvencies – Solon SE, Solar Millenium AG and Solarhybrid AG – now the world's biggest solar-cell maker, Q-Cells SE, has also collapsed. According to a report by Bloomberg, the German state of Saxony-Anhalt may come to the rescue, but it does bring to light the serious trouble the German solar industry finds itself in.

Many commentators blame China's rapidly growing renewable energy industry swamping the global market with cheaply manufactured products. However, the German industry could have seen the Asian writing on the wall, but for too long chose to rest on high subsidies and a market with a seemingly

insatiable hunger for anything solar. As the German Government winds down its support, the industry has now to come to terms with the stiff competition from Chinese manufacturers.

Certainly there are lessons to be learned for the emerging Australian renewable industry, but if anything, the collapse is a sign of a booming and not of a faltering market, as the efficiencies of solar cells have increased and prices have dropped at an astounding pace. And some German commentators have made the point that most of the 150,000 Germans employed in the solar sector work in businesses associated with installing and operating the systems rather than in production, and thus will continue to be employed regardless of where the solar cells are produced.

Stay with me, my honey

The weakness of the Australian automotive industry, which has particularly hit Victorian and South Australian economies, continues to be a headache for the nation's political leaders.

In March, the **Commonwealth** and the **Victorian** and **South Australian Governments** announced a \$275 million co-investment support package for **GM Holden**. The funding includes \$215 million from the \$5.4 billion **New Car Plan for a Greener Future**.

The new investment will keep GM Holden's car manufacturing in the country, at least over the medium term, after the company had threatened closing its entire Australian design and manufacturing operations. As part of the deal, GM Holden has agreed to inject \$1 billion in its production and to continue making cars here at least until 2022, including two next generation vehicles that are cheaper and more environmentally friendly.

As part of the agreement, Holden will also create a new **Suppliers' Working Group** to help Australian suppliers sell into its world-wide supply chains.

The Australian and Victorian Governments have also agreed to jointly invest in a \$35 million **Automotive New Markets**

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Initiative, a new program to help firms in the automotive supply chain move into export markets and supply their products to other industries.

► **More information:** <http://minister.innovation.gov.au>

The Australian Government is trying to keep GM operations in this country and wants it to build smaller and greener cars. Meanwhile, a related story, now almost in its final chapter, is noteworthy: In Europe, GM owned car manufacturer Opel continues to cost its parent dearly, and the closure of German and UK based factories is now on the cards. This is despite the support of billions of German taxpayers money in 2009. (Sweden's 60 year old Saab, another GM legacy, just filed for bankruptcy).

Many European car makers are facing tough times. But some German car makers report record profits on the back of growing demand in emerging markets – for premium cars. A similar picture emerges in Britain. According to a recent report in the Guardian, premium producers JLR, Bentley and Mini are booming while mass volume manufacturers are struggling.

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Complexity with trade-offs

The **Bacillus Systems Biology** (BaSysBio) project, a collaboration between 15 research organisations in Europe and the **University of Newcastle**, is one of the most groundbreaking large scale international studies Australian scientists are involved in. It commenced in 2006, funded with €12 million (\$20 million) from the **Sixth European Union Framework Programme**, with the aim to comprehensively study how the model laboratory organism bacterium *Bacillus subtilis*, a model organism in laboratories, adapts to changes in its environment.

In March, the team's work was published in two papers in the journal *Science**. In addition, a commentary by scientists from the **University of Cambridge** in the same issue emphasises the significant step the research has taken towards the integrative characterisation of an entire organism**.

Bacteria are among the simplest of living organisms, yet they are complex in their ability to sense and react to new living conditions. They adjust the relative abundance of individual messenger RNA (mRNA) transcripts produced from protein-encoding genes – around 4200 in the case of *B. subtilis* – to the conditions they live in. This is reflected in changes in the bacterium's 'transcriptome'. Other strategies target the activity of the protein production chain after a gene has been transcribed into mRNA.

One of the studies analysed gene transcripts, proteins and the abundance of metabolites in the bacterium as it adapted to a shift in the balance of two preferred sources of carbon. By adding either malate or glucose to a bacterium culture grown in the other, the authors found astonishingly complex adaptation processes dependent on the type of nutrient added. Thus, following a shift from the malate to glucose, the bacterium adapted slowly but with huge changes in the transcription pattern of almost half of its 4200 genes, while a shift to malate from a glucose-rich environment, triggered almost instantaneous changes that mostly involved the activity of enzymes already present.

The advantage for the bacterium to employ a slow 'transcriptional' or a fast 'post-transcriptional' adaptation strategy seems to depend on the environmental conditions. Complex regulation is not an advantage 'per-se', the authors write, but evolutionary constraints appear to "provide incentives to favor complex control programs".

The project tested a total of 104 different nutritional and environmental conditions as they would occur in the bacterium's natural habitat and followed its adaptation to these changes across the whole genome in a time-resolved system analysis. This required new mathematical models to interpret the extremely complex layers of interacting molecular components and

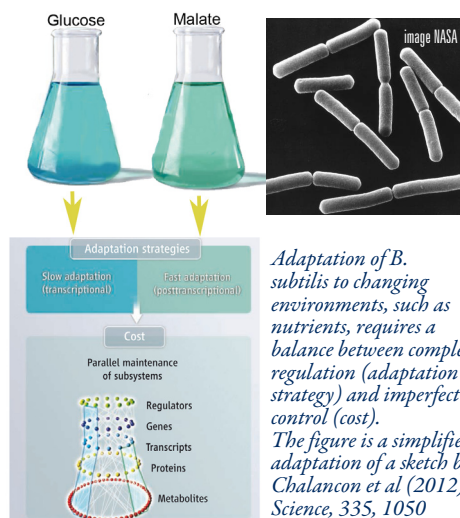
strategies employed.

The regulation of gene transcription was found to involve a rich architecture of sequences on the genome that regulate the transcription of protein-coding genes, so called promoters. The study identified over 3000 new promoters, tripling the number previously known. Around 50% of the analysed genes were controlled by more than one promoter. Their level of activity was linked to so called sigma factors, which are part of the transcription machinery and appear to be the major mechanism for switching a genetic program. Most genes were highly active in at least one condition, but less than 3% were always fully expressed into protein. This, the researchers say, is an unexpected high transcriptional plasticity enabling the cells to optimise their performance. However, there are trade-offs, such as the accidental production of antisense RNA as a result of imperfect transcription, although antisense RNA can also have important biological functions.

Complex gene regulation is common in the bacterial world and by having comprehensively described the

'system' *B. subtilis*, the researchers may now be able to extend their work, for example to pathogenic bacteria.

► **More information:** www.newcastle.edu.au; *Nicolas et al (2012) *Science*, 335, 1103; Buescher et al (2012) *Science*, 335, 1099; **Chalancón et al (2012) *Science*, 335, 1050;



Who are you?

Compared to the detailed human fossil records from Europe and Africa, we still know relatively little about early humans in Asia. Findings include the 17,000 year old and highly enigmatic Indonesian *Homo floresiensis* ('The Hobbit') and potential evidence for modern human interbreeding with the little known Denisovans from Siberia, which may have also occupied Southeast Asia..



Skull from Longin (left), and a depiction of a Red-deer Cave man (right). Source: Skull from Daniel Curcio; Red-deer Cave man depiction by Peter Shouten

However, due to the scarcity of well of described, reliably classified and accurately dated fossils, palaeoanthropologists rely so far on genetic research data which suggests that around

70,000 to 60,000 years ago a wave of the earliest humans left Africa into Eurasia and colonised Southeast Asia and Australasia. A second wave then migrated into Eurasia 40,000 to 30,000 years ago and gave rise to the modern Northeast Asian and European populations.

A [recent study](#) published in *PLoS One**, with *Associate Professor Daniel Curnoe* from the **University of New South Wales** one of the lead authors, sheds some new light on human development in East Asia focussing on the end of the last glacial period around 14,500 to 13,000 years ago. In a collaborative work, six Chinese and five Australian institutions examined human remains from two caves in Southwest China, a region in East Asia known to be a hotspot of human genetic diversity. They studied skulls and teeth from three individuals found in a small cave in the Yunnan Province and a fourth skull from a cave some 300 kilometres away in the Guangxi Zhuang Autonomous Region. Dated to between 14,500 and 11,500 years ago, the fossils appear to belong to the same population revealing a very similar and, particularly for Eurasia, unusual mixture of archaic and modern anatomical features.

The authors speculate that the fossils may represent a previously unknown archaic population – named ‘Red-deer Cave people’ – which in remote locations could have survived from an earlier migration into Asia and then shared the landscape with modern-looking people up to the time of China’s earliest farming cultures. Alternative scenarios include that populations of *Homo sapiens* could have retained a large number of ancestral features.

Attempts to find more definitive answers through ancient DNA analysis were so far unsuccessful due to a lack of recoverable genetic material. But the authors argue that their findings point to a more complex evolution of early humans in East Asia than previously thought. Thus, when *Homo sapiens* arrived, the region may not have been ‘empty’ of our evolutionary cousins.

► **More information:** <http://newsroom.unsw.edu.au>; *Curnoe et al (2012) *PLoS One*, 7: e31918

Pasta saviours

Durum wheat, first produced in Australia in the 1930s, is known for its hardness, protein content and intense yellow colour, and widely used for semolina, pasta and couscous.

In Australia, the history of the industry is centred on developments at the **Tamworth Agricultural Research Station** and the South Australian **Waite Institute of Agricultural Research**, which developed a series of varieties improving the quality and production of the crop. Total production of the premium wheat is now around 500,000 tonnes each year, still a small contributor to the 24 million tonnes of wheat produced overall in Australia. But the quality of Australian durum is now highly regarded by Italian millers/producers, with Italy a major export market for the crop.

With global food requirements on the rise and salinity also



becoming increasingly a problem for agriculture due to land degradation, urban spread and intrusion of seawater, any gains in wheat production have to be made in saline soils.

In Australia, the world’s second largest wheat producer, salinity is increasingly affecting prime wheat-growing areas.

However, the vulnerability of commercial wheat varieties, especially durum, to salinity is to some extent a result of the domestication and breeding of the crops. Thus durum varieties have lost genes still present in bread wheat that help crops to lower the sodium concentration in their leaves, which reduces the potential impact on crucial processes such as photosynthesis.

Addressing this, researchers from **CSIRO Plant Industry** and the **University of Adelaide*** have recently described in *Nature Biotechnology*** their discovery of a salt-tolerant gene in an ancestral cousin of modern-day wheat, *Triticum monococcum*. The gene produces a protein that removes the sodium from the



Salt tolerant durum in a field trial
Photo: CSIRO

cells lining the xylem– the ‘pipes’ plants use to move water from their roots to their leaves.

Using ‘non-GM’ crop breeding techniques, the scientists introduced the gene into a commercial durum variety. They then showed in field trials across Australia, including a commercial farm in northern NSW, that on saline soils the presence of the gene significantly reduced the concentration of sodium in the leaves and increased durum wheat yield by 25%. Importantly, under standard conditions the modified variety performed similar to the variety without the gene.

According to a statement by Adelaide University, the study is the first of its kind to fully describe the improvement in salt tolerance of an agricultural crop from understanding the function of the salt-tolerant genes in the lab, to demonstrating increased grain yields in the field.

And with the modified crop now set for commercial development, the researchers are taking the next step – crossing the salt-tolerance gene into bread wheat.

► **More information:** www.adelaide.edu.au; *Further collaborators in the project include the NSW Department of Primary Industries, the Australian Centre for Plant Functional Genomics and the ARC Centre of Excellence in Plant Energy Biology; **Munns et al (2012) doi:10.1038/nbt.2120;

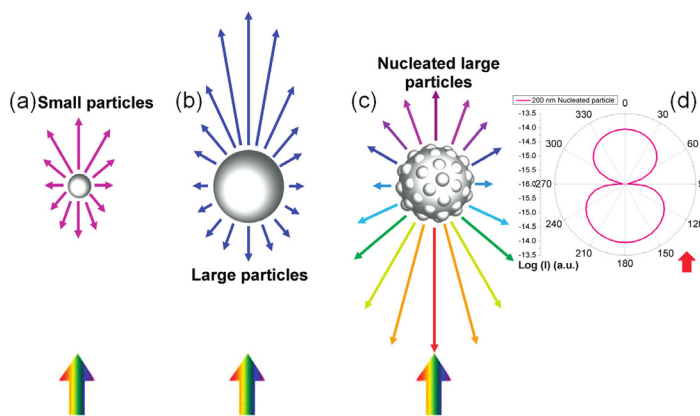
Plasmonic record

A collaboration between **Swinburne University of Technology** and **Suntech Power Holdings** is on track to develop efficient thin-film silicon based solar cells that can be cheaply produced for commercial applications.

Thin-film solar cells, in which the thickness of the silicon is greatly reduced, could provide a cheap alternative to the bulk crystalline silicon solar cells commonly used for the conversion of light into electricity. For example, they could be used in coatings for conventional glass which in the future may enable buildings and skyscrapers to be powered entirely by sunlight.

However, as the amorphous silicon layer reduces it also becomes less sufficient in absorbing sunlight, which is reflected in a lower energy conversion efficiency.

The use of 'plasmonic effects' has been proposed to overcome the problem. A plasmon is a quantisation of plasma, such as electron gas in a metal, and analogous to photons, which



are quantisations of light. And similar to photons, plasmons are considered to be used for transmitting information or on computer chips.

Plasmonic effects are also at the basis of the extraordinarily efficient light absorbing and scattering properties of silver nanoparticles. This is due to 'surface plasmon resonance', which describes how electrons on the metal's surface can undergo a collective oscillation when excited by light at specific wavelengths - and they do so in quantum steps.

Using metallic nanoparticles, such as silver nanoparticles, have been proposed to boost the efficiency of thin-film silicon based solar cells. The concept is, for example, at the core of the solar plasmonic project SOLAMON, which the **European Commission** launched in 2009 as a collaboration between 5 European partners and the **University of New South Wales**.

But while silver nanoparticles could trap light in the silicon layer of thin-film solar cells, in order to be effective the enhancement would have to be over a broader range of wavelengths. In a recent paper in *Nano Letters*, the team from Swinburne and Suntech describe a novel strategy to achieve this by changing the geometry of the nanoparticles. Using an industry friendly method, they created large nanoparticles

nucleated with smaller ones, which effectively scattered the incident light in a broad spectrum range. When integrated with thin-film amorphous silicon solar cells, the nucleated particles boosted the conversion efficiency to 8.1%, a world record for broadband nanoplasmonic thin-film cells.

Importantly, according to Swinburne professor and project leader **Min Gu**, who is also the director of the \$12 million **Victoria-Suntech Advanced Solar Facility (VSASF)**, the nanoparticle integration is inexpensive and easy to upscale.

Professor Gu said in a Swinburne statement that there is still considerable scope to improve the cells and that at the current rate of progress 10% per cent efficiency could be achieved by mid 2012 - "well on track to reach the VSASF's target to develop solar cells that are twice as efficient and run at half the cost of those currently available."

► **More information:** www.swinburne.edu.au; *Chen et al (2012) *Nano Letters*, [dx.doi.org/10.1021/nl203463z](https://doi.org/10.1021/nl203463z)

Survivors in a changing world

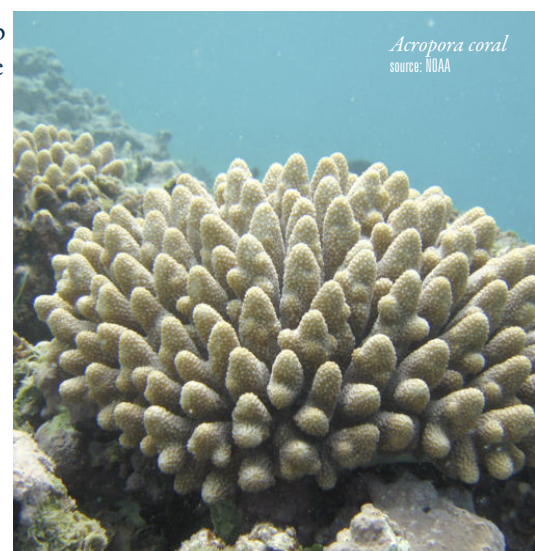
Despite broad agreement among experts in the field that coral reefs are under stress from negative environmental conditions, such as increasing pollution, ocean acidification and sea temperatures, there remains uncertainty about the extent of these threats on the survival of corals.

Warm surprises

Scientists have reported a strong correlation between unusually warm seas and mass bleaching of corals, a sign of the breakdown of the symbiotic relationship between algae and the coral animal.

But a recent study in *PLoS One** by researchers from Singapore and Australia** suggests that some fast growing coral species may be able to adapt to increasing ocean temperatures. This is controversial as many scientists believe that corals have exhausted their capacity to adapt to thermal stress.

The researchers based their conclusion on an analysis of a mass bleaching event in South-East Asian waters in 2010, which found that in Indonesia around 90% of fast-growing branching species - such as staghorn corals - were dying. This was consistent with a trend seen so far by scientists that hardier, slow-growing massive species are more resistant to bleaching than fast-growing branching species, which they may gradually



Acropora coral
source: NOAA

replace in a warmer climate.

But at two further sites monitored in Singapore and Malaysia, the usual trend was reversed despite the occurrence of a similar magnitude of thermal stress: normally susceptible colonies of fast-growing *Acropora* corals appeared healthy and fully pigmented, while most colonies of massive coral were severely bleached.

Historical data revealed that a prior bleaching event in 1998 had occurred only at sites where the hierarchy of susceptibility was found reversed, which thus may have adapted and/or acclimatised to thermal stress.

According to the authors, the data support the hypothesis that corals in regions subject to more variable temperature regimes are more resistant to thermal stress than those in less variable environments.

They stress that the findings do not lessen the global threat to reefs from climate change, as there likely are limits to the observed thermal adaptation of certain taxa in some few locations.

► **More information:** *Guest et al (2012) *PLoS ONE* 7:e33353; **the study was led by Professor James Guest from the National University of Singapore, who is currently with the Centre for Marine Bio-innovation at the University of New South Wales and co-authored by Professor Andrew Baird from the ARC Centre of Excellence for Coral Reef Studies at James Cook University

Acid resilience

With increasing carbon dioxide concentrations in the atmosphere, an associated effect of ocean acidification could impact on coral reef survival.

New research by scientists at the **ARC Centre of Excellence for Coral Reef Studies**, at the **University of Western Australia** and France's **Laboratoire des Sciences du Climat et de l'Environnement** suggests, though, that not all corals are equally susceptible to the stress posed by a more acidic ocean environment. This could explain previous conflicting reports which either found corals to be highly sensitive or less sensitive to acidification.

The study published in *Nature Climate Change** reports the finding that some marine organisms forming calcium carbonate



image: Sergio Silenzi

skeletons in a process called 'biogenic calcification', have molecular 'pumps' which up-regulate the pH at the site of calcification. The species-specific mechanism supports the calcification process at little additional energy cost as it locally increases the concentration of carbonate ions.

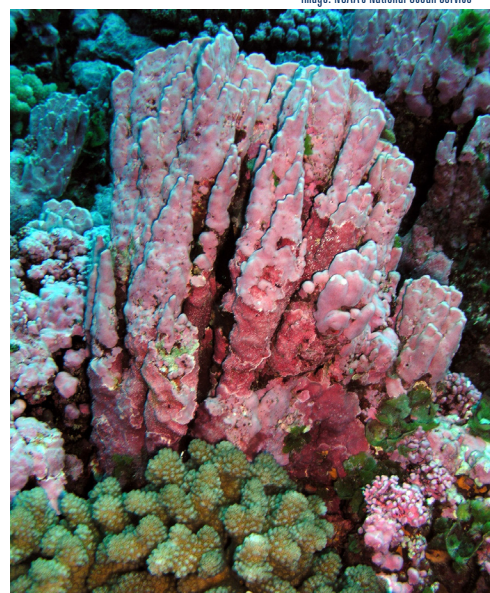
The effect also buffers the rising acidity of seawater – and it

is enhanced at higher temperatures. Thus, as long as the corals are able to cope with the warmer conditions, the effect may compensate the negative impact of ocean acidification.

Illustrating this, the authors predict that in the last major period of warming on earth, between the Last Glacial Maximum to the late Holocene around 25,000 years to 5,000 years ago, the rate of calcification increased by around 15%. (Notably, the authors point out that the warming in this period occurred over a period of around 10,000 years, whereas our present-day greenhouse-induced warming is occurring within 100-200 year).

However, the presence of this potential defence against ocean acidification appears to also depend on the type of carbonate structure the corals form, which is either aragonite or calcite. The two forms of calcifications share the same chemistry but differ in the symmetry in which the carbonate ions are arranged.

The study broadly finds that most corals producing aragonite skeletons, including the common corals *Porites* and *Acropora*, have the buffering system. By contrast, corals using the calcite pathway generally cope less well with acidification. This includes some important coral species such as



Coralline Algae
image: NOAA's National Ocean Service

coralline algae, which act as a kind of 'glue' holding coral reefs together. In addition, a large class of phytoplankton, a vital component of the marine food web, is equally threatened by acidification. Consequently, the authors warn that calcifying species lacking the ability to locally up-regulate the pH are likely to undergo severe declines in calcification as CO₂ increases.

The authors are therefore cautious in drawing broader conclusions on the overall outlook of coral survival, noting that "...the overall health of coral reef systems is still largely dependent on the compounding effects of increasing thermal stress from global warming and local environmental impacts, such as terrestrial runoff, pollution and overfishing."

► **More information:** www.news.uwa.edu.au; McCulloch et al (2012) *Nature Climate Change*, doi:10.1038/nclimate1473

Warmth beats acid

The results in the study above are broadly consistent with a study published in *Science** by researchers from the **Australian Institute of Marine Science** (AIMS) in February. The

researchers examined calcification rates of massive, long-lived corals by measuring the annual growth bands in cores extracted from reefs across a 1000 kilometre north-south gradient off WA.

Focussing on the past 110 years, they found no evidence of a recent widespread decline in coral calcification rates on Australia's western coral reefs. This contrasts, for example, the situation in the Great Barrier Reef, where growth rates of *Porites* corals have declined by 14-21%.

Corals at the most northerly sites off Western Australia, where sea temperatures are already high and warming has been small, showed no change in calcification. In contrast, the study found that calcification rates of corals have increased at the most southerly reef sites, where sea temperatures are cooler but the rate of warming has been greater. This suggests that rapid warming of parts of the tropical oceans appears to be driving

the coral calcification responses that are currently observed, rather than ocean acidification.

In a statement released by the AIMS, lead author **Dr Tim Cooper** said that some corals in some

locations are able to keep up with these changes, whilst others are already showing that the temperature changes have exceeded optimal conditions for coral growth.

The statement also notes the significant benefit the \$35 million **National Sea Simulator** will provide for future studies on the potential impact of a changing environment. Currently built at AIMS in Townsville, the simulator will enable scientists to regulate temperature, acidity, salinity, sedimentation and contaminants in large volumes of water.

► **More information:** www.aims.gov.au; *Cooper et al (2012) *Science*, 335: 593-596.

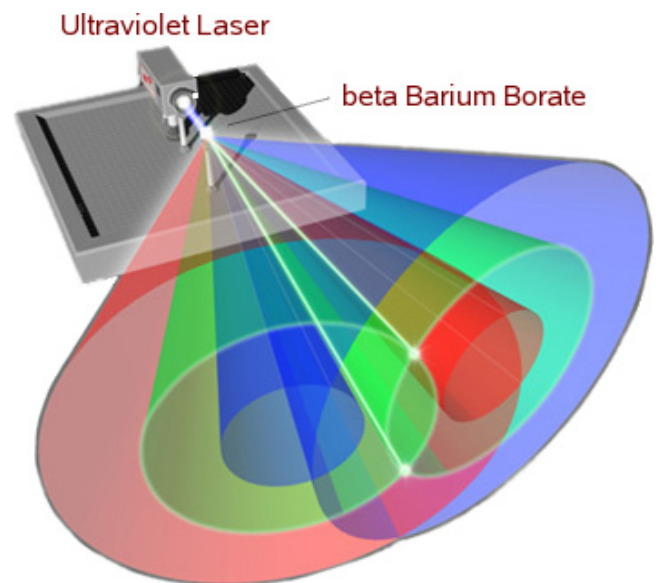
Quantum steps

One of the next big leaps in computing is expected to stem from quantum physics, although realising this anticipated revolution in processing and communication power may still have some way to go. Australian scientists are strongly involved in continuously pushing this development, with perhaps the most significant recent progress made by **Professor Michelle Simmons** and her group at the **University of New South Wales**. The researchers created a single atom transistor by precisely positioning a phosphorus atom in a silicon crystal.

Researchers from the University of NSW have also recently added a new level to our understanding of the mechanisms for electron transport in nanostructures at the atomic level, and Australians were also involved in exploring the 'science of the undecided', the quantum walker.

But before detailing these advances we report on recent

Einstein may have been wrong: entangled photons seem to communicate instantaneously. A single photon from an ultraviolet laser through Beta Barium Borate may split and exit from the Beta Barium Borate as two entangled photons.



Australian work that relates to 'quantum entanglement', according to which quantum particles can share indefinite states such as position, momentum, spin and polarisation. Entanglement can, for example, occur when a photon is absorbed by matter and then released, split into two and both with a longer wavelength than the original.

According to Austrian physicist Erwin Schrödinger, disturbing the quantum state of one entangled particle, such as through measurement, will instantly influence or steer the state of the other irrespective of how far apart they are.

This brain twisting theory of 'non-locality' has some believe that information could be sent faster than light, thus contradicting Einstein's special relativity.

Unfortunately, as most physicists agree, there are constraints that will make this impossible.

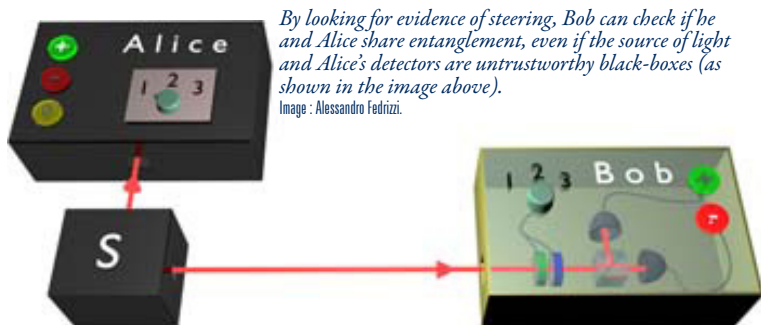
Spooky communication...

Understanding quantum entanglement and quantum steering is not an easy feat. Even for experts in the field, making sense of quantum mechanics is still a tough ask given the theory is utterly counterintuitive and defies our understanding of the basic laws of space and time.

Albert Einstein famously decried it as "spooky action-at-a-distance", believing it was theoretically implausible. Together with **Boris Podolski** and **Nathan Rosen**, he published in 1935 the 'EPR paradox', which in its essence suggested that the theory of quantum mechanics, according to which states of particles are 'undecided' until they are measured, was incomplete. The scientists postulated 'hidden variables', which if we just knew them would allow us to accurately predict measurements of quantum states rather than work with probabilities. These hidden variables would also explain the seeming interdependence of entangled particles and thus overcome the problem of 'spooky actions' over distance.

But experiments indicate the phenomenon has a firm place in the real world.

John Stuart Bell provided the theoretical framework to determine in the laboratory the existence of hidden variables. The 'Bell inequalities' are a set of mathematical rules which need to be satisfied or obeyed if locally acting hidden variables are at play. As experiments have found violations of these inequalities, they support the 'non-local' action of entangled particles. However, there are still some doubts about the conclusiveness of these tests due to experimental deficiencies or loopholes.



By looking for evidence of steering, Bob can check if he and Alice share entanglement, even if the source of light and Alice's detectors are untrustworthy black-boxes (as shown in the image above).

Image: Alessandro Fedrizzi

This is also the case for quantum steering, which offers another perspective to test entanglement, as one party through its choice of measuring certain quantum states of a particle can prepare the quantum state of the entangled pair.

Lets assume two experimentalists, Alice and Bob, share a pair of entangled photons. If Alice also controls the photon source she may claim to Bob that she sent to him an entangled photon and is able to 'steer' its state – but how does Bob know that Alice is not cheating and indeed has sent an entangled photon? Similar to the Bell inequalities, by determining a violation of 'steering inequalities' Bob could verify entanglement, even if he does not trust Alice's measurement, and provided he can detect the entangled photons with an efficiency of more than 50%.

...almost ringing the Bell

Researchers from the **University of Queensland** and **Griffith University** and coworkers have now reported in *Nature Communications** that they have doubled the previous record in the detection ratio of entangled photons to an unprecedented 62% and were able to close 'detection loopholes' that have hampered the development of practical applications in quantum information computing.

The researchers achieved this by combining a highly-efficient entangled photon source with extremely sensitive detectors, so called transition edge sensors, which detect tiny temperature changes as a photon is absorbed. The results imply that a fully loophole-free Bell test is now at arms reach, the authors write. They also point out that by further increasing the detection efficiency above 66% it will be possible to perform secure quantum communication even if one party has untrustworthy equipment. This could finally pave the way for practical

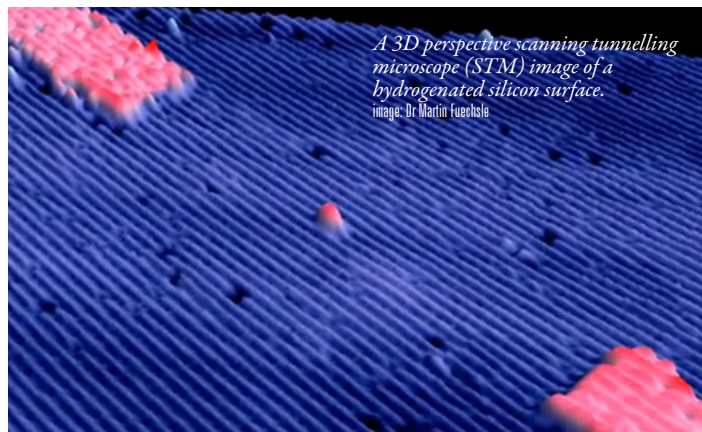
applications of quantum steering.

► **More information:** www.uq.edu.au; *Smith et al (2012) *Nature Communications*, 3:625

Cracking the law

Reducing the size of transistor components to atom scale size is an important step towards a silicon based device down to one atom. Thus one of the earliest proposals for a solid-state quantum computer involved arrays of single phosphorous atoms in a silicon crystal, as UNSW **Professor Simmons** and her coworkers write in a landmark paper in *Nature Communications**.

The paper describes the precise placement of a phosphorous atom in a silicon crystal, which the researchers achieved by replacing one silicon atom from a group of six with one phosphorus atom using a scanning tunnelling microscope. Their accuracy of placement was better than half a nanometre, which compares to a margin of error of 10 nanometres in previous studies, and which so far has limited practical applications. The researchers were able to position the phosphorous atom between atomic-scale electrodes and electrostatic gates, and when they applied voltages across the electrodes, the nano device worked like a transistor used to



A 3D perspective scanning tunnelling microscope (STM) image of a hydrogenated silicon surface.
Image: Dr Martin Fuechsle

amplify and switch electronic signals.

Their results demonstrate that in principle single-atom devices can be built and controlled with anatomically thin wires, the authors conclude. This would represent also the physical limit for conventional silicon-based computers, which according to Moore's law is to be achieved by 2020 (**Intel** co-founder **Gordon Moore** estimated in the 1960s that the number of transistors inexpensively placed on a circuit-board would double every two years).

The nanofabrication of atomic-scale silicon transistors, which the researchers show retain their discrete quantum states, could also be applied for spin-based quantum computation. The equivalent to the classical bit in a solid-state quantum computer, the so called quantum bit, would be based on entangled quantum states of phosphorous atoms, including the spin of

nuclei and electrons and their charge.

While quantum computing may still be decades away, this new research takes a significant step towards realising a vision by **Professor Bruce Kane** at UNSW, who proposed in a *Nature** article more than a decade ago that building a quantum computer using silicon 'doped' with phosphorous could be achieved, and the widespread use of silicon in computer chips would accelerate progress.

► **More information:** *Fuechsle et al (2012) *Nature nanotechnology*; doi:10.1038/nnano.2012.21

Circuit breaker

In February, a statement released by **Griffith University** reported research led by the university's **Professor Dave Kielpinski**, which it states has shown for the first time how atoms may communicate with conventional electrical circuits, thus paving the way for quantum control of macroscopic objects such as computers.

The research, which also involved the **University of Queensland** and collaborators in the US was published at the end of March in *Physical Review Letters**.

The paper proposes a method that allows the engineering of an interface between the storage and processing of quantum information and an electrical circuit in an electronic device.



The coupling of quantum information with the electrical circuit in a electrical devices could be similar to how voices are transmitted over radio.

The authors use mathematical modelling to describe the coupling of the electric dipole induced by the motion of single trapped ions with the electric field of microwave superconducting circuits. This generates a hybrid quantum system with operating speeds similar to those for ion spins, which then can be integrated in existing microelectronics.

According to Professor Kielpinski it is the first time that the quantum theory of a single atom has been combined with a quantum electrical model.

The Griffith statement further quotes Professor Kielpinski saying that atom-based quantum communication is guaranteed to be secure by the laws of physics, so the atom-circuit interface can extend this security to electronic devices. Hence, the research could have far reaching implications for the future of secure communication and code braking.

Atoms are excellent for storing, processing, and communicating quantum information, and are also excellent sensors for acceleration, gravity, and electrical fields, he said.

"The atom-circuit interface will let us plug atom-based devices into more widespread electronic technology such as computers".

► **More information:** www3.griffith.edu.au; *Kielpinski et al (2012) *Phys. Rev. Lett* DOI:10.1103/PhysRevLett.108.130504

Walking in 2 dimensions

Advancing our understanding of the complex phenomena of quantum mechanics will require simulations of quantum events, but the implementation of such schemes in a laboratory setting is challenging.

A recent study published in *Nature** describes the use of light to implement a so called quantum walkers spreading on a two-dimensional (2D) grid.

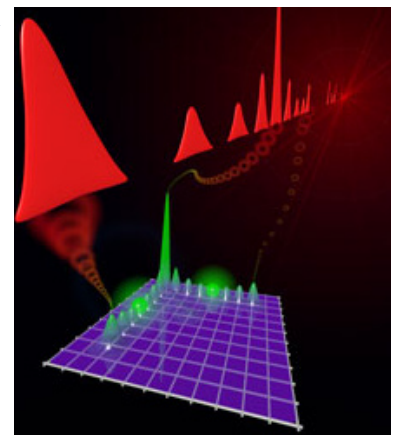
Quantum walks are the quantum analogy of random walks, which are a mathematical simulation of classical random movement, such as that of a particle around a graph or the price of a fluctuating stock. As random walks are useful for developing classical algorithms, quantum walks allow the



development of quantum algorithms to describe complex quantum phenomena. However, a 'quantum walker', such as a photon or an atom,

exhibits markedly different behavioural characteristics to a classical counterpart, as in the quantum world a single walker can go multiple ways at once, and if coming across way points twice at the one time could be cancelled out.

So far, though, quantum walks with a single photon have been demonstrated in only one dimension, but as the authors point out, this restriction hinders the analysis of complex interactions and multiple entanglement. Previous attempts to increase the dimensional complexity of quantum walk simulations achieved this by adding additional walkers, but according to the authors this has limitations in the observable quantum features.



By contrast, the study used entirely classical light sources, attenuated laser pulses, in a highly scalable experimental setting to perform optical quantum walks with a single photon on a 2D grid and based on defined parameters as the walker propagates

between discrete vertices on a graph: a position and a so called quantum coin which determines the directions the walker takes from a position.

The experiment demonstrated that a classical experiment can simulate many genuine quantum features.

Commenting on the German led study, Australian contributor **Dr Peter Robde** from the **ARC Centre for Engineered Quantum Systems** at **Macquarie University** said: "...our experiment did exactly what we expected of it, and in doing so, proves particular theories on 'quantum walkers'".

► **More information:** www.mq.edu.au; *Schreiber et al (2012) 336, DOI: 10.1126/science.1218448

Cold blooded progress

Australian scientists are taking part in a study that will not only help reveal the genetic evolution across amniotes but also promises to boost the domestic crocodile industry.

Non-avian reptiles such as crocodiles differ from mammals and birds in being 'cold blooded' as well as in their sex-determining systems and extreme physiology. The study of reptilian genomes will be essential in understanding how these differences evolved, the US led international team writes in a [paper](#) in *Genome Biology*, in which the scientists outline the current status and time-line of the **International Crocodylian Genomes Working Group** (ICGWG).

The project will include a detailed analysis of the American alligator, saltwater crocodile and Indian gharial genomes.

So far, there is only one genome sequence published from a non-avian reptile despite the clade being more diverse than either birds or mammals. The ICGWG has previously mapped the general structure of the genome of the alligator and crocodile and recently made significant progress with the completion of the first phase of sequencing.

According to co-investigator **Professor Chris**

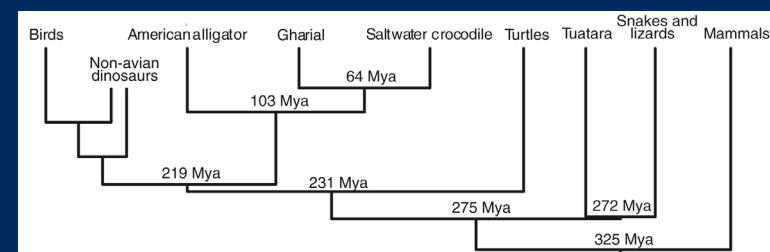
Moran from the **University of Sydney** the progress compares with stepping up from having a map of Australia on a single page to having a detailed street directory. He also highlighted the rapidly decreasing costs and time required to sequence the genomes of even complex organisms.

Beyond the scientific significance, there are also important benefits for industry that may flow from this research. Currently

breeders have to wait at least seven years, when crocodiles become sexually mature, before they can choose suitable breeding stock. With the available sequence, they will be able to use DNA samples from hatched crocodiles to make that choice, with the help of genetic 'markers' that relate to the likely health and breeding quality of an animal.

The genome analysis will also be important for the study of the evolutionary relationships among crocodylians, especially between the alligator family and crocodile family, and the relationships of crocodylians to other reptiles including their closest living relatives, the birds. As crocodiles and birds are the only living members of the Archosauria, which include

The figure shows the phylogenetic relationship between amniotes. Mya = million years ago. Figure adapted from St John et al. *Genome Biology* 2012 13:415 doi:10.1186/gb-2012-13-1-415



dinosaurs and pterosaurs, their genomes provide the best hope for elucidating the gene and genomic properties of the extinct members of the clade, the authors write.

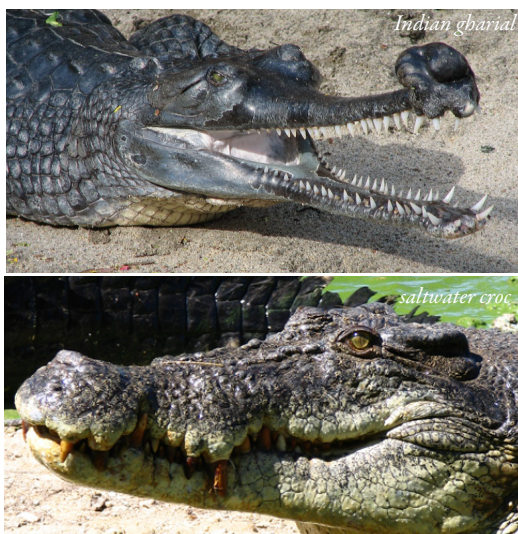
► **More information:** <http://sydney.edu.au>; St John et al (2012) 13:415

Devilish shuffle

Two major studies recently published in *PLoS Genetics** and *Cell*** , which were either led by or with contributions from Australian scientists, have investigated the genetic changes that have caused the fatal and transmissible devil facial tumour disease (DFTD).

First recorded in 1996, the Tasmanian devil continues to be threatened by DFTD, and in some regions populations have declined by over 90%. Unless a cure is found the largest marsupial carnivore is predicted to become extinct in 25-35 years.

The occurrence of a transmissible cancer that survives beyond the death of an individual animal is highly unusual, with only one other known example in nature, the canine transmissible venereal cancer (CTVT) of dogs. It is generally believed that the spread of DFTD is due to a lack in genetic diversity between populations, as the immune system of healthy devils fails to recognise the foreign living cancer cells that are transferred by the bite of a diseased animal. This may not be the whole picture, though, as some recent studies have found that devils can mount immune responses when challenged with foreign tissue from other devil individuals. The animals usually die within six months after getting infected, either directly from the tumour or they starve to death as the disease deforms their



faces so badly that they cannot eat.

Understanding the genetics of the disease could help the conservation of the species but also provide important insights into the origins and evolution of a transmissible cancer.

In *PLoS Genetics*, researchers from the **Australian National University** (ANU) and collaborators describe the broader changes in the devils genome, such as a reshuffling of chromosome segments that underlie the disease development. Studies at the genome-level have so far not been performed, the authors write and label their work as an essential first step to understand the evolution of the disease. They believe that their results provide a framework for subsequent studies of genome changes at the sequence level.

The team mapped the genome of three different strains of the tumour and compared it with that of the normal devil genome and other marsupials. This revealed rearrangements in the DFTD genome compared to the normal genome of healthy animals. Some regions were found to be hotspots of rearrangements, including on chromosome 1, where the researchers also predict a large number of so called tumour suppressor genes and oncogenes. Several candidate genes were revealed that may play a role in the disease development.

The *PLoS Genetics* study found little difference between strains of the disease suggesting that the DFTD genome is highly stable and that the disease is only slowly evolving. This contrasts the rapid genomic changes that occur in many human tumours, the authors write. The results also support that DFTD indeed originates from a clonal cell line which, after a major reshuffling of chromosomal segments, is now stably transmitted between devil populations.

The conclusions were supported in the second study, published in *Cell* in February and led by Tasmanian born **Dr Elizabeth Murchison** at the **UK Wellcome Trust Sanger Institute**. The team, which included scientists from several Australian institutions, analysed the genome of normal devils and that of isolated DFTD clones at higher resolution. They undertook an extensive sequence analysis of two normal devil genomes and that of two geographically distant DFTD cancer subclones, and mapped the genetic diversity of 104 DFTD tumours collected over a period of 7 years.

In line with the *PLoS Genetics* study, the researchers found that the DFTD is a relatively stable lineage, which may indicate



that a high level of genomic instability may not be required for the cancer to become transmissible.

The study was able to trace the likely origins of DFTD back to a cancer clone that developed in a female Tasmanian devil and from where it then spread across Tasmania. Investigating the pattern of evolution and spread of the 'parasitic' cancer, the researchers identified genetically distinct subtypes, some of which even coexist within one animal. However, they also found in one area of Tasmania, the Forestier Peninsula, evidence of a so called 'selective sweep' as one subtype became more dominant over the

others.

The authors also describe the genetic features and processes that may have given rise to the disease, identifying more than 400 mutated genes in the DFTD genome including three genes that are known to be involved in human cancer.

The study included contributions from **The University of Tasmania**, the ANU, the **Walter and Eliza Hall Institute**, the Tasmanian **Department of Primary Industries** and the **University of Melbourne**.

► **More information:** <http://news.anu.edu.au/?p=13721>; *Deakin et al (2012) *PLoS Genetics* doi:10.1371/journal.pgen.1002483; **Murchison et al (2012) *Cell*, DOI 10.1016/j.cell.2011.11.065

Egg problems

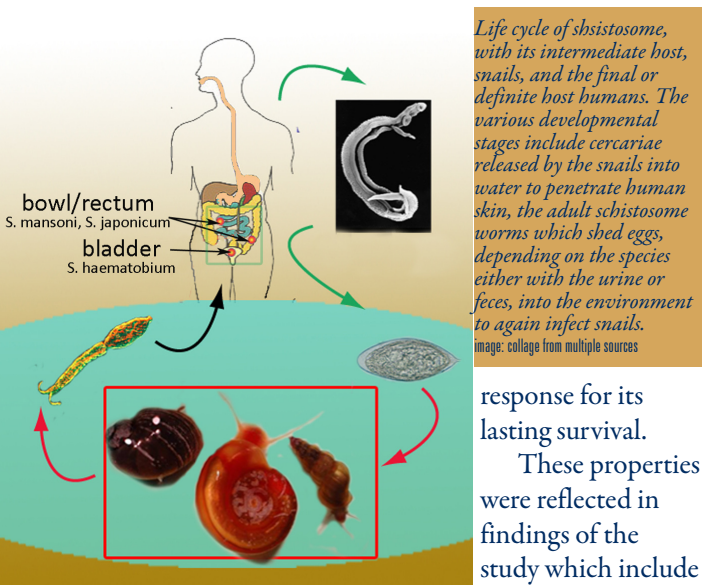
An international study led by **Dr Neil Young** and **Professor Robin Gasser**, both from the **University of Melbourne**, has analysed the genome and its products of a Schistosome parasite species, *Schistosoma haematobium*, which affects the urogenital tract of humans and is also known to cause bladder cancer. They compared the *S. haematobium* genome data with previously published genome sequences of Schistosoma species residing in the intestines. This revealed a number of genes unique to the urogenital species *S. haematobium*, reflecting the different conditions the parasites encounter in their respective host environment. Overall, though, the parasite genomes and their respective products were very similar.

With their study recently published in *Nature Genetics**, the researchers believe that they provide an unprecedented resource for many fundamental research areas, and pave the way for the design of new disease interventions. This is urgently needed as

there is currently no vaccine against the parasite, and only one drug available to treat the infection.

Schistosomiasis is considered to be the second most socioeconomically devastating parasitic disease after malaria. And it is a largely neglected tropical disease predominately affecting the African continent, while also occurring in other parts of the world including Asia and South America. Each year around 200 million people are infected, usually as they come into contact with water contaminated with *Schistosoma* larvae. Shed from snails, the intermediate host in the parasite's life cycle, the larvae burrow through the skin of people and migrate to liver and lungs to develop into mature flukes. *Schistosoma* species vary in the route they use to release massive amounts of eggs back into the environment. And because it is the eggs rather than the adult flukes that cause disease symptoms, there are marked clinical and biological differences between urogenital and intestinal parasites.

In contrast to intestinal species, such as *S. mansoni* and *S. japonicum*, which shed their eggs in faeces, *S. haematobium* flukes mate in the blood vessels of the urogenital tract and their eggs penetrate through the walls of the ureter and bladder to be flushed out with urine. The inflammation that occurs in response to these eggs, some of which may be washed with the blood circulation to organs such as lung and liver, can cause major damage. Since 1911 it is also known that *S. haematobium* infections can induce a squamous cell carcinoma of the bladder. However, although 300,000 people die each year from Schistosomiasis, it is considered a chronic disease, with flukes often residing for many years in their human host. Consequently, the parasite has to modulate the host immune



haematobium that relate to proteins believed to modulate the immune responses; 73 genes unique to the blood fluke, of which some are likely to be important for the attachment of eggs to the bladder wall; and a number of identified proteins that may relate to the development of bladder cancer.

► **More information:** <http://newsroom.melbourne.edu>; *Young et al (2012) *Nature Genetics* 44:116

Power of diversity

There is considerable concern among scientists and policy makers how the loss of biodiversity, which is often associated with increasing socio-economic development, will negatively impact on ecosystem services. This is reflected, for example, in the establishment of an **Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)**, which was recently launched by the **International Union for Conservation of Nature** to investigate gaps in our knowledge about this relationship.

Until recently, our understanding of the impacts of biodiversity loss and ecosystem function relied on small-scale experiments from a limited number of ecosystems. A global scale research project has now investigated whether plant richness

Semi-arid woodlands are widespread across the western plains in NSW

image: courtesy M. Fagg, Department of Sustainability, Environment, Water, Population and Communities



in semi-arid ecosystems can enhance the ability of ecosystems to maintain a number of simultaneous functions such as incorporating carbon into energy and structural building blocks, also called carbon gain, storing carbon and cycling nutrients. In total they collected soil samples from 224 dryland ecosystems from all continents except Antarctica and analysed 14 functions in the carbon, nitrogen and phosphorous cycle.

The 53 contributing scientists from six countries including Australia confirmed that among the major variable factors affecting ecosystems, the number of growing perennial vascular plants at a site is one of the most dominant factors for its 'multifunctional' performance.

However, only few species are required at a site to have significant impact. Thus the scientists found that the positive

impact on ecosystem functions is steepest in the range of up to five plants at a site, suggesting that only few plant species are required to establish 'multifunctionality'.

As the authors note in their paper in *Science**, drylands cover 41% of Earth's land surface, including large parts of Australia. They support 38% of the global human population, and are home to many endemic plant and animal species.

However, these ecosystems are also highly vulnerable to global environmental change and desertification. The scientists conclude that the preservation of plant biodiversity will be crucial to buffer the negative effects from these abiotic factors. In the event of temperature rises as predicted by climate change models, maintaining plant species richness "may be particularly important for maintaining ecosystem functions linked to carbon and nitrogen cycling that sustain carbon sequestration and soil fertility", they write.

In a commentary** accompanying the paper, **Professor Guy Midgley** from the **South African National Biodiversity Institute** highlights the importance of the study for providing robust data on the biodiversity - ecosystem function relationship. But he also notes that the study did not account for potentially important factors such as land-use history and the potential impact of key species, which should be investigated in follow up studies.

Australian researchers involved in the study were from the **University of New South Wales**, the **University of New England**, and the **NSW Office of Environment and Heritage**.

► **More information:** [http://blog.une.edu.au/news/*Maestre et al \(2012\) Science, 335:214;](http://blog.une.edu.au/news/*Maestre et al (2012) Science, 335:214;) **Midgley (2012) *Science* 335:174.

Interactive stressors

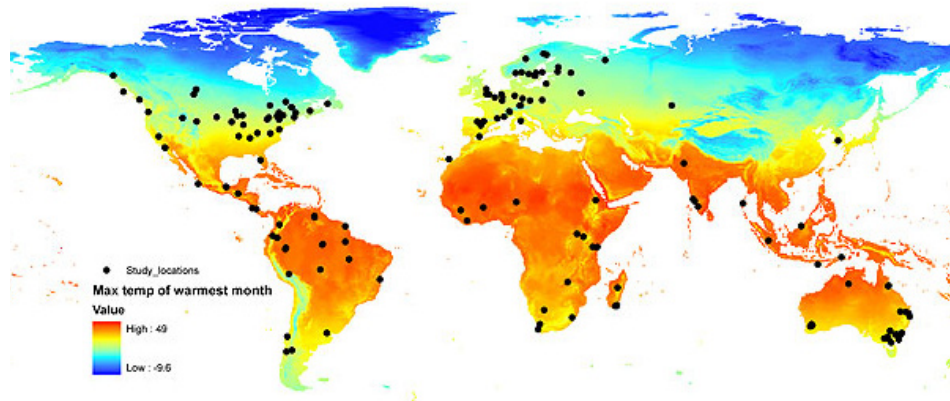
Ecosystems and species are at risk from a multitude of factors, and it is becoming increasingly clear that to understand their combined effect there needs to be more research on how they interact with each other.

While the previous study highlights the need for global scale studies to understand the impact of plant richness on ecosystem functions, another study, undertaken by researchers from the **University of Queensland** and the **CSIRO**, looked at the synergistic effect of global stressors, such as climate change, habitat loss and fragmentation.

Published in *Global Change Biology**, the researchers carried out a meta-analysis examining the data of 1319 studies to investigate how climate change and habitat loss together impact on species density and/or diversity. The methodology of bringing data from numerous separate studies together to create more reliable and general information is widely accepted,

the authors say.

The analysis, the first of its kind, found that across species and geographic regions both the current temperature in an area, as well as the effects of climatic changes, such as changing precipitation patterns, effect species survival. Habitat loss and



The magnitude of habitat loss/fragmentation effects were greatest in regions with high maximum temperatures.
image: University of Queensland

fragmentation were greatest in areas with the highest current maximum temperature in the warmest month of the year, whereas changes in the mean precipitation, measured over the last 100 years were of secondary importance.

The study results also suggest variations between species. Thus higher order species, such as mammals, reptiles and amphibians, appear to be more adversely affected by habitat loss and climatic interactions.

Lead author **Chrystal Mantyka-Pringle** from the **University of Queensland** and her co-workers emphasise the important implications of their results for conservation of biodiversity under climate change.

"The overall breakthrough that emerges from this article is the discovery that areas with high temperatures where average rainfall has decreased over time augment the negative effects of habitat loss on species density and/or diversity," they write. They recommend that management strategies focus on areas with warmer climates, especially those that are more susceptible to precipitation change. By contrast, in areas where climate change interactions may be small, business as usual may be the best approach.

► **More information:** www.uq.edu.au; *Mantyka-Pringle et al (2012) *Global Change Biology* 18:1239

Nervous printing

Researchers from the **University of Wollongong's Intelligent Polymer Research Institute (IPRI)** have taken a significant step towards engineering inkjet printed micro-structures for the controlled growth of nerve cells through electrical stimulation.

The research, which is published in the journal *SMALL**, builds on previous work in which the team identified a

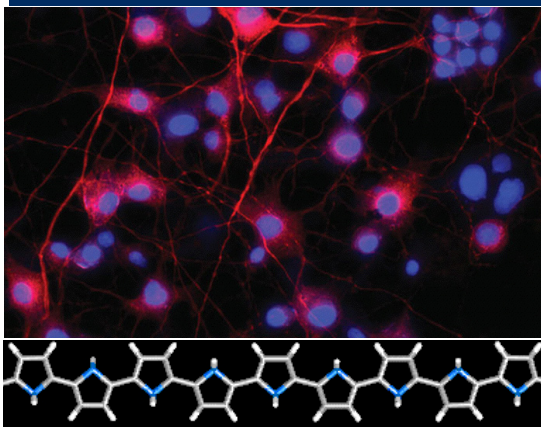
nanoformulation of an organic polymer, so called polypyrrole (PPy), which makes it suitable for inkjet printing. This was an important breakthrough as the polymer, while a described substrate for tissue engineering, has properties that are usually not compatible with inkjet printing.

A feature of PPy is that it conducts electricity, and with certain nerve cell types can be used as a substrate to electrically stimulate the growth of nerve cell projections, known as neurites. In the current work, the researchers show that they not only were able to print high-quality PPy films, but also could use it as a surface for the cultivation of nerve cells. This paves the way for exploring inkjet printed PPy films for biomedical applications including the electrical stimulation of nerve cell growth.

According to IPRI director **Professor Gordon Wallace**, these sorts of bionic devices will enable researchers to interface the world of biology with the world of electronics. Ongoing advances in materials (especially in the area of organic

Nerve cells grown on polypyrrole, the chemical structure of which is shown below.

Image: University of Wollongong



conductors) and fabrication methods, such as 2D and 3D printing technologies, are bringing the pursuit of regenerative bionic devices for nerve and muscle repair closer to

realisation, he said in a media statement by the UOW.

► **More information:** <http://media.uow.edu.au>;

Speedy evolution

Dramatic changes in the environment, including climatic conditions, were a regular feature in recent earth's history, but it is unclear how species were able to adapt to it. The conventional theory is that species evolution is driven by Darwinian selection processes that lead to changes in the genome sequence of species. However, this mechanism may have been too slow to respond to some of the more rapidly occurring events, such as the climatic oscillation in the late Pleistocene.

A study on ancient DNA by two teams, led by **Professor Alan Cooper** at the **University of Adelaide** and **Dr Catherine Suter** at the **Victor Chang Institute**, points to epigenetics as an alternative mechanism of adaptation, which may have played an important role in species evolution.

Epigenetic modifications, which change the activity of genes, are an attractive model for how species may have rapidly responded to selective pressures as they can result in

multiple stable and inheritable phenotypic outcomes without requiring changes in the genome sequence. Such modifications include, for example, biochemical alterations of DNA building blocks, including the methylation of the pyrimidine base Cytosine (see figure).

The researchers studied the DNA of 30,000 year old bison bones, discovered in Canadian permafrost, and they show for the first time that by applying a special sequencing technology, epigenetic changes can be accurately revealed in ancient DNA samples, with sites of modification comparable to that of modern cattle. The key finding of their work, which is [published](#) in *PLoS One*, is that these modifications are stable over extensive time frames and thus enable the study of their involvement in the evolution of species in natural populations.

► **More information:** www.adelaide.edu.au/news/news50641.html; *Llamas et al (2012) *PLoS One* 7:e30226 (doi:10.1371/journal.pone.0030226)

Lucky defense

B-cells play a crucial role for the body's ability to mount an adaptive immune response against intruding microbes. A commonly held view is that external cues, such as signals by T-cells, direct the numerous possible fates of B-cells as an immunological challenge occurs. Thus a stimulated B-cell may develop into a cell secreting large amounts of antibody, so called plasmablasts, or switch the type of antibody it produces, and either die or divide into thousands of cells.

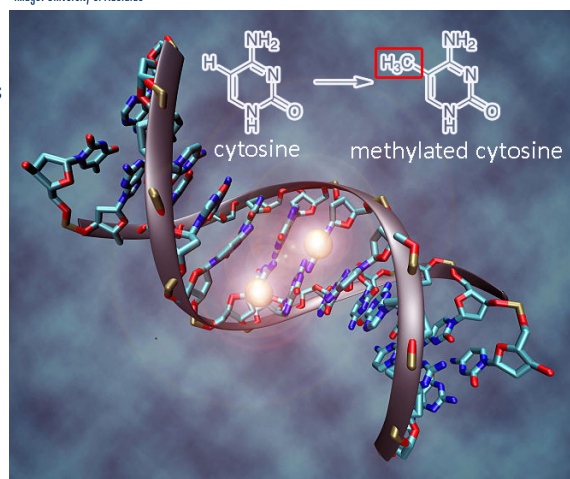
However, a recent study published in *Science** suggests that rather than directly triggered by external factors, these various complex processes are all pursued in a B-cell, and which of the competing cellular fates will ultimately

...continued page 44



30,000-year-old bison bones have revealed how animals are able to adapt to rapid changes in climate.

image: University of Adelaide



...continued from page 1

Agency (IEA) separates first and advanced biofuels based on the maturity of development, rather than its sustainability aspect.

The **European Biofuels Technology Platform's** definition again **emphasises** that 'advanced' relates to non-food feedstocks (e.g. waste, agricultural and forestry residues, energy crops), and a similar understanding is reflected in **statements** by the Australian Government, according to which advanced biofuels are not derived from or compete with food sources and do not deplete native forests.

The apparent difficulty to define 'advanced' may reflect that, by and large, the industry is still in its infancy.

Conventional first-generation biofuels dominate the scene.

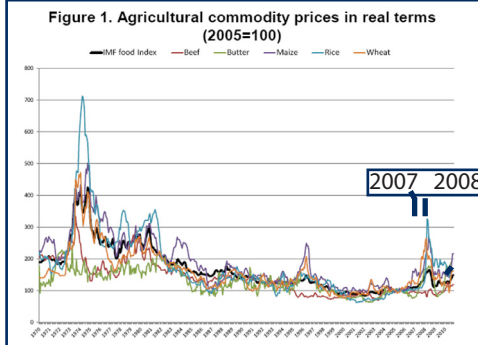
Between 2000 and 2010, global annual output of biodiesel and bioethanol increased from 16 billion to more than 100 billion litres, with the US and Brazil generating most of the bioethanol, while the European Union is the leading producer of biodiesel.

This rapid increase in global output of bioethanol from corn or sugar cane and biodiesel from canola oil, soybean oil, or palm oil, brought to light a potential competition with food production in some regions of the world.

The emerging conflict made global headlines in 2007, when at the height of the 'Tortilla Crisis' tens of thousands of Mexicans marched in the streets to protest a leap in international corn prices, which they partially blamed on corn previously destined for food being diverted into the production of bioethanol.

A link between biofuel production and global food price hikes is not entirely clear and is disputed by some experts. But a 2011 report, collaboratively **prepared** by a number of world organisations including the OECD, World Bank and the World Trade Organisation, makes a strong case for it, recommending that G20 governments remove mandates and subsidies for biofuels production or consumption*.

But there are other significant issues questioning the sustainability of the industry, as the first-generation biofuels



Food versus biofuels:

According to a policy report released by the World Trade Organisation in 2011 by a number of world organisations, including World Bank, WTO, OECD and others, found biofuels overall now account for a significant part of global use of a number of crops. "On average, in the 2007-09 period that share was 20% in the case of sugar cane, 9% for both oilseeds and coarse grains (although biofuel production from these crops generates by-products that are used as animal feed), and 4% for sugar beet."

The report recommends that G20 governments remove provisions of current national policies that subsidise (or mandate) biofuels production or consumption.

Figure: Price Volatility in Food and Agricultural Markets: Policy Responses (2011) prepared by FAO, IFAD, IMF, OECD, UNCTAD WFP, the World Bank, the WTO, IFPRI and the UN HLPF

industry is water, but also surprisingly energy intensive. Furthermore, there is an ongoing debate about the actual potential of currently produced biofuels to reduce greenhouse gas (GHG) emissions – a key benefit associated with the development. The persistent uncertainty that surrounds this issue reflects the still immature science that current estimates are based upon.

In January, 'leaked' EU data were **reported** to show that over a lifecycle GHG emissions calculated for first-generation biofuels, including biodiesel crops such as palm, soybean, and rapeseed oil, may be greater than for fossil fuels if effects such as Indirect Land Use Change (ILUC) are included.

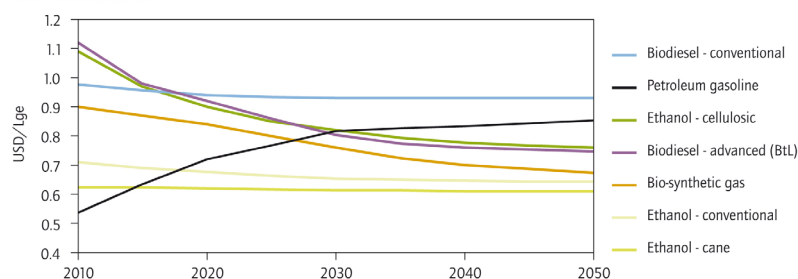
Already in 2008, a paper in *Science* **dampened** hopes that the use of biofuels could reduce transport related GHG emissions, finding that diverting corn from food to ethanol production would instead lead to increased emissions as it resulted in more land being deforested for agricultural use.



There are now calls for a revision of European policy which currently targets a 10% portion of transport fuels to be produced from renewable sources by 2020.

And most **recently** in the US, the **Environmental Protection Agency** ruled that palm-oil based biodiesel will not meet GHG emissions standards under the **US Renewable**

Low-cost scenario



Fuels Standard, which targets 7.5 billion gallons of renewable fuels to be blended into gasoline by the end of 2012.

Predicted price development for biofuels and conventional fuels out to 2050, as presented in a technology roadmap for biofuels development by the International Energy Agency.

However, while reducing GHG emissions is an important objective, it is the prospect of improving fuel security that has driven strong Government support, especially in the US.

Current global proven crude oil reserves are estimated at 1.5 trillion barrels in 2010. Of this, roughly 80%, or 1.3 trillion barrels, is controlled by the **Organisation of Petroleum Exporting Countries** (OPEC). Some 65% of the OPEC oil



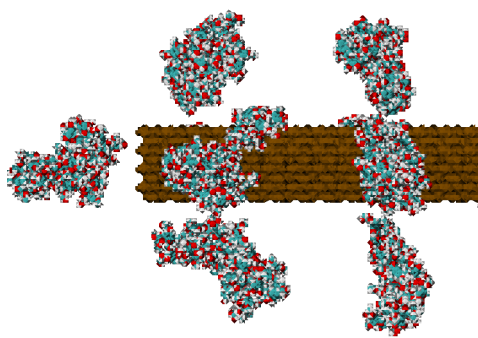
Biofuels: Indirect land use change can substantially reduce potential environmental benefits

reserves are located in the Middle East creating a significant dependency of much of the consuming world on a small region of producers frequently troubled by difficult political circumstances. Obviously, this presents a strong incentive for Governments to seek alternative sources of fuel.

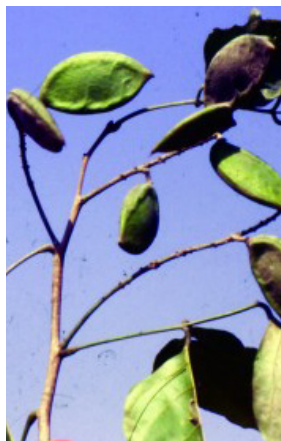
While first-generation biofuels will continue to be the backbone of production in the foreseeable future, the emergence of the next-generations of biofuels is expected to solve the fuels versus food challenge, as they are derived from non-edible sources that do not compete with food production, and also could help to substantially reduce GHG emissions reduction.

However, their substantially higher production costs could make their development prohibitive.

According to the IEA, the cost of producing and retailing diesel and ethanol from cellulose is about US\$1.10 per litre of



Atomic-detailed model of lignocellulose of softwoods. Based on experimental data on the structure of cellulose (brown) and lignin (cyan and red). The image is courtesy US Oak Ridge National Laboratory (ORNL)



Oilseeds such as from *Pongamia* are one potential source for advanced biofuels.
image: ecoglitiz

petrol-equivalent, compared to 62-75 US cents per litre petrol-equivalent for corn and cane derived ethanol.

But according to the IEA's recently [established](#) technology roadmap for biofuels development, the price for cellulose-based bioethanol is set to fall as low as 75 US cents by 2050. This is on the back of renewable fuel targets in the US and Europe, and similar targets in India, China, Canada and Brazil, which will push the global share of biofuels in total transport fuel from 2% today to 27% by 2050.

Global biofuels production could increase five-fold by 2030, and by then advanced biomass will account for up to around 50% of feedstock.

For this to become reality requires significant technology breakthroughs as current approaches to generate fuel from advanced sources are far from straight forward. Global research efforts diverge

greatly in their technology pathways, and a similar variety exists in the potential feedstocks they are based upon.

For second generation biofuels, the process typically requires the break-down of cellulose, lignin and hemicellulose polymers, which together can form a complex and tightly compacted 'lignocellulosic' biomass. This can be achieved by, for example, pre-treating the material with heat and strong chemicals. The products – mostly sugars but also other chemicals such as furans – can then be processed to biofuels using enzymes or chemicals.

But second generation biofuels still fall short in producing a general substitute for petroleum, the most ideal form of transport fuel, as the industry's primary product remains bioethanol, which has only around 70% the energy density of petroleum. This may not be enough to lift planes into the sky or push heavy trucks along the road.

Ethanol is also water soluble and potentially corrosive, and so far its use in conventional engines has been restricted to a blend of around 10-15% with petrol, although dedicated fuel-flex engines can optionally run on up to 85% of ethanol and are common in Brazil and other parts of the world.

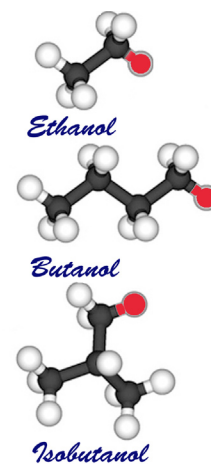
The next generational change for biofuels promises a major advance by producing fuels that deliver more energy per litre than ethanol, while still derived from sustainable sources of organic matter.

One stream of research investigates alcohols with a larger carbon backbone, such as butanol and its structural brother isobutanol. These compounds deliver 25% more energy than equal volumes of ethanol and, as they do not mix with water, are less corrosive. Recent advances in the US exploit naturally existing pathways, such as the butanol producing bacterium *Clostridium*, to produce these isoforms from sugar and also protein.

Several international companies are now developing this to commercial scale. An example is **Butamax Advanced Biofuels**, a venture between **BP** and **DuPont**, which plans to [establish](#) a demonstration plant, although at this stage the production of the butanol is still based on first generation feedstock such as sugarcane, wheat and corn.

Ideally, though, advanced biofuels are produced as 'drop-in' fuels, which resemble the hydrocarbons of fossil fuel sources to such a degree that they can be used without major changes to existing infrastructure.

Global interest is high. Particularly the aviation industry



Ethanol's corrosive properties could pose problems for the transportation through pipelines.

would benefit, since for planes high-energy biofuels present about the only feasible renewable energy alternative.

In the US, the defence force could become a major driver for the sector, and also stimulate development elsewhere.

In August last year, the US **Departments of Agriculture, Energy and Navy** [announced](#) a plan to invest up to \$510 million over three years into the production of advanced drop-in biofuels to power military and commercial transportation. The plan is still subject to Congressional approval, but in December 2011, the **Defense Logistics Agency** (DLA) already [signed](#) a \$12 million contract for the purchase of 450,000 gallons (1.7 million litres) of advanced drop-in biofuel produced from used cooking oil (**Dynamic Fuels, LLC**) and algae (**Solazyme**). The contract represents the largest ever purchase of biofuels in the US.

The announcements are part of an overall plan by the US Navy to source 50% of its enormous energy needs from renewable sources by 2020, with the constraint that the fuels must be interchangeable with petroleum in existing supply lines, ships, aircraft and all other vehicles.

The plan will include the 'Great Green Fleet', which will set sail in 2016 and then require around 8 million barrels of advanced biofuels, including bio-jet fuel for its planes and bio-diesel for its ships. The source of this fuel will not be restricted to the US, and could provide a significant opportunity for the emerging Australian advanced biofuels industry.

Alongside the maturing of the global biofuels industry is a new trend towards the use of dedicated crops that require low nutrient input but result in high yield per acre, and a renewed focus on algae.

A recent *Science News* story [traced](#) the remarkable comeback of algae, after the U.S. Department of Energy (DOE) ceased a program in 1996 that was designed to discover algae strains containing oils suitable for biofuel production. Instead, funds were restricted to turning agricultural wastes and other 'cellulosic' material into ethanol. As **Robert F. Service** reports, since 2000, more than \$2 billion in private funds have seen the re-emergence of a significant industry in the US, made possible by advanced synthetic biology techniques to create new algae



Green vision of a Navy
image: Artistic modification of an US Navy image of Commander, Task Force Fifty One (CTF-51)

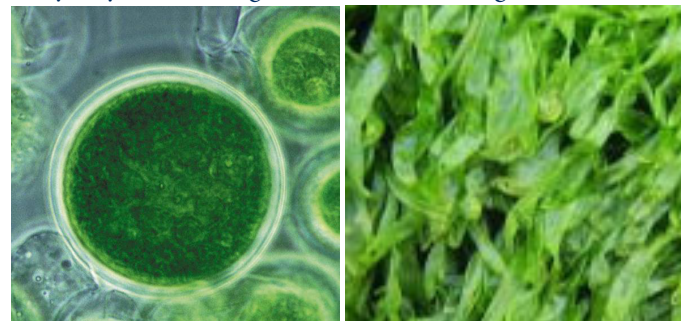
strains that generate more oil, along with other biotech and engineering advances.

But as with other advanced biofuels options, there is still a long road to travel before algal-derived fuels are cost competitive with petroleum,

particularly when sustainably produced.

Compared to lignocellulose and oil based biomass, algae do offer some significant advantages for the production of biofuels, foremost a high scalability, and their cultivation requires substantially less land. There are also other benefits potentially associated with the use of these photosynthetic aquatic organisms.

However, in light of algae also attracting considerable interest in Australia, it is important to note that they comprise many very different organisms – there are single cellular micro-



Algae
left: single cell micro algae;
right: seaweed

algae, which comprise photosynthetic marine plankton species and while sometimes forming larger assemblies of cells, they have distinct features that are different to the larger aquatic macro-algae plants which also include seaweeds. And to add to the confusion, there are also cyanobacteria, also known as blue-green algae, although they are not actually algae in the biological sense.

To make matters worse, there are huge variations between the various strains within certain species of algae. Together with the many different kinds of processes currently employed to generate algal oil, it is not an easy feat to navigate through current projects and



Sapphire Energy's integrated biorefinery in Luna County, New Mexico.
Photo: Sapphire Energy.

understand their significance.

To give an example, last year California-based **Solazyme** raised \$227 million on the stock market, after it was able to deliver over 80,000 litres of algal-derived marine diesel and jet fuel to the **US Navy** in 2010. The company is now also part of the recent \$12 million Navy purchase of biofuels and hopes to sell algal oil to commercial refineries by the end of 2013.

Solazyme's technology entails keeping the algae in the dark, thus shutting down photosynthesis, and then feeding them with large amounts of sugar, which induces a kind of fermentation process that converts sugar to oil. Obviously this is very different to a process in which algae – so far much less efficiently – produce oil as a result of photosynthesis.

At a recent trip to the US promoting Australia's emerging biofuels industry, Resources and Energy Minister **Martin Ferguson** also visited a demonstration-scale algal bio-refinery from **Sapphire Energy**. The plant is located in New Mexico, at a site chosen because of the abundance of non-arable desert - conditions akin to many parts of Australia. According to the company, the plant is the world's first commercial demonstration scale algae-to-energy facility, integrating the entire value chain of algae-based fuel, from cultivation, to production, to extraction of ready-to-refine 'green crude'.

Sapphire was only founded in 2007, but has quickly [developed](#) into a pioneer in the production of 'green crude', which it extracts from algae grown in large open saltwater ponds. The green algal oil is chemically equivalent to crude oil and could therefore be an ideal substrate for the production of drop-in fuels.

In 2008, Sapphire announced that it had produced 91-octane gasoline from algae derived green crude, and in 2009 it participated in the flight of a commercial aircraft using its algae-based jet fuel.

Supported with over US\$100 million from the **US Government**, and [recently](#) US\$144 million from private investment, Sapphire's demonstration scale algae plant now aims to produce 4 million litres of green crude annually, with the added benefit that the algae will also 'fix' around 56 tonnes of CO₂ each day.

Algae biofuels is also a hot topic in Australia – no surprise given the country has particularly favourable conditions for its production: abundant sunshine, large areas of marginal land, and sources of saline water.

ARDR has frequently reported a project led by researchers at **Murdoch** and **Adelaide** universities, which is similarly based on single cellular micro-algae (as opposed to macro-algae) grown in open ponds. According to a paper published in 2009 by project leader **Professor Michael Borowitzka** at Murdoch University, using an open pond system reduces the high capital cost

Australia's current biofuel production

At present, Australia's share of the more than 100 billion litres produced worldwide is still relatively small, primarily producing biodiesel and ethanol.

According to the 'Energy in Australia 2011' report, biofuels represent around 1% of the nation's petrol and diesel supply, with three major ethanol production facilities having a combined capacity of just over 450 million litres per year, mainly derived from wheat starch, grain sorghum and molasses. A facility run by the Manildra Group in NSW is by far the largest, with a capacity of around 300 million litres, with a further two facilities, the Dalby Biorefinery and the CSR Distilleries, located in Queensland.

Soon to be added to the mix, the former Queensland Government approved in February a \$425 million sugar/ethanol/power generation facility by the [North Queensland Bio-Energy Corporation Limited \(NQBE\)](#), the first multi-functional facility of its kind in Australia. Producing 330,000 tonnes of



sugar, it has a distillation capacity of around 70 million litres of ethanol per year and a generation capacity for 80-85 megawatts of renewable power. Australia's biodiesel capacity stands at 275 million litres per year, with three major production facilities, the largest of which, with a capacity of 100 million litres per year, is run by Smorgon Fuels in Melbourne.

Yet a significant boost is expected from a US\$220 million soybean processing facility at Port Kembla, for which construction began in April. The plant, approved in 2009, will have a capacity for 288 million litres of biodiesel per year, using 1.3 million tonnes of mostly imported Soybean. In addition, the plant will produce high protein Soybean meals and pharmaceutical grade vegetable glycerine.

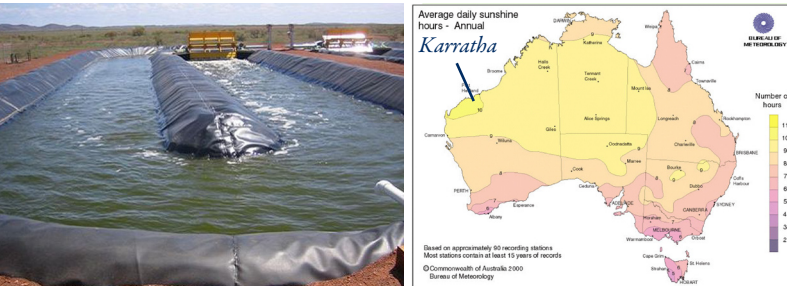
However, over the past years biodiesel production has been struggling. In December the NSW Government decided to suspend a scheduled increase of a current biodiesel mandate under the Biofuels Act 2007, which requires primary petrol wholesalers to include 2% biodiesel to their total sales in NSW. The mandate was scheduled to increase to 5% on 1 January but according to the State Government local production of biodiesel is at present too low to meet this target.

By contrast, the replacement of regular unleaded petrol with E10, a 10% blend of ethanol with petrol, will go ahead as scheduled in the Act from 1 July 2012.

associated with the alternative of a closed bioreactor. However, it also presents the challenge of contamination with bacteria or other unwanted microorganisms.

To minimise this risk, the researchers use an algae strain which not only has very high oil content but also can be grown in high salt water, and they were able to grow the algae in large quantities over long periods without contamination.

Funded with close to \$2 million by the **Australian Government** as part of the **Asia-Pacific Partnership on Clean Development and Climate** (the grant finished last year), the project developed a complete production chain from cultivated algae to biodiesel. A plant covering one acre was constructed in Karratha, WA, and commissioned in November 2010 as the first algae biofuels pilot plant in Australia.



images: left algae grown in open pond, Muradel; right: Bureau of Meteorology

It is now run by **Muradel Pty Ltd**, a joint venture company of **Murdoch University**, the **University of Adelaide** and **SQC Pty Ltd.**, a South Australian biofuels company with strong links to India.

Karratha was chosen as it offers significant environmental advantages, most importantly lots of sunshine – according to the **Bureau of Meteorology** around 11 hours a day on average.

With production rates of 50 tonnes of algae per hectare per year, the project partners aim to push the costs of producing biofuels including biodiesel from algae oil and ethanol from algae sugars from around \$5 per litre reported in January 2011 down to less than \$1 per litre to become market competitive.

The challenge will be to bring the project to industrial scale, with millions of cubic metres of algae cultivated in marine ponds open to temperature, wind and dust. This will still require a series of technological breakthroughs in the development of new, cost effective ways of harvesting such quantities of algae, extracting the oil and refining it to biodiesel.

Still, Muradel's development plan aims for a 400 hectare commercial scale plant by 2015.

In 2011, the Government announced a \$20 million **Australian Biofuels Research Institute** (ABRI), which provides for a new \$15 million **Advanced Biofuels Investment Readiness Program** [launched](#) in February to support pre-commercial advanced biofuels demonstration projects producing drop-in fuels.

In addition, the Government also unveiled funding of \$5

million for the **High Energy Algal Fuels Project** at **James Cook University** as ABRI's foundation project.

The JCU is undertaking the project in collaboration with **MBD Energy** and the **Advanced Manufacturing Cooperative Research Centre**, and through a separate agreement between JCU, MBD Energy and the CRC it will leverage a further \$6 million. Other partners involved are the **University of Sydney** and its commercial partner **Licella**.

The project aims to develop and demonstrate Australia's first example of using freshwater and marine macro-algae to produce biocrude for fuel conversion. Apart from delivering biofuels, the project is expected to also produce fertiliser, animal feed, human food and nutraceuticals.

In two separate programs, the collaboration will optimise biomass productivity and critically, biomass organic yields for biocrude production using hydrothermal methodologies. In the next step, the project will then enter a commercial scale production and processing of macroalgal biomass.

A significant benefit of the research will be to capture CO₂ from a major power plant, which capitalises on what is a problem for large scale algae production elsewhere – high growth is dependent on CO₂, and atmospheric supply may be insufficient. Supported with \$1 million [from the Queensland Government](#), the venture partners JCU and MDB are already involved in a project using waste flue gas emissions from the **Tarong Energy** coal power plant to promote macroalgal growth, thus sequestering significant amounts of GHG emissions. Tarong, which comprises four coal-fired units with a gross generating capacity of 1,400 megawatts (MW), is one of the largest energy generators in Queensland, and according to MDB, the project is well advanced in the construction of a one hectare carbon capture and recycling Algal Synthesiser Display Plant at the site. The plant is anticipated to capture 700 tonnes of CO₂ per year and produce one tonne per day of algal biomass.



If successful, the carbon abatement and algal biomass production trials may provide a blue-print for a much larger potential commercial-scale facility at one or more of the coal fired power stations the company has early stage agreements with.

The project not only has potential for producing biomass for fuel production and for climate change mitigation, as well as other potential products including food, there are also likely benefits for regional Australia, as independent member of Parliament **Tony Windsor** pointed out in an address at the **National Press Club** in early March.

A partner in the project [will be](#) NSW-based **Licella**, a wholly owned subsidiary of **Ingite Energy**. In the past, Licella attracted considerable media attention, recently in connection with the opportunities arising through the US Navy.

The company developed a process involving the treatment of biomass in a hydro thermal reactor with water in a supercritical state, which it reaches under high pressure and heat. The process, also known as CAT-HTR, can produce bio-crude oil for drop-in fuels from almost any form of feedstock, ranging from wood and agricultural waste, sugar bagasse and grasses to algae.

Previously supported through a \$2.3 million grant from the Australian Government's **Second Generation Biofuels Research and Development (Gen 2) Program**, the technology has now [progressed](#) to a commercial demonstration facility, which was opened at Somersby, NSW, in December last year. Reflecting the potential for drop-in fuels for aviation, the company entered Memorandum of Understanding agreements with **Virgin Australia** and **Air New Zealand**.

The versatility of the technology is underscored with a further agreement [attained](#) with joint venture partners **TRU Energy** and **Norske Skog**, which will see, following extensive testing, the Somersby commercial demonstration plant reassembled at the **Yalloum Power Station** in the Latrobe Valley sometime in 2012, and supply upgraded CAT-HTR energy products to the power plant.

Another example for the growing commercial push in using algae for advanced biofuels is the US-Australian company **Algae Tec**. Founded in 2008, Algae Tec has [reached](#) a global reach, with offices in the US and Perth, and publicly listed in Australia, the US and Germany. The company, which in Australia has now exceeded a market capitalisation of \$90 million, was co-founded by its executive chairman **Roger Stoud**, who is currently also the chairman of the **Centre for Research into Energy and Sustainable Transport**, a collaborative initiative by **Curtin** and **Murdoch Universities**.

The company's technology, dubbed the McConchie-Stoud system, uses a modular system of photo-reactors, which it says

allows high efficiency production of micro-algae. In addition, the company claims that its algae harvesting and product refinement technologies provide improved productivity, product yield, carbon dioxide sequestration, plant footprint requirements and capital/cost savings compared to agricultural crops and other competitive algae processes in the industry.

Backed by numerous trials at various scales, the attractive offering of a potential alternative transport fuel combined with a possible solution for carbon emitting industries appears to have resonated with investors, reflected in a successful ASX share placement of \$5 million in January this year.

Mr Stoud was recently appointed a member of the advisory board for the **Fuels and Energy Technology Institute**, which was launched at **Curtin University** in February, and together with a new **Biofuels Research and Development Facility** will develop and seek to commercialise advanced biofuel technologies and processes.

The Curtin researchers have already developed a new pyrolysis technology that uses simplified equipment, does not produce a residual product that requires disposal, demands less energy and can accept nearly all biomass as the feedstock.

Such significant technology breakthroughs will be necessary to get an advanced biofuels industry off the ground, here in Australia and elsewhere.

Given the vast potential bioenergy resources, Australia's share of worldwide production is still relatively small (see box) and centres on ethanol and biodiesel.

However, the development of advanced biofuels could present Australia with an immense opportunity to build an industry of significant scale – provided the sector receives adequate financial support from public and private sources to develop to a substantial scale.

This is the central conclusion of a report^{***} summarising a Government commissioned **Advanced Biofuels Study**. Released in December 2011, the outlines the various alternatives in producing advanced biofuels, the potential of the industry for Australia's economy and fuel security, and the steps required to help the still fragile development of the sector.

Prepared by **L.E.K. Consulting**, the report makes a strong case that the development of the industry will rely on Government willingness to meet considerable early stage challenges, and to help attract private investment.

image: Licella



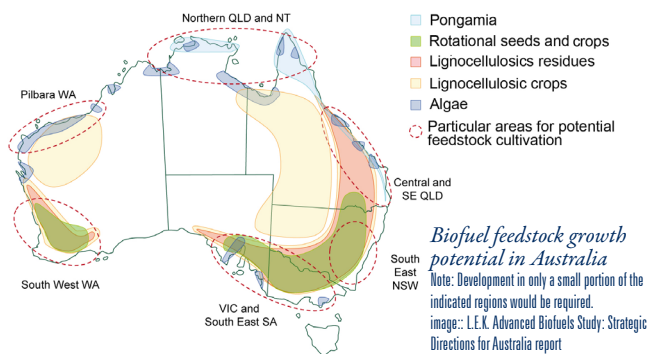
Algae Tec Photo-Reactors
image: Algae.Tec

Notably, biofuel production will require the concurrent development of all stages in the supply chain. For example, at present there is insufficient feedstock being produced, in part because conversion technology and refinery infrastructure are not yet available.

With adequate Government support in the first 5 years driving a portfolio of pilot and demonstration initiatives, the private sector is predicted to take an increasingly strong lead from then onwards.

Foundations should be laid now for an industry delivering at least 15-30 giga litres (GL) petrol-equivalent per year of advanced biofuel – supplying most of the fuel needs of industries such as aviation, defence, freight road transport, marine and mining – with the potential to grow into an industry producing more than 70 GL, which would cover most of the domestic fuel demand and potentially even export.

This is an ambitious proposition that would demand significant investment and imply substantial change of land use: A 15-30 GL industry would require more than \$50 billion in upfront capital, and if feedstock were to be met through crops, plantations would have to cover an area larger than Tasmania – around 5-10 million hectares of new crop based plantations, although, this could be substantially less with the use of, for



example, algae.

However, the report emphasises that this would establish a new industry of around \$10-20 billion, equivalent to the size of the existing automotive, appliance and equipment manufacturing sectors.

“The opportunity to develop a new major industry of the future does not often present itself, and as cost competitiveness for ABF may be attainable in the medium term, there are strong merits in acting now to lay the foundations for a sustainable ABF industry,” the report states.

Australia has competitive advantages because of its expertise in agricultural sciences, its abundance of flat land and sunlight, and is ideally positioned for the use of algae and dedicated crops that require low nutrient input but result in high yield per acre.

The authors predict they could become cost competitive

within 5-10 years, as prices for non-renewable fuels continue to rise and production costs for advanced biofuels fall.

Among the potential benefits for Australia, the report lists:

- potential mitigation of risks to Australia’s fuel security;
- potentially significant reduction in GHG emissions, with refined fuels currently accounting for 23% of Australia’s total GHG emissions; and
- meeting of specific industry needs such as aviation, but also defence (assorted fuels), freight road transport (diesel), mining (diesel) and marine (diesel and fuel oil).

The potentially vast benefits of an established industry could be even more widespread with the development of drop-in biofuels, which the report considers as the more attractive option compared to ethanol and biodiesel, as they would alleviate the need for costly changes to existing infrastructure, and considerably expand the range of potential end-user applications.

Notably, with ethanol and biodiesel production Australia is at a comparative disadvantage to countries with larger, more established, conventional biofuels industries.

For the establishment of an industry of the proposed size, scalability of advanced biofuels technologies will be crucial and will, in the longer term, require the planting of new dedicated lignocellulose crops and/or the use of algae.

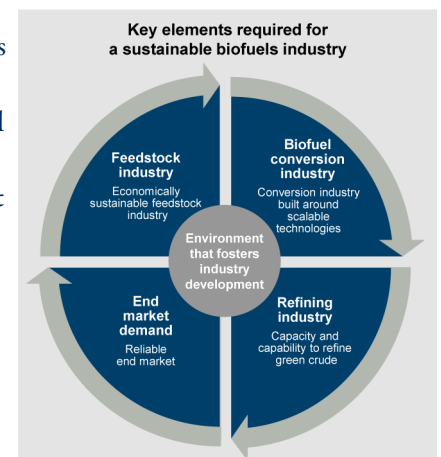


diagram: L.E.K. Advanced Biofuels Study, Strategic Directions for Australia report

Each of these feedstock groups have the potential to produce up to around 30 GL of biofuels. To put this in perspective: Australia currently consumes 51 GL of liquid fuels, which is set to rise to 67 GL by 2030. The use of algae would also provide the additional benefit of requiring substantially less land use.

However, there is also a much higher risk involved in the development of biofuels based on these feedstocks. While Australia should set the foundation stones for these bigger, more transformative outcomes, smaller, near term, commercially prospective choices should be part of diversified portfolio of targeted technologies and feedstocks. These would include lignocelluloses from available biomass such as agricultural, wood, forest and waste residues, and oilseeds from species such as juncea, camlina and pongamia.

- * Price Volatility in Food and Agricultural Markets: Policy Responses (2011) prepared by FAO, IFAD, IMF, OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF. ** Borowitzka MA (1999) Journal of Biotechnology 70: 313-321; ***L.E.K. Consulting; Advanced Biofuels Study; Strategic

Dry nightmare

Back in October 2010, the **Murray-Darling Basin Authority** [released](#) its *Guide to the proposed Basin Plan*, an ill fated document born out of the intention to fulfill a mandatory requirement set out in the *Water Act 2007* that the MDBA has to determine the environmental needs for water in the Murray-Darling Basin. The Act requires the MDBA to establish new limits on water that can be taken out of the Basin, so-called long-term average sustainable diversion limits (SDLs), which “must not compromise key environmental areas”.

In our [ARDR November 2010](#) edition we featured the Guide together with a number of key reports that still provide relevant context.

Back then the MDBA, chaired by **Mike Taylor**, concluded that to fulfill this requirement at the very basic level, water available for consumption, including water taken by farm dams and by forestry, would have to be reduced by 3,000 to 4,000 gegalitre per year (GL/y). This would have required a limit to the average diversions of surface water to 9,700-10,700 GL/y.

On 28 November 2011, the MDBA [released](#) the Draft Basin Plan for a 20 week period of consultation, which ended in April.

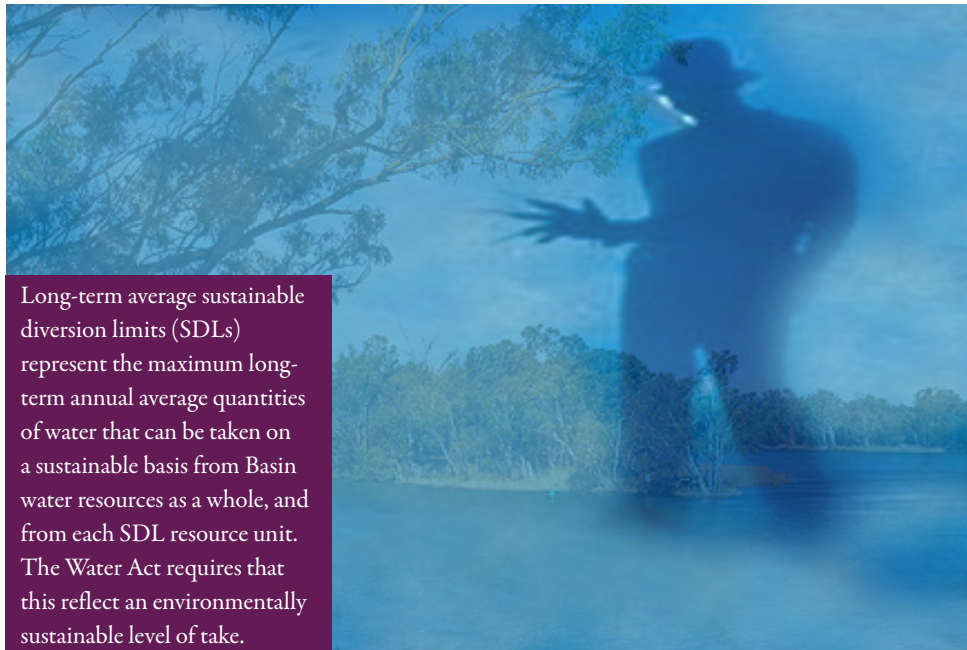
The proposal is an attempt to build a pathway for sensible water management of Australia’s major river system out to 2019. But already it is marred by similar controversy that surrounded its predecessor.

In its forward, the MDBA states that there is no single number that will magically fix the health of the Murray–Darling system. “What is done with the water, how the rivers are run, how flows are controlled, historical constraints in the system, and how water is recovered all add to the complexity and make a ‘just add water’ solution laughable”.

Now led by **Craig Knowles**, the MDBA says that, according to more recent and robust modelling, key environmental objectives can be met through the recovery of 2,750 GL/y, which is lower than the range suggested in the Guide.

To achieve this only 1,468 GL/y remain to be recovered over the next seven years, due to previous water buy backs and infrastructure improvements. The long-term average use of surface water would be limited to 10,873 GL/y.

The lower volume, based on the new modelling, will achieve the objectives of keeping the Murray flowing to the sea nine years out of 10, to flush salt from the system and important sites



Long-term average sustainable diversion limits (SDLs) represent the maximum long-term annual average quantities of water that can be taken on a sustainable basis from Basin water resources as a whole, and from each SDL resource unit. The Water Act requires that this reflect an environmentally sustainable level of take.

in the Basin.

The MDBA emphasises that its vision is to establish an adaptive management approach, and that to bridge the current gap to sustainability would not include compulsory acquisitions of water.

The proposed plan also includes a process of monitoring, evaluating and adjusting, with a mid-point review set in 2015.

A further central point is the recognition of a northern and a southern part of the basin requiring different river management approaches. For the Northern Basin the MDBA proposes the establishment of a Northern Basin Committee of community representatives to work with the MDBA.

Water repellent

In April, the **NSW Government** [announced](#) it would not support the proposal in its current form. Nationals leader and Deputy Premier **Andrew Stoner** said in a statement that the MDBA has not clarified the environmental outcomes, nor validated the proposed SDLs or the mechanisms for their recovery through the large downstream share component.

The State Government proposes in its submission to pursue environmental outcomes through infrastructure, environmental works, and smarter management of the basin as the main instruments.

Victoria’s Government also rejects the proposal. Water Minister Peter Walsh described the plan as too costly for the State. In its submission to the MDBA [it states](#): “The efficient and smart use of environmental water [...continued page 57](#)”

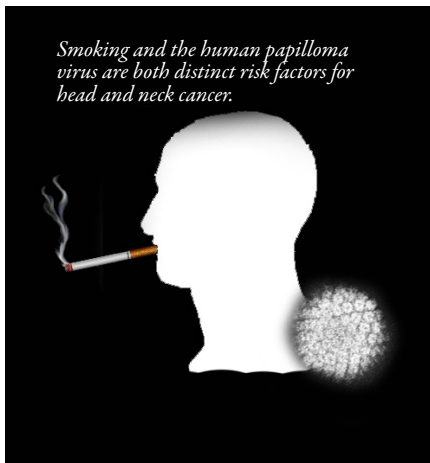
Welcome benefactors

Atlantic Philanthropies, a private foundation created in 1982 by US businessman **Charles Feeney**, will contribute \$15 million towards the establishment of a head and neck cancer research centre in Queensland. It will be largely based at Queensland's **Princess Alexandra Hospital** and the \$354 million **Translational Research Institute**, which is currently under construction due to be completed in October 2012.

Announced in early March, the head and neck cancer research centre will develop novel diagnostic and treatment therapies, form partnerships with commercial collaborators and train healthcare workers in Australia and Southeast Asia. According to a lead investigator in the project, **University of Queensland's Professor Ian Frazer**, the centre will also bring critical new equipment for developing tests to help treat head and neck cancers

Other lead investigators include **Dr Chamindie Punyadeera** from the **Australian Institute of Bioengineering and Nanotechnology**, and **Drs Peter Parsons** and **Chris Schmidt**, both from the **Queensland Institute of Medical Research**.

► **More information:** www.uq.edu.au



Freebies revolution

At the end of last year, the **University of New South Wales (UNSW)** was the first in Australia to announce it would implement a new **Easy Access IP** strategy to provide businesses better – and partially free – access to university owned intellectual property (reported in ARDR Sep-Dec 2011).



Macquarie University has now followed suit in joining the **Easy Access Innovation** partnership, providing industry free access to a selected portfolio of its research and technology.

According to deputy vice-chancellor (research) **Professor Jim Piper**, the Easy Access development, first established at

three universities in the UK, is revolutionising the relationship between academic research and commercial enterprise overseas. The benefits for companies are twofold, as they can use and develop university IP for free and beyond that also eliminate the costly process of negotiation by using straightforward one-page agreements.

► **More information:** www.mq.edu.au/newsroom

Disseminating networks

The **CSIRO Organic Geochemistry of Mineral Systems Cluster** was officially **launched** at **Curtin University's Resources and Chemistry Precinct**, funded with \$3 million from the **CSIRO National Research Flagships Collaboration Fund** with a matching in-kind contribution from **Curtin University, The University of Western Australia, The University of Melbourne** and **The Australian National University**.

Curtin's **Professor Kliti Grice** will lead the project, which by combining local mineral system knowledge with internationally recognised skills in organic geochemistry will provide the latest tools and technologies for Australia's mineral explorers.

The centre will establish a skills base to understand the crucial role organic compounds and processes played in the formation of Australia's major metal deposits, and work towards the integration of organic geochemistry and inorganic chemical systems in ore deposits. To this end it will work closely with **CSIRO's Minerals Down Under National Research Flagship**, which draws on a multi-disciplinary global expertise to transform the Australian minerals industry with new technologies.

The cluster will strongly emphasise on building partnerships and networks, which according to Curtin's vice-chancellor **Professor Jeanette Hackett**, will help disseminate findings more widely. The University of Western Australia, one of the partners in the project, **announced** that three of its internationally renowned scientists will join the cluster. They are:

- **Winthrop Professor Malcolm McCulloch**, an expert in the development and application of innovative geochemical approaches;
- senior research fellow from the **West Australian Biogeochemistry Centre Dr Paul Greenwood**; and
- **Centre for Exploration Targeting** director, **Professor Campbell McCuaig**.

► **More information:** <http://news.curtin.edu.au>

Engineered health

The **University of Sydney (USYD)** has officially opened its new **Institute of Biomedical Engineering and Technology**, bringing together a team of around 35 researchers working in one of the fastest growing branches of engineering. The institute will cover a broad field of biomedical engineering and technology including biomechanics, biomaterials and tissue engineering; biotechnology and biomolecular engineering;

biomedical devices and instrumentation; and imaging, visualisation and information technologies.

Professor David Feng, who will lead the facility, said the BMET will work closely together other partners, particularly with USYD's **Charles Perkins Centre**, which focuses on obesity, diabetes and cardiovascular disease.

He said that the BMET will play an important role in bridging the gap between core engineering and technology research and the translation of research outcomes into clinical practise or application. "For example, our researchers are developing ambulatory solutions using impedance imaging, bio-impedance and bio-potential monitoring to assist in both the rapid diagnosis and long-term monitoring of heart attacks and strokes."

► **More information:** <http://sydney.edu.au>

Electrifying India

Alternative energy transport is the focus of a new research collaboration between **Swinburne University of Technology**, the **Co-operative Research Centre for Automotive Technology** (Auto CRC) and the Indian **Jaypee University of Information Technology** (JUIT).

The project will consider the social and technological barriers and challenges that exist in relation to consumer uptake of alternative energy transport in India. Consumers in New



Mumbai traffic
image: flickr

Delhi, Mumbai, Bangalore, Chennai, Chandigarh and Shimla will be studied to determine factors that drive the use of alternative energy transport,

the availability of alternative energy transport, and the feasibility of using electric cars.

► **More information:** www.swinburne.edu.au

Bonding with India

Bond University has entered a partnership with **Tata Consultancy** (TCS), the IT service arm of Tata group, one of India's largest industrial conglomerates. The agreement provides for research collaboration, the exchange of academics and industry experts, and professional development programs. It builds on a number of established partnerships between the university's **School of Information Technology** and industry,

which includes **IBM** and Microsoft.

With its headquarters in Mumbai, **Tata Consultancy** (TCS) is one the largest providers of software services consulting in India with 42 offices worldwide including Australian offices in Sydney and Melbourne.

► **More information:** www.bond.edu.au

Google Reef

An unusual venture between **University of Queensland's Global Change Institute**, not for profit organisation **Underwater Earth**, insurance company **Catlin Group Limited** (sponsor) and global technology giant **Google** will undertake a scientific expedition to explore the health of coral on the **Great Barrier Reef**.

The **Catlin Seaview Survey** aims to carry out the first comprehensive study of the composition and health of Reef coral to an unprecedented depth range (0-100m).



image: University of Queensland

The project will be led by UQ's **Professor Ove Hoegh Guldberg** and comprise a series of studies which also will aim to reveal to the public one of the last frontiers on Earth: the oceans. Through the use of a camera developed for the project the venture will capture roughly 50,000 of 360-degree underwater panoramas, which will be made available to the public through Google. The survey will be accessible in partnership with **Google Earth** and **Google Maps**, and will also have a dedicated YouTube channel. In addition to the Google platforms, the project generated content will also be made available at www.catlinseaviewsurvey.com.

The project will include three surveys:

- The Shallow Reef Survey provide a visual census of corals, fish and many other organisms at 20 sites across the entire length of the 2300km Great Barrier Reef to establish a broad-scale baseline for understanding climate change on coral reefs.
- The Deep-Water Survey will use diving robots to explore the reef at depths of 30-100 metres for a comprehensive study of the health, composition and biodiversity of deep-water reefs.
- The Mega-Fauna Survey will study the migratory behaviour of tiger sharks, green turtles and manta rays in response to increasing seawater temperatures.

► **More information:** www.uq.edu.au

From small things...

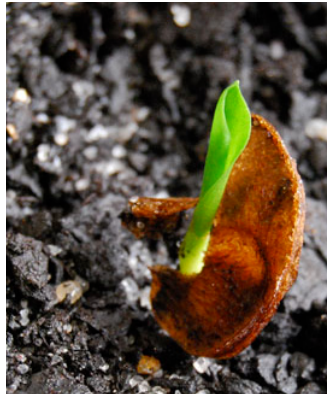
Set up two years ago under former Innovation Minister **Senator Kim Carr**, **Commercialisation Australia** has to date supported 248 Australian innovations in the early stages of commercialisation with grants totalling \$97.1 million. This includes two announcements in February and early April, in which grants worth \$22.4 million were offered to 74 businesses.

The diverse range of successful applications include:

- **Licella Pty Ltd** – \$2.00 million for its Cat-HTR (Catalytic Hydrothermal Reactor) technology, which converts second generation biomass feedstock into bio-crude oil, an alternative to petroleum crude oil. The oil can then be “dropped in” to existing refinery infrastructure (see also lead ‘Green fuel for the future’.
- **On-Market Bookbuilds Pty Ltd** – \$1.85 million for the development of an early-stage marketing and sales post-launch strategy of a process to more efficiently price and allocate private placements and initial public offerings (IPOs).
- **AtCor Medical Pty Ltd** – \$1.22 million for the developer of a SphygmoCor®, widely used for the non-invasive measurement of aortic pressure. The funding will support an innovation to capture the central aortic waveform for accurate results and to make the system easier to use.
- **Optimized Ortho Pty** – \$2.16 million for the marketing of pre-operative computer simulations that help predict the behaviour of knee and hip implants.
- **Innovate AG Pty Ltd** – \$1.5 million for the commercialisation of a non-toxic organic pesticide for the cotton and other agricultural industries.
- **Australian BioRefining Pty Ltd** – \$0.86 million for targeted pilot trials of its technology which facilitates the recovery and regeneration of used acid, such as sulphuric acid, from mining and industrial waste applications, and the concurrent recovery of metals from the same process streams.
- **A W Bell Pty Ltd** – \$1.53 million to commercialise a new process that casts complex aluminium parts suitable for aerospace and defence applications, with the same mechanical properties as machined parts. The process known as Aluminium Billet Equivalent (ABE) was developed in conjunction with **CSIRO** and virtually eliminates material wastage.
- **Hydrexia Pty Ltd** – \$0.76 million to commercialise a high capacity and low cost hydrogen storage system based on novel magnesium alloys which store hydrogen as a solid metal hydride, targeting the industrial gas and refuelling markets.

In addition to these Early Stage Commercialisation grants (up to \$2 million), the program offers proof of concept grants (up to \$250,000), grants to build skills and knowledge (up to \$50,000) and grants supporting the recruitment of experienced executives (up to \$350,000).

► **More information:** www.commercialisationaustralia.gov.au



Renewable investment

The \$200 million **Southern Cross Renewable Energy Fund**, currently the largest venture capital fund dedicated to renewable energy in Australia, is open for business.

In December 2011, Resources and Energy Minister **Martin Ferguson** announced **Southern Cross Venture Partners Pty Ltd** as the successful fund manager of the fund in which **Softbank China Venture Capital** and the **Australian Government** are investing \$100 million each.

The fund’s investments will help early-stage Australian renewable energy companies overcome capital constraints, develop technologies, increase skills and forge international connections.

The fund, which will be part of the \$3.2 billion **Australian Renewable Energy Agency (ARENA)** commencing in July, will actively seek private sector funding to support a portfolio of companies. The Government has appointed **Mark Bonnar** as investment director playing a key role in evaluating potential investments.

► **More information:** <http://minister.ret.gov.au>

A still largely untapped renewable energy resource



Happy couple

The **CSIRO** and **Boeing** have entered a five-year \$25 million strategic research program, the **Australian Government** announced. The agreement represents the next stage in a 23 year old partnership in which both organisations have together invested around \$110 million across a wide range of projects. This includes innovations in sustainable aviation fuels, aircraft assembly processes, fire retardants and aircraft maintenance management software.

For example, the partnership resulted in a metal alkoxide-based surface treatment that modifies and activates an ‘aged’ paint surface, forming a strong chemical bond with the fresh paint layer. According to **Ian Thomas**, president of **Boeing Australia & South Pacific**, the technology has been applied to over 800 commercial aircraft since June 2008.

The strong relationship has played a key role in the development of Boeing’s operations in Australia including the decision to establish research and development laboratories in



Brisbane and Melbourne.

► [More information](http://minister.innovation.gov.au): <http://minister.innovation.gov.au>

Encapsulating progress

Over the past 7 years or so, LCT's market development has been a rollercoaster ride for investors, and its share price is now a fraction of previous highs just a few years back.

Yet, late last year LCT's clinical development received a major boost through a partnership agreement with Japanese **Otsuka Pharmaceutical Factory Inc**, with which it formed a 50:50 venture called **Diatranz Otsuka Limited**.

The \$50 million venture will continue the clinical development of LCT's **DIABECELL** product for the treatment of type-1 diabetes, which is currently in Phase II trials in New Zealand and now also in Argentina.

The product is based on insulin producing pancreas cells from a unique stock of disease-free Auckland Island pigs, for which LCT [was granted](#) US patent rights in January. The cells are delivered wrapped in a seaweed-derived alginate capsule, which allows nutrients, oxygen and the produced insulin to

permeate through the capsule's membrane, while the porcine cells are isolated from the patient's immune system.

There are [similar approaches](#) elsewhere, such as by US company **ViaCyte**, which is conducting pre-clinical trials of pancreas progenitor cells derived from human embryonic stem cells that are

delivered in retrievable, non-biodegradable capsules. Protected from immunological attack, the progenitor cells are expected to differentiate into functioning islet cells producing insulin – and hopefully without the development of scarring tissue or leaking of capsules over time.

However, throughout the Phase II clinical trials LCT's **DABECELLS** have lived up to the promise of providing functional cell replacement for the damaged pancreatic beta cells in diabetes patients without the need for immunosuppressants, and the company [refers to](#) one patient whose implanted cells are still producing insulin after more than 10 years.

Tissue from the Auckland Island pigs encapsulated with LCT's **Immupel** microcapsule technology also forms also the basis for other therapies, which are based on LCT's **NTCELL** product for neurodegenerative conditions. Potential applications for the product include Parkinson's and Huntington's disease.

According to [data](#) which LCT also [presented](#) at the

BioPharma Asia 2012, **NTCELLS** transplanted into affected brain regions of non-human primate models with Parkinson's reduced movement disorders and neurological defects associated with the disease, compared to controls with empty capsules. The more than 50% improvements were seen within two weeks and persisted for at least six months, the end-point of the trial. Treated regions also showed an increase in dopamine producing neurons, without any adverse events recorded.

Medical director **Professor Robert Elliott** announced that LCT would now apply for a NZ Phase I clinical trial in Parkinson's patients.

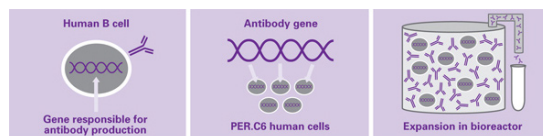
► [More information](http://www.lctglobal.com): www.lctglobal.com

Naturally safe

In the ARDR Sept-Dec 2011 edition we broadly reviewed **Patrys'** development of its natural human antibody pipeline (ARDR Sep-Dec 2011). This included **PAT-SM6**, which targets a protein (**GRP78**) on cancer cells that is involved in the cell's survival, growth and cancer metastasis. The antibody is a potential treatment for a number of cancers, including multiple myeloma and melanoma.

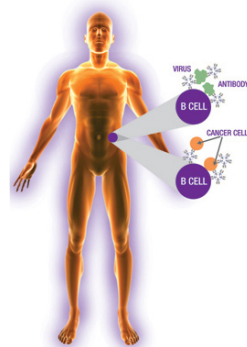
The company recently [reported](#) that its Phase I safety trial of **PAT-SM6** in patients with a recurrent form of melanoma has been successful. The therapy was found to be safe and well tolerated during the trial and month-long follow up period. There was also no significant immune response to **PAT-SM6**, which the company says supports its decision to advance the antibody's production through the human cell line **PER.C6**, a FDA/regulatory compliant, high producing human recombinant cell line which Patrys licensed from **Crucell N.V.**

Beyond the positive safety profile of the therapy, the trial results also support the anti-cancer activity of the antibody. The



The development path of Patrys antibody therapies is different to classic approaches, in which targets are identified and then potentially therapeutic antibodies are raised. Instead, Patrys approach started with the isolation of B-cells from human donors. B cells producing cancer killing antibodies were identified and then their target antigen characterised. Novel targets on cancer cells were discovered and a pipeline of candidate B-cells obtained. Recombinant versions were then produced in large amounts in the human recombinant cell line PER.C6[®], licensed from Crucell N.V.

image: modified images from www.patrys.com



company says that despite the low dose used, increased cancer cell death was observed to be widespread in at least one of the patient's following the treatment. The company also reported that much higher doses, exceeding the expected maximum therapeutic dose, were used in a supporting animal toxicology study. No adverse effects were observed, which would create a significant safety margin for dosing in future trials.

With the development the company progresses its second

potential anti-cancer therapy based on its natural human antibody pipeline, the most advanced being PAT-SC1 for the treatment of gastric cancer.

► [More information: www.patrys.com](http://www.patrys.com)

All smiles again

Pharmaxis had crucial breakthroughs with its Bronchitol as a new treatment for cystic fibrosis. First, the company succeeded in getting the treatment on the Pharmaceutical Benefit Scheme (PBS), and has it now also approved in the EU market.

In November, the **Pharmaceutical Benefits Advisory Committee** (PBAC) had first opted not to recommend the listing – which according to chief executive officer **Dr Alan Robertson** highlights Australia as one of the most challenging reimbursement environments in the world. However, a resubmitted application has secured a positive response from the Government's advisory body.

It is now up to the **Australian Pharmaceutical Benefits Pricing Authority** (PBPA) to finalise the reimbursement process.

An application for the sale of Bronchitol as a treatment for cystic fibrosis in the European market had also a positive ending, after a less than smooth ride for the company.

In June last year, the **European Committee for Medicinal Products for Human Use** (CHMP) had shocked the company by refusing the marketing authorisation, but then adopted a positive opinion after the body reexamined the application (see also 'Significant stress relief', ARDR Sep-Dec 2011).

The happy ending came in

April, when the European Commission approved the product for patients 18 years and older. The company announced that Bronchitol would be made available at an ex-factory price of 20-25 Euros, and be first distributed to patients in Germany and the UK. The product will be launched at the *Cystic Fibrosis Symposium* in Dublin in June.

Bronchitol is a key development in the company's product portfolio, with sales of its asthma diagnostic test Aridol only modestly, although steadily growing in Europe and the US.

► [More information: www.pharmaxis.com.au](http://www.pharmaxis.com.au)

Silencing moments

Antisense partnership

With a market capitalisation of less than \$20 million, **Antisense Therapeutic** is still part of a pool of smaller players

in the now over \$20 billion Australian biotech market, despite it being listed on the **ASX** since more than a decade. The company has based its business strategy on developing therapies using antisense oligonucleotides, backed by a crucial alliance with US antisense technology specialist **ISIS Pharmaceuticals**, the developer of the first **FDA** approved antisense antiviral, marketed as Vitravene.

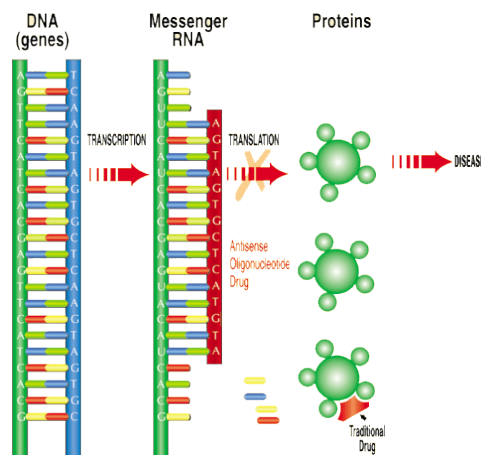
However, despite the success of the locally administered drug Vitravene, antisense therapies are still to achieve a significant clinical breakthrough, according to a recent review in the *Journal of Pathology**

This may change with new 'second generation' oligonucleotides that are now in development.

ATL1102, which Antisense has licensed from ISIS, is one of those new compounds – a 'second generation' antisense inhibitor that targets a key receptor molecule in the development of inflammatory diseases. Antisense focused the development of ATL1102 on multiple sclerosis, but also investigates its potential for treating allergic reactions such as asthma.

However, the road of ATL1102 development has been bumpy.

Antisense compounds are short sequences of chemically stabilised nucleotides which bind specifically to a target mRNA, which interferes with the protein the mRNA codes for.
image: Antisense Therapeutics



In 2008, the company completed a promising Phase II efficacy and safety trial, in which ATL1102 was found to significantly reduce the number of brain lesions in MS patients. But a following license agreement with global heavyweight **Teva Pharmaceuticals**

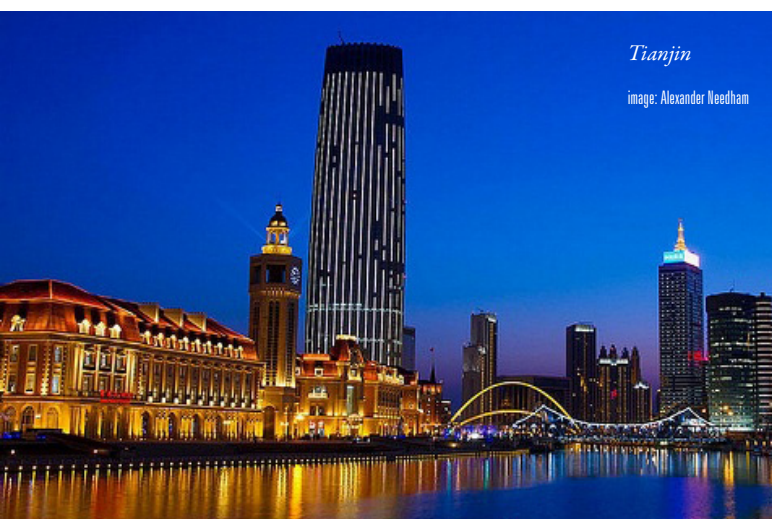
ended in 2010, when Teva cancelled the development saying that the drug was found to be no longer in line with the company's preferred product profile.

It was a significant disappointment for Antisense. Now, two years down the track, the company is again pushing forward with its ATL1102 clinical program through a prospective partnership with Chinese **Tianjin International Joint Academy of Biotechnology and Medicine** (TJAB). The development is of interest also because there are still few examples of Chinese-Australian partnerships in the biotechnology space.

Situated at the heart of a new technology park in Tianjin, TJAB was officially opened in 2009 as an important element

in China's push to become a global top player in biomedical innovation and industrialisation. Endowed with an investment of \$162 million the innovation hub is housed in a 19 story, 70,000 m² building boasting over 70 labs complete with modern equipment and instrumentation. So far it has not only attracted more than 100 R&D groups, but also completed notable international deals, including with **Genzyme Corporation** and **Johnson and Johnson**.

In February, Antisense [announced](#) a Terms Sheet Agreement with TJAB, which precludes a joint venture agreement to further develop and commercialise ATL1102. Under the agreement, TJAB will progress the clinical development of ATL1102 in China, with trials planned in MS and asthma.



Tianjin

image: Alexander Needham



In addition, the Chinese partners will investigate a potentially new application of the compound as a stem cell mobilisation agent in cancer patients, which Antisense had announced in September 2011. The finding is now also the

subject of an international patent application.

If successful, TJAB will commercialise the product for the Chinese market, while Antisense will retain the rights for the rest of the world.

The venture may just be the start of an extended relationship with the Chinese, as TJAB senior vice president **Professor Yao-Zhou Zhang**, who himself has worked in a related technology area, expressed the hope that the proposed alliance may result in a broader group of joint initiatives or projects.

Antisense is also progressing with the development of its ATL1103 product for the treatment of growth and sight disorders. The compound is designed to block the growth hormone receptor (GHR), and thereby suppresses a signalling pathway that leads to the growth promoting effector molecule IGF-1. The company is investigating a number of potential

clinical applications for the compound. This includes acromegaly and diabetic retinopathy, which both result from an oversupply of growth hormone causing associated excess levels of IGF-1 in the blood.

In a recently [completed](#) Phase I trial of ATL1103 in healthy men, the drug was found to be safe and well tolerated at the low dose levels used. All adverse events were reported as 'mild to moderate', the company said in a statement. In addition to the positive safety profile, the company is also encouraged by the pharmacological activity of the drug, which was assessed as a secondary endpoint and despite the low dose regimen established a significant reduction of IGF-1 in the blood.

In March, the company announced it [successfully raised](#) \$6.5 million to support its plans for a Phase II trial of ATL1103 in patients with acromegaly. The trial is expected to commence in the second half of 2012.

► [More information:](#) www.antisense.com.au

Interfering benefits

After its long legal battle over its intellectual property, **Benitec Biopharma** is continuing the development of clinical applications for its DNA-directed RNA interference (ddRNAi) technology.

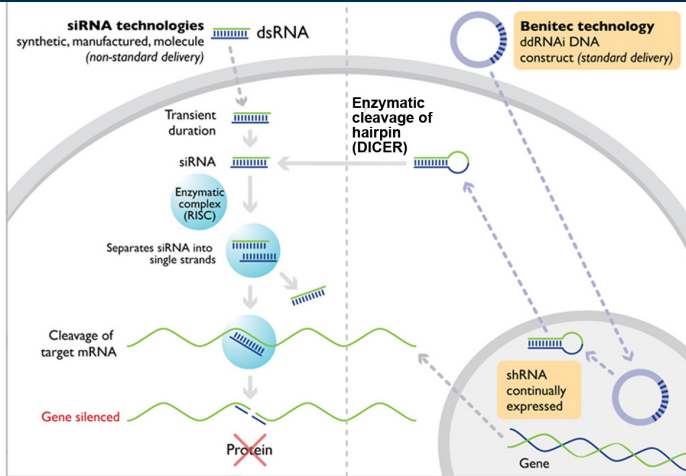
RNA interference occurs naturally in eucaryotic cells as an added sequence of double stranded RNA is cleaved by an enzyme called DICER to produce small RNAi fragments, of which one strand – facilitated by an enzymatic complex RISC – binds specifically to a target messenger RNA (mRNA). This prevents the mRNA from being translated into its protein product, in effect silencing the gene from which it is derived.

Experimentally, synthetic RNAi fragments can be directly introduced into a cell to transiently shut down target genes, a discovery awarded with the Nobel prize in 2006.

However, efficiently loading cells with RNAi in a clinical setting is extremely challenging.

Benitec's answer to the problem is to instead use DNA constructs, which are designed to enter body cells in a similar way to viruses, where they continuously produce a so-called short hairpin RNA (shRNA) designed to spontaneously fold into a double stranded substrate for the DICER enzyme. Cleavage then produces RNAi fragments with sequences targeting the mRNA of clinically relevant genes.

The technology promises to overcome significant obstacles for RNAi based therapies, and is protected in mammalian cells by the so called Graham family of patents, for which the company holds an exclusive worldwide license from the **CSIRO**. However, in 2004, this intellectual property became part of a legal dispute in which Benitec first sued US firm **Nucleonics** and two other companies for infringing a core patent of the Graham portfolio, and Nucleonics then chose to challenge the patent's validity. While Nucleonics went into liquidation in 2008, the world-wide re-examination of the patent as a result of the dispute still caused considerable distraction for Benitec,



a small company with a market capitalisation of less than \$20 million. A final breakthrough was achieved in March 2011, when the **US Patent Office's Board of Appeal** reinstated the patent.

Over the period, the company's portfolio of patents covering RNA interference for human therapeutic applications has increased significantly, with over 50 either owned or licensed from CSIRO, and around 50 applications pending. And freed from legal distraction, Benitec is also progressing in its still early stage therapeutic program, for which it provided an update in November 2011. Its in-house developments cover four clinical areas, with its cancer related projects being most advanced (preclinical stage):

- Cancer-associated pain (collaborating with the **University of Queensland**) – the company has two targets in neuropathic pain, the enzyme D-amino acid oxidase (DAO) and its lead target the enzyme PKC gamma, which the company believes has advantages including that it may overcome morphine intolerance. Earlier in 2011, Chinese researchers independently [validated](#) the potential of a silencing of PKC through RNA interference.
- Drug resistant lung cancer (collaborating with the **University of New South Wales**) – the company conducts pre-clinical experiments in animal models targeting a gene associated with chemotherapy drug resistance, and according to Benitec, preliminary results indicate the target gene is silenced without apparent adverse effects.
- Hepatitis B ([collaborating](#) with China's **Biomics Biotechnologies**) – the project has identified several ddRNAi molecules for silencing a key hepatitis B gene, and in an animal model achieved nearly 100% delivery of the molecules to the liver with a single intravenous injection, which Benitec says supports the feasibility of its therapeutic approach. A clinical trial is planned for 2013.
- Oculopharyngeal muscular dystrophy – the company [announced](#) in October 2011 it would collaborate with the **Royal Holloway University London (RHUL)** on the inherited, slow progressing, late onset degenerative muscle disorder. The project will develop a ddRNAi-based therapy to silence the expression of a mutant gene that causes the degeneration in muscle cells of OPMD patients. Further applications of Benitec's technology include:
- Benitec supported a clinical trial of its technology in HIV/AIDS by researchers at the **US City of Hope National Medical Center**, who in a follow-up study found that one participant still expressed the gene silencing RNA in his blood stem cells three years after receiving the construct. In addition, the number of blood cells carrying the construct, although low, increased 6-fold over the period. In March, buoyed by the results, Benitec [announced](#) a world-wide non-exclusive licensing agreement with US-based **Calimmune** to use the ddRNAi

Benitec's technology is using the naturally occurring DICER enzyme to produce small antisense RNA. The DICER substrate is delivered through continued expression of a DNA construct introduced into cells. This contrasts with other RNAi approaches, which require double stranded RNA delivered into the cells, bypassing the DICER mechanism.

technology in the HIV/AIDS area. The companies expect that Calimmune's approach will lead to clinical trials within the next 12 months.

- In 2006, Benitec secured a licence deal with US company **Tacere**, which is developing a Hepatitis C treatment based on the ddRNAi technology. As part of the deal, Benitec acquired a 5% equity stake in Tacere. In 2008, Tacere entered a license agreement with Pfizer worth US\$145 million to develop and commercialise the treatment. In January, Benitec [announced](#) that preliminary results published in *Antimicrobial Agents and Chemotherapy* were "extremely positive", showing the treatment is "highly effective at inhibiting the commonly circulating clinical isolates of HCV, with the ability to eliminate resistance to the molecule through the use of three shRNA sequences".

► [More information](#): www.benitec.com

Excremental linkage

Recent news stories in domestic outlets, such as the [ABC](#), but also internationally, have highlighted the emergence of virulent strains of the stomach bug *Clostridium difficile* in hospitals.

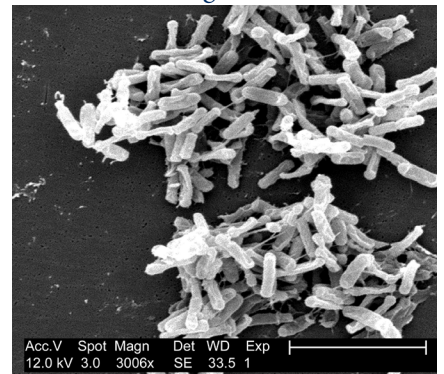
Professor Thomas Riley from the **University of Western Australia** told the ABC that infection rates in Australian hospitals have doubled over the past 12 months. Professor Riley and coworkers have recently detailed the emerging problem in a paper published in the *Medical Journal of Australia* *.

The bacteria produce toxins that can cause inflammation of the colon that may result in severe diarrhoea with a potentially fatal outcome. This could become an even greater threat with the emergence of antibiotic-resistant strains.

At the end of January, **Immuron Limited** and **Monash University** announced a [collaboration agreement](#) to develop new prevention and treatment options for *C. difficile* infections, based on the company's hyper-immune

colostrum platform technology. The research is supported through an **ARC** linkage grant, which will entail joint ownership of generated technology, and provide Immuron with exclusive global commercialisation rights on potential products.

Oral immunotherapies based on hyper-immune colostrum could have certain advantages for targeting the gastrointestinal infection, including, as Immuron points out in a company statement, a high safety profile. This could expedite the pre-clinical and clinical development of any potential treatment. The company has also already commercialised a colostrum based product targeting pathogenic microbes in the gastrointestinal tract – **Travelan** for the prevention of travellers' diarrhoea.



Clostridium difficile revealed in a scanning electron micrograph of a stool sample.
image: CDC Public Health Image Library

...and fatty prospects

Hyper-immune colostrum may also provide benefits by modulating unwanted systemic immune responses.

The company's Imm124-E product is based on colostrum from cows immunised against bacterial lipopolysaccharide (LPS). Given orally in mice, the product exerts an anti-inflammatory effect by influencing the activity of so called



T-regulatory (also known as T-suppressor) cells. The effect could deliver significant benefits for patients suffering from chronic inflammatory disorders, such as non-alcoholic steatohepatitis (NASH), the most severe form of fatty liver disease.

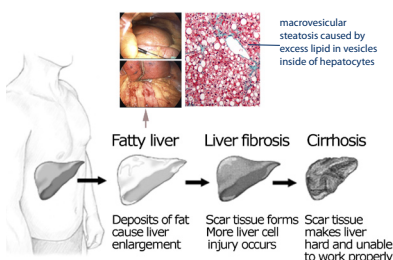
NASH is a common complication of Metabolic Syndrome and associated with insulin resistance, abnormal liver function, excessive amounts of triglycerides and other fats inside liver cells.

Immuron says that its approach could lead to the first approved treatment for the condition, and also the first that addresses the pathogenesis of the disease.

Following a successful Phase I/II trial, the company [announced](#) in January that it is now on track to commence a Phase 2b trial in the US, after the US FDA cleared

a respective Investigational New Drug (IND) without any concerns. The trial will determine the safety and efficacy of IMM-124E in patients with biopsy-confirmed NASH.

► [More information:](#) www.immuron.com; * Richards et al (2011) *Med J Aust* 194: 369-371



Progressive stages of liver damage caused by fatty liver, and, in a progressed stage, nonalcoholic steatohepatitis (NASH), which also features tissue inflammation.

image: adapted from NIH and other sources; creative commons license 3.0

Collaborative benefits

South Australian company **Bionomics Limited** is continuing its path of forming strategic partnerships.

Its most prominent collaboration was [forged](#) in 2008 through a Development and Licensing agreement with **Merck Serono**, under which Merck is using Bionomic's compounds that act on the immune response modulating potassium channel KVI.3. Blockers of the channel are being developed as therapeutics for a diverse range of autoimmune diseases including multiple sclerosis, which is the target of the Merck Serono collaboration, and which Merck [extended](#) last year to at least June 2012.

In March, Bionomics [announced](#) a new alliance with US based company **Ironwood Pharmaceuticals**, which licensed the anti-anxiety compound BNC210.

The deal comes early in the clinical development of the compound. Two Phase Ib trials, completed last year, indicated that BNC210 could provide rapid relief of anxiety without the common side effects of current treatments. On the back of the promising data, the company started looking for a suitable development partner.

The deal with Ironwood, which has a market capitalisation of around \$1.2 billion and a new drug ready to be launched in the US, is potentially worth over US\$345 million. It entails a relatively small upfront payment of US\$3 million and another US\$10 million over the next 2 years in research funding and milestones. A further US\$332 million will depend on achieving clinical and regulatory milestones. In addition, Bionomics could earn undisclosed royalties on net sales of BNC210.

According to Bionomics, the license agreement is the largest for a drug at such an early stage of development in the Australian market, and the undisclosed royalties may provide a significant stream of revenues in the future. It may also set Bionomics on a path to self-funding without the need for capital raisings in the near future.

The company will now also be able to refocus on the development of its most advanced drug, BNC105 for the treatment of solid tumours. The small molecule, a product of the company's MultiCore® chemistry platform, is a vascular disrupting agent (VDA) that shuts down existing and new tumour blood vessels. According to Bionomics, the compound also exerts a direct cytotoxic effect on tumour cells.

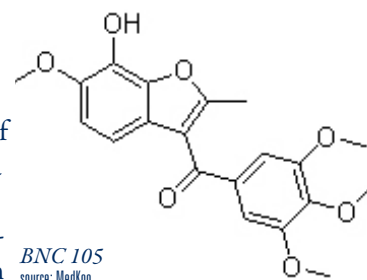
Last year, a trial in advanced stage mesothelioma patients revealed an overall clinical benefit of 43.3%, with one patient recording a 57% reduction in tumour size.

BNC105 is also in a trial as a co-treatment of renal cancer patients in the US. The trial builds on a Phase I trial completed in 2011 in which the drug [was found](#) to be safe and well tolerated when combined with Afinitor, a current treatment option for patients who have failed therapy with Tyrosine Kinase Inhibitors.

And the company [announced](#) in March that a Phase I/II trial in women with ovarian cancer has been approved, which will evaluate BNC105 in combination with current platinum-based chemotherapies (carboplatin and gemcitabine).

According to Bionomics, there is a clear unmet need for a more effective systemic therapy, as at present the majority of patients who are treated with surgery and chemotherapy still relapse and die from the cancer.

According to a company statement [released](#) in early April, BNC105 was found to be very effective against a human ovarian cancer cell line. The compound was also found to reduce blood flow in platinum resistant solid tumours of mice, in accordance with its vascular disruption activity. And in line with the



effective suppression of tumour growth, treated mice bearing platinum resistant ovarian tumours revealed significant survival benefits.

► [More information: www.bionomics.com.au](http://www.bionomics.com.au)

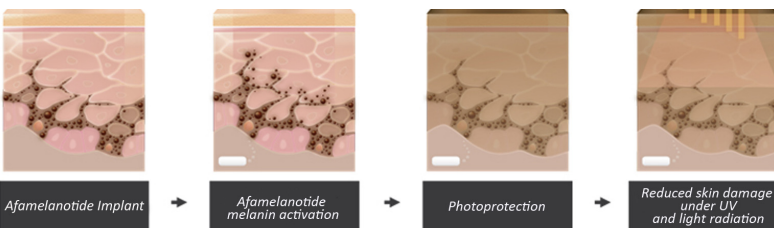
Enlightened protection

A series of recent announcements by **Clinuvel Pharmaceuticals** have outlined a path to the market for its lead dermatology product SCENESSE®. The small subcutaneous implant contains afamelanotide, which mimics the function of naturally occurring alpha-melanocyte stimulating hormone (α -MSH). By inducing skin pigmentation, the synthetic compound could thus potentially reduce sun (UV) damage.

Clinuvel has developed SCENESSE® as a treatment of erythropoietic protoporphyria (EPP), a rare but often very painful photosensitivity of the skin, which affects an estimated 10,000 people world-wide with no effective treatment options available.

As announced in December 2011, a pivotal European Phase III trial confirmed that patients who received afamelanotide had significantly less pain associated with phototoxicity, and only half as many phototoxic reactions compared to patients not receiving the treatment. On the back of these results, Clinuvel [applied](#) for a European market authorisation of SCENESSE® as a prophylactic treatment for EPP in adult patients.

The development is not quite as progressed in the US, where a Phase II study is just completed. Clinuvel announced the



results in November 2011, stating that the study overall demonstrated a strong clinical benefit to patients, despite their deeply learned behaviour to avoid reactions caused by sun exposure. A Phase III study in EPP patients is now expected to commence in May, after Clinuvel [reached](#) an in principle agreement with the FDA to conduct the trial.

While the EPP treatment development is most advanced, SCENESSE® is also in earlier stage studies as a repigmentation therapy in nonsegmental vitiligo, a common disorder in which absent or less active pigment producing cells result in lighter depigmented patches of the skin. In addition, SCENESSE® is [evaluated](#) in a Phase II study for its ability to limit UV-

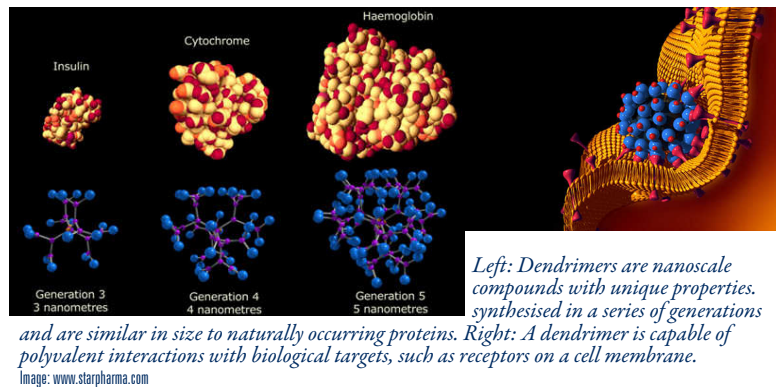
induced damage in organ transplant recipients, who are at an extreme risk of developing skin cancer due to the use of immunosuppressant drugs.

► [More information: www.clinuvel.com](http://www.clinuvel.com)

Big Nanosteps

With its dendrimer technology, **Starpharma Holding** is making steady progress in targeting a broad range of clinical and agricultural applications, as reviewed in our previous issue. One area of current research, although still in an early stage of development, is to improve the solubility and potential efficacy of existing drugs, including the widely used cancer drug docetaxel.

Starpharma has recently [released](#) data on a study with breast



cancer xenograft in mice. The animals were either treated with the company's dendrimer-docetaxel formulation or with Taxotere®, a docetaxel formulation marketed by **Sanofi Aventis** and the leading chemotherapy drug for solid tumours including breast, lung and prostate.

According to Starpharma, its dendrimer-docetaxel formulation was markedly more effective than Taxotere®, as 60% of treated animal had undetectable levels of the tumour 94 days after treatment, while at that time point all animals treated with Taxotere® showed significant re-growth or recurrence of the tumour. Up to day 60, both drug formulations were comparable, but from then on regrowth became apparent with Taxotere® but not with the dendrimer formulation. Starpharma says in a statement that this is likely to be due to a longer circulating half-life, and extended release of docetaxel from the dendrimer and the targeting of the dendrimer construct to tumour tissue.

In addition to the improved efficacy, there are potential clinical benefits resulting from a 5000-fold increased water solubility of the dendrimer-docetaxel, including the removal of components present in current formulations that can cause severe allergic reactions and fluid retention in some patients.

Deadly gels

However, the company's most advanced developments are

based on VivaGel®, a gel-based formulation of the antimicrobial dendrimer SPL7013. With licensing agreements in place with **Ansell Limited** and **Okamoto Industries Inc** to develop VivaGel®-coated condoms, Starpharma is focussing on the use of the gel for the treatment and prevention of bacterial vaginosis (BV) and as a vaginal microbicide for sexually transmitted diseases.

In latest news, Starpharma has commenced two pivotal Phase 3 trials for the BV indication. Starpharma expects to announce results from the trials, each conducted with around 220 participants, before the end of 2012, with the expectation that they will confirm safety and efficacy results established in previous phase 2 trials. If successful, the company will then submit a New Drug Application (NDA) with the US FDA while negotiating marketing rights with a prospective partner.

According to chief executive officer **Dr Jackie Fairley**, VivaGel® is not a conventional antibiotic and also has the potential for use in the prevention of recurrent BV, which could represent a major advance in the management of the most common vaginal infection worldwide.

► **More information:** www.starpharma.com

Humanely starved

Circadian Technologies Limited is an old player in the Australian biotech scene, although with a market cap of little more than \$20 million still one of the smaller companies. It was founded in 1985, primarily as a commercial vehicle launching biotech companies such as **Antisense Therapeutics** and **Optiscan Imaging**, in which it still holds interests.

In 2008, Circadian redirected its strategy by developing research programs that largely focuss on intellectual property owned by its 100% subsidiary **Vegenics Pty Ltd** and cover the use of Vascular Endothelial Growth Factor (VEGF)-C and -D. As members of the VEGF family, these proteins belong to a class of signalling proteins that regulate tumour blood supply and growth in the lymphatic system.

The company has built clinical programs around its IP that target therapeutics as well as diagnostics, with a blood based VEGF-D test for detecting lymphangiomyomatosis (LAM) marketed in the US. It also has partnered with **ImClone Systems** for the development of a treatment for solid tumours using a 'fully human' anti-VEGFR-3 antibody.

However, the company's internal development is centered around VGX-100, a 'fully human' monoclonal antibody targeting VEGF-C.

Potentially acting synergistically to Avastin®, a cancer blockbuster drug targeting VEGF-A, Circadian is currently directing its VGX-100 program on the treatment of glioblastoma metastatic colorectal cancers and a number of

other cancers, as well as for the treatment of front-of-the-eye diseases. The company has now commenced a first Phase 1 trial of VGX-100 in patients with advanced solid tumours who have no other treatment options. The company will test the antibody either as a monotherapy or in combination with existing therapies, which in previous studies in animals was demonstrated to be more effective than treatments with Avastin® and/or chemotherapy alone.

A new potential application for Circadian's VGX-100 antibody has recently been indicated in a study published in *Investigative Ophthalmology & Visual Science*, which found that VEGF-C is markedly up-regulated in mice that have received a corneal graft, and that treatment with VGX-100 significantly improves the survival of the corneal graft in the mouse model.

Circadian says [in a statement](#) that improving graft survival could address a major unmet clinical need in patients who are at risk of graft rejection.

In collaboration with **Healthscope Advanced Pathology**, the **Peter MacCallum Cancer Centre** and **NICTA**, the company has also [developed](#) a diagnostic test for carcinomas of unknown primary (CUP), the fifth most common cause of cancer related death in Australia. The test identifies a patient's tumour type by comparing its pattern of gene expression to a database of known

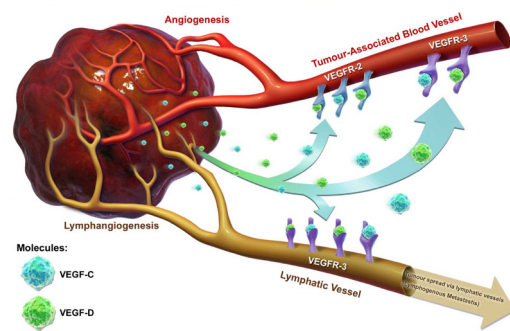


image: Circadian

tumours. According to data announced in March, the diagnostic is capable of detecting primary sources of cancers with high accuracy and specificity across 15 different tumour types.

Healthscope, through its subsidiary **Clinical Laboratories Pty Ltd**, has the rights to develop, clinically validate and market the test throughout Australia, New Zealand, Malaysia and Singapore, against a paid fee and potential royalty payments to Circadian, which owns worldwide exclusive rights to the test.

► **More information:** www.circadian.com.au

Painless end game

QRxPharma Limited is making the first steps into the US market with its pipeline of MoxDuo pain relief products, which are based on a 3:2 ratio of a fixed dose combination of morphine and oxycodone. In August last year it submitted a New Drug Application for its MoxDuo immediate release (IR) product for moderate to severe acute pain management to the US FDA, which is set to be completed in June 2012.

In the lead up to the decision, QRxPharma has executed a License and Option Agreement (LAO) with **Actavis, Inc.** in March, under which Actavis assumes exclusive rights to

commercialise and further develop MoxDuo IR for the US market. The deal entails royalty payments between 10% and 30%, depending on net sales thresholds, and after a period of 3-6 months, in which QRxPharma will receive 50% royalty on sales of cumulatively up to US\$ 150 million of net sales.

Actavis will also have an option to negotiate US marketing and sales rights of two other products in the pipeline, MoxDuo CR for chronic pain and the MoxDuo IV, hospital-based intravenous formulation.

In April, the company [announced](#) results from two recently completed Phase I studies with healthy volunteers with the MoxDuoCR product. Designed to provide at least 12 hours of analgesia in patients suffering from moderate to severe chronic pain, the product showed sustained blood levels for up to 24 hours, and was superior to current treatments, OxyContin® and MS Contin®.

► [More information](#): www.qrxpharma.com

Gut wrenching progress

Research by *Dr Bob Anderson* and his team at the **Walter Eliza Hall Institute for Medical Research** is on track to lead to the first vaccine against Coeliac disease, after US company **ImmusanT** [raised](#) \$20 million to advance the development.

The common inherited

autoimmune disorder affects around 1% of the population, although it is often unrecognised. This is a major concern given the serious debilitating symptoms, such as long-term intestinal damage, patients experience after eating gluten rich food. Currently the only treatment option is a strict diet that eliminates gluten, the main protein in wheat, rye and barley.

In his time at **Oxford University**, Dr Anderson discovered three peptides potentially responsible for the disease, as they can trigger an immune response in people carrying the immune recognition gene HLA-DQ2 – approximately 80% of coeliac disease patients have this gene.

From 2002, he continued his research at the WEHI, in collaboration with London-based BTG **International Ltd**. He co-founded Melbourne-based biotech **Nexpep Pty Ltd**, which then led to the establishment of ImmusanT, of which he is

currently chief scientific officer.

In Coeliac patients, the vaccine, developed under the name Nexvax2®, reprograms the T-cell response to the three peptides, and reduces the inflammation in the nutrient absorbing villi that line the small intestine. A-human phase I clinical trial of Nexvax2®, conducted in 2011 in Melbourne and Brisbane, indicated that the drug is safe and specific for patients' immune reaction to gluten.

The \$20 million raised will be spent to progress the company's Nexvax2 plan, including Phase 2 clinical trials and the development of a companion diagnostic and monitoring tool for the disease.

► [More information](#): www.wehi.edu.au

...continued from page 25

win out over the other is stochastically determined.

The role of external cues may be to shape the probabilities of individual outcomes and thus direct the allocation of the right proportion of immune cell types required in the body.

The international team of researchers, including from the **Walter and Eliza Hall Institute of Medical Research**, the **University of Melbourne** and the **Peter MacCallum Cancer Centre**, arrived at this conclusion by observing the fate of B-cells after they stimulated the cells in a laboratory experiment. They then filmed the developmental processes occurring in individual cells, including siblings of cells, by applying new technology and image analysis methods, and matched their observations against a mathematical model developed by *Dr Ken Duffy* from the **National University of Ireland**.

Led by WEHI's *Professor Phil Hodgkin*, the researchers found that the mechanistic model of competing fates matched the observations. Accordingly, each cellular fate appears to be pursued autonomously and stochastically, with the outcome determined by competition and censorship, as the occurrence of a particular fate will exclude that of a competing outcome.

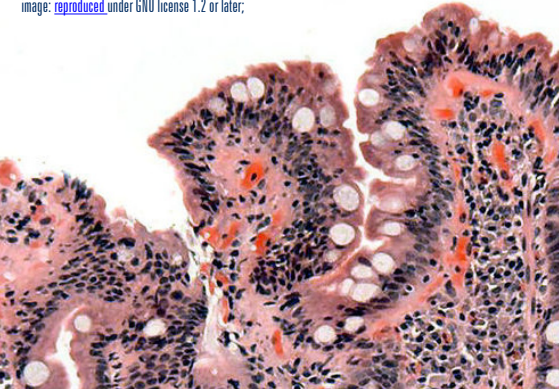
Similar mechanisms may explain the complex allocation of multiple fates in other cell systems, the authors write, indicating that the study may have wider implications.

Explaining the study results, co-author *Dr Mark Dowling* said in a media statement from the WEHI that in defense against an infection the body may tweak the odds of producing particular cell types depending on the situation.

The researchers hope that mathematical models could be developed to accurately predict the fate of immune cells in response to external signals, and lead to the design of new immune therapies for autoimmune diseases and improved vaccines.

► [More information](#): www.wehi.edu.au

Biopsy of a small bowel showing coeliac disease.
image: reproduced under GNU license 1.2 or later;



Coughing up in Vic

A statement issued by Minister for Technology **Gordon Rich-Phillips** has revealed plans by **Biota Holdings Ltd** to significantly expand its facilities at Notting Hill after the drug company won a US\$231 million, five-year contract from the **US Biomedical Advanced Research and Development Authority (BARDA)** in March 2011.

The expansion will allow the company to advance the development and registration of its second-generation influenza product Laninamivir for the US market.

Mr Rich-Phillips said that the **Victorian Government** would support Biota's expansion and



upgrade of the existing Notting Hill facility, which will ensure it has the capacity in terms of lab space, security, supporting infrastructure, and capability to service the BARDA contract.

In 1990, Biota successfully licensed the first-in-class inhibitor for the treatment and prevention of influenza Zanamivir to **GlaxoSmithKline**, which it markets as Relenza™.

Laninamivir, a neuraminidase inhibitor, is already approved in Japan, where it is marketed as Inavir by **Daiichi Sankyo**, which co-owns the product.

► [More information: www.premier.vic.gov.au/](http://www.premier.vic.gov.au/)

Renewable efforts

Concentrated funding

In addition to the \$41 million in funding for the **Energy Technology Innovation Strategy (ETIS)** announced in the 2011-12 State budget, the **Victorian Government** will contribute \$1 million to the first stage of the **RayGen solar power project**.

The project develops technology for high performance large scale solar systems that concentrate solar power from a field of heliostats onto an array of super-efficient solar cells on a central tower. The funding will go towards fine-tuning design components and optimising cost, performance and reliability in the overall design in the lead up to a demonstration plant planned in the Gannawarra Shire near Kerang.

RayGen Resources and partners also received support

through a \$1.75 million grant from the **Australian Solar Institute** (see also 'Sun spots down under' page 9),

► [More information: www.premier.vic.gov.au](http://www.premier.vic.gov.au/)

Downhill power

Australia is the driest inhabited continent on earth, with highly variable rainfall, evaporation rates and temperatures between years.

However, figures in the Government report *Energy in Australia 2011* show that hydro, together with bagasse, remain by far the most dominant component of Australia's total renewable energy mix, although the relative share of wind and solar is increasing. As a share of the around 7% renewable energy used for electricity generation, hydroelectricity still contributes around 4.7%, followed by wind energy a distant second with 1.5%. But given the natural constraints in Australia, much of the nation's economically feasible hydro energy resource is considered to already be harnessed.

However, the **Victorian Government** has announced it will contribute \$1.6 million to the demonstration of a unique Victorian-developed technology that could increase the amount of power generated from existing schemes.

Cetus Energy has developed a blade turbine system that harnesses kinetic water energy from multiple directions, increasing the efficiency of conventional turbine systems that only use water flowing from one direction. To demonstrate that the technology can add significant electricity generation capacity to existing hydro-electric assets without the need for major infrastructure investment or upgrades, Cetus will install a 100 kilowatt system in the outfall flows of **AGL's Rubicon Valley hydroelectric plant** north-east of Melbourne, with 10 turbines drawing energy from the water flowing in the channel system.



Sugarloaf Power Station, below the Eildon Weir Spillway, part of the Rubicon Hydroelectric Scheme

Gill, Herman (1949). *Three Decades: The story of the State Electricity Commission of Victoria from its inception to December 1948*. Hutchinson & Co.; public domain

Nowadays, the **Rubicon Hydroelectric Scheme** generates only 0.02% of Victoria's energy supply, but in the early days, after it was established in 1922, it supplied around 17% of the State's electricity.

► [More information](http://www.premier.vic.gov.au): www.premier.vic.gov.au

Digital future

The **Victorian Government** has launched its \$11 million **Digital Futures Fund**, which is a component of the \$85 million **Victoria's Technology Plan for the Future – Information and Communication Technology** program.

The first round of the program, for which applications closed 2 April 2012, will provide a total of between \$4 million and \$5 million for projects developing ICT solutions that address major business challenges. Successful projects will require involvement of at least two Victorian small to medium sized enterprises with fewer than 200 employees, and may be funded with up to \$500,000 each.

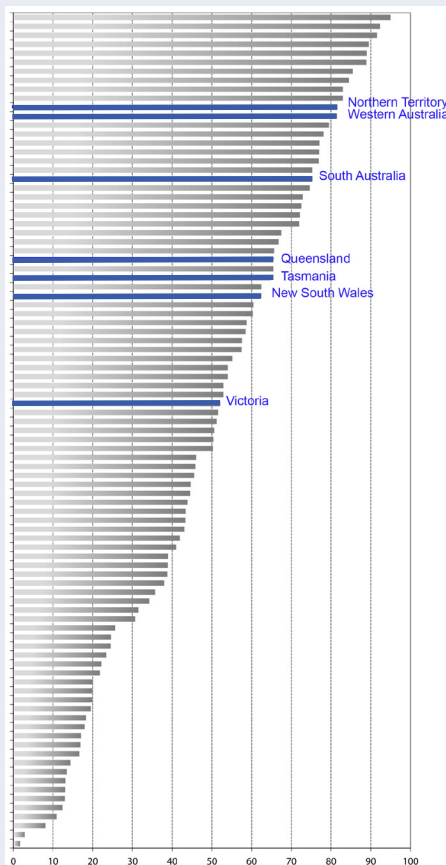
Preferably, applications should reflect areas of strategic importance to Victoria such as data mining and analytics, cloud computing and cyber security.

► [More information](http://www.premier.vic.gov.au): www.premier.vic.gov.au

Still attractive despite the tax

Mining remains the big foot the Western Australian economy stands on, with record investments highlighted by the *Australian Mineral Exploration Review 2011* from **Geoscience Australia** (see 'Cashed up explorers', page 52).

Together with the Northern Territory, the State now also has the most attractive policy settings for international investors in mining and exploration projects in Australia. This is at least according to the *2011-12 Fraser Institute Survey*, which ranked WA and the Northern Territory equal 11th out of 93



Relative ranking of policy potential of Australia's States against other jurisdictions.

Figure: adapted from Fraser Institute mining survey 2011-12

international jurisdictions in its overall 'Policy Potential index', up six places from last year. WA and the NT have steadily improved their position over the past 4 years. By contrast, South Australia slipped from 11th position last year and is now ranked 19th, although the State came out tops in Australia as the least corrupt State, a newly introduced category.

The **Fraser Institute** survey is part of an annual series in which metal mining and exploration companies assess how mineral endowments and public policy factors such as taxation and regulation affect exploration investment.

The Policy Potential Index is a composite index that measures the effects on exploration of government policies, and includes such debated issues as taxation and uncertainty concerning native land claim.

The overall steady outcome for Australian states came despite the **Australian Government's** mining and carbon taxes. Queensland improved its position by ten spots on last year's results and is now ranked 28th.

Tasmania follows in 30th position and New South Wales slipped from its 20th position last year to the 32nd position. Of all states, Victoria made the largest step backwards, after it was ranked 31st last year, it fell 12 positions and is now ranked 44th.

► [More information](http://www.fraserinstitute.org): www.fraserinstitute.org

Malignant news

Cancer is the focus of major initiatives by the **Victorian** and **NSW Governments**.

Tackling men's menace

In Victoria, a major prostate cancer project is underway at **Monash University**, which is supported with a \$2 million **Victorian Cancer Agency Prostate Cancer Collaborate Research Grant**.

Associate Professor Mark Frydenberg will lead the largest project on prostate cancer undertaken in the State so far. It involves 25 clinicians and researchers studying the genetics of prostate cancer and alternative treatments for men with low risk of prostate cancer, and to carry out laboratory testing of new drugs.

In addition, the State Government will support six clinical trial teams with \$2.9 million through the **Victorian Cancer Agency's Clinical Trial Capacity Building Grants program** to support proven or potential clinical trial sites in Victoria, which will help attract international clinical trials to the State.

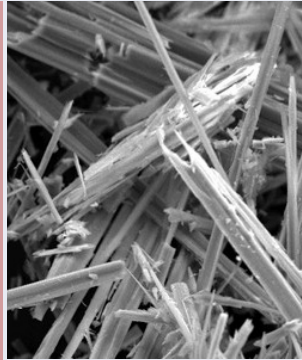
► [More information](http://www.premier.vic.gov.au): www.premier.vic.gov.au

Not to be lost in translation

The **Asbestos Diseases Research Institute (ADRI)** and the **ANZAC Research Institute**, which are based at the **Concord Repatriation General Hospital** in Sydney, have been granted each \$3.5 million through the **NSW**

Not published yet, but presented at a major international conference:

Researchers at the ADRI have [identified](#) a microRNA molecule, miR-625-3p, which is elevated in the blood of mesothelioma patients. By measuring the molecule, they were able to discriminate malignant pleural mesothelioma patients from healthy individuals with an accuracy of 82.4%. This could pave the way for a simple blood test for the diagnosis of the disease, which so far requires a tissue biopsy.



Government's translational cancer research program. The funding is in addition to the \$30 million over five years the Government has

already provided through the program.

Medical Research Minister *Jillian Skinner* [said](#) in a Government statement the translational cancer research program was a key part of the Governments effort to boost medical research, with over \$100 million funding allocated in 2011-12. The program will bring together staff from seven new research hubs to share knowledge, resources and technology, she said.

► [More information: www.health.nsw.gov.au](http://www.health.nsw.gov.au)

Start me up

Silicon Valley is still the hottest technology hub on the planet, buzzing with start-ups formed by young entrepreneurs chasing their luck with new IT developments. There are also quite a number of Australians eager to run with the US tech bull.

The **NSW Government** has announced it will help its startup companies to get a foothold in Silicon Valley by assisting up to 12 early-stage technology ventures with the costs of renting office space and accommodation at the new technology incubator **StartUpHouse** in San Francisco.

The incubator is a joint venture between Australian entrepreneurs *Elias Bizannes* and *Bardia Houseman*, and

New Zealander *Stephen Weir*. They established a new co-working studio comprising a 3,000 square metre facility with a co-working space housing 210 desks, a cafe, and a hostel, which they offer for entrepreneurs and early stage companies.

The subsidy offered under the **Australian Technology Showcase** (ATS) program will cover up to 50% of the costs (up to \$1,250) to utilise the facilities.

The first four companies receiving assistance include:

- **RecruitLoop** - gives employers a smarter way to recruit online, with a marketplace of experienced recruiters charging an hourly rate and recorded video interview platform, saving employers 80% of costs and hours of time.
- **ScriptRock** - offers simple, online storage of IT system configuration information which can be stored, downloaded and executed as a test to improve system quality, reduce downtime and save money.
- **ZeroMail** - a simple email client with an integrated virtual assistant that builds personalised filters to sort priority emails and separate views for notifications, newsletters, mailing lists, and social media.
- **Brainworth** - this company presents a personalised curriculum in a compelling and beautiful game environment.

► [More information: www.business.nsw.gov.au](http://www.business.nsw.gov.au)

Resurrection intended

The **South Australian Government** has issued a **Manufacturing Green Paper**, which was open for comments from the public until 7 May 2012.

As other parts of Australia, South Australia is experiencing significant strain on its manufacturing industry, which is faced with a challenging environment: international export markets

experienced significant downturns in the wake of the global financial crisis, while domestically a major mining boom with record investments contributes to high-wage and high-dollar conditions.

Traditionally, manufacturing has been a major component of the State's economy, but exports peaked at \$7.7 billion in 2007-08, and after a massive 32% decline led by the automotive industry are only now beginning to recover, reaching \$6.2 billion in 2010-11. According to the paper, wine is now the State's largest sector by revenue, with \$3 billion in 2011, followed by iron and steel (\$2.7

billion), copper, silver, lead and zinc (\$2.5 billion), automotive (\$1.1 billion) and meat and poultry processing (\$1 billion). Manufacturing is, however, still the largest spender on R&D,



StartUpHouse - Google Street View



although yearly spending declined from \$347 million to \$247 over the past five years. Manufacturing is also still the second largest employer, after the food and beverages sector, providing a strong incentive for helping the sector get back on its feet.

Compared to mining, which has a similar economic activity, manufacturing employs around four times as many people. There is also the realisation that countries, such as Germany, Switzerland, Finland and Sweden, which all feature robust high-tech manufacturing sectors, came out of the crisis better than others.

Accordingly, the State Government has renewed its efforts to halt or even reverse the trend.

The discussion paper pinpoints possible ways to create new opportunities for the sector, informed to a large part by the current Thinker in Residence *Professor Goran Roos*. Together with final submissions, the Green Paper will form the basis of a Manufacturing Strategy, a framework within which the Government will allocate appropriate resources to the sector.

Four areas have been identified as key for a turnaround:

- Smart decisions – the Government intends to map the manufacturing industry landscape in SA, including its capabilities, opportunities, technologies and value chains, to inform decisions and take advantage of emerging trends.
- Smart opportunities – by promoting innovative industry clusters linked to value chains the Government hopes to overcome the State's disadvantage of small-scale businesses, and accelerate transfer of knowledge and information between companies, and business and education and research bodies.
- Smart firms – the Government intends to assist manufacturing firms to adopt innovation strategies to improve competitiveness.
- Smart people – the Government will assist in the harnessing of strategic management skills among local manufacturers to enhance competitiveness.

► **More information:** <http://www.dmitre.sa.gov.au/article/view/1105>

Radiant rush

A ban of 26 years on the exploration of uranium deposits in New South Wales has been overturned, with the passage of the *Mining Legislation Amendment (Uranium Exploration) Bill 2012* through Parliament on 28 March, although mining of potential deposits remains off the cards in the State.

The move by the **NSW Government** was driven by the motivation that the State should also take part in the current mining boom. "It is time for NSW to look at every opportunity to join the mining boom which is delivering enormous profits and jobs to Western Australia, Queensland and South Australia," NSW Premier *Barry O'Farrell* said in a statement in February. He said that overturning the ban would bring the State in line with all other States, excluding Victoria.

However, little is known about potential deposits, with the most valuable assumed to exist in the west of the State, as abundant resource is on the South Australian side of the border.

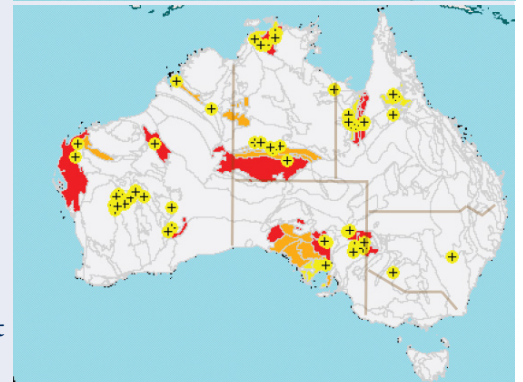
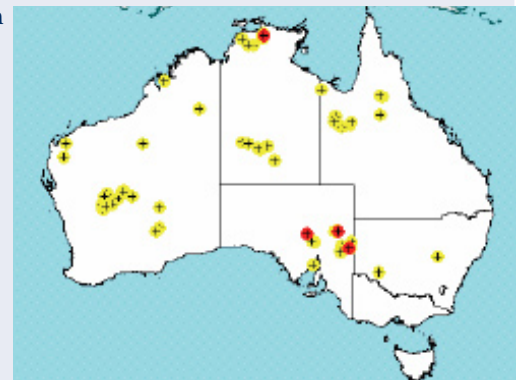
According to the Geoscience [report Australia's identified minerals resources 2011](#), Australia's uranium deposits that can be

recovered at a cost of less than US\$130/kg, deemed an economically demonstrated resource (EDR), were estimated to total 1.15 million tonnes. With 33% of the world's EDR grade uranium Australia has the world's largest identified resource and the vast majority of that is within just five deposits:

Olympic Dam in SA, Janger and Jabiluka in the NT, Kintyre and Yeelirrie in WA. More than 80% of the identified EDR grade uranium deposit is located in SA.

► **More information:** www.parliament.nsw.gov.au

Uranium mines, deposits and deposit potential
Data source Geoscience Australia



Engineered leadership

From January 2013, the chancellor of Monash University, **Dr Alan Finkel**, will take over from **Professor Robin Batterham** as president of the Australian Academy of Technological Sciences and Engineering (ATSE). Before he commenced as chancellor at Monash in 2008, Dr Finkel was chief executive officer of Axon Instruments, an ASX-listed American company developing electronic instruments used in medical research.



Alan Finkel

Dr Finkel is currently also chief technology officer of Better Place Australia, a company dedicated to providing clean energy to run electric cars, and founder of two magazines – Cosmos and the G magazine.

Steady upwards trajectory...

Twenty-one years after he began at Curtin University as a lecturer in spatial science, **Professor Graeme Wright** has now been appointed as Curtin's deputy vice-chancellor (R&D). His new position will include the oversight of all research, research training, and commercialisation and knowledge transfer activities within the University. He is currently also a Curtin representative on several research centre boards, including the **Rio Tinto Centre for Materials and Sensing in Mining**, the **Centre for Exploration Targeting**, and a non-executive director of the **CRC for Spatial Information**.



Graeme Wright

...and also been on the block

Former director of the **Australian Sustainable Development Institute (ASDI)**, **Charlie Thorn**, has been appointed as Curtin's new director Research and Development. Mr Thorn has more than 30 years experience in research management, commercialisation and technology transfer in the agriculture, fisheries and university sectors. Mr Thorn has previously held positions in the university sector as director Research and Innovation at Edith Cowan University and associate director Research and Development at Curtin.



Charlie Thorn

Infectious leadership

The World Health Organisation (WHO) has appointed **Professor John Reeder**, who is currently co-head of the Burnet Institute's Centre for

Population Health, as the new director of the Special Programme for Research and Training in Tropical Diseases (TDR). He commenced the Geneva based position in February. TDR is the United Nation's leading research programme on infectious diseases of poverty, executed by the WHO and cosponsored by UNICEF, UNDP, the World Bank and WHO. It identifies new or improved tools and strategies, and helps build research capacity and leadership in countries where the diseases occur. For example, many of the drugs and strategies for the treatment of diseases such as leprosy, malaria and onchocerciasis (called 'river blindness') were developed in partnership with TDR.



John Reeder

Numerical honour

The Swedish Royal Academy of Sciences has awarded the Crafoord Prize in Mathematics 2012 to an Australian who graduated at the age of 17 from Flinders University and became professor at the University of California aged 24. **Professor Terence Tao** shares the prize worth 4 million Swedish Krona (around \$560,000) with Princeton **Professor Jean Bourgain**, recognising their important contributions to fields of mathematics that range from number theory to the theory of non-linear waves. The majority of their most fundamental results are in the field of mathematical analysis, having developed and used new methods of analysis in groundbreaking and surprising ways. In 2006, Professor Tao also won the prestigious Field Medal in Mathematics as the youngest and first Australian to win the prize.



Terence Tao

Clean head

Previously chair of the National Water Commission (NWC), **Chloe Munro** is now inaugural chair and chief executive officer of the new Clean Energy Regulator. The independent statutory authority commenced in April to implement and administer the Australian Government's carbon price mechanism, the National Greenhouse Energy Reporting Scheme, the Renewable Energy Target, the Australian National Registry of Emissions Units and the Carbon Farming Initiative. Prior to her role at NWC, Ms Munro was an executive director at Telstra and has prior to



Chloe Munro

that held leadership positions in human resources, business operations, information technology, public policy and communications and customer service. The Government also appointed a further two members to the new facility, **Jennie Granger**, whose previous positions include Second Commissioner at the Australian Taxation Office, and **Dr Michael Sargent**, who is currently director at the Australian Energy Market Operator

Resourceful Swedish fellow

Australian edible oils industry and bio-energy expert **Professor Rod Mailer** has been awarded a fellowship by the Royal Swedish Academy of Agriculture and Forestry. Until 2010, he has been with the NSW Department of Primary Industries where he managed research projects in various oil crops, particularly canola and olive oil. He was also head of the department's edible oils research program at Wagga Wagga, where he was responsible for the development of the Australian Oils Research Laboratory.



Rod Mailer

Exporting expert

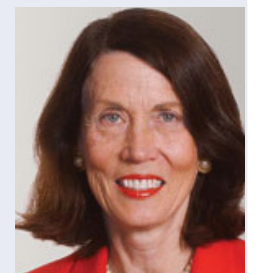
Long-serving senior public servant **Paul Morris** has been appointed as new executive director of the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). Mr Morris was previously deputy executive director of ABARES, and had a role in the department's live animal export program since 10 June 2011, including the development of a new regulatory framework for livestock exports.



Paul Morris

Risk alert installment

The University of Melbourne has officially installed **Elizabeth Alexander** as chancellor, succeeding the current Victorian Governor Alex Chernov in the position. A Melbourne graduate with a Bachelor of Commerce degree, Ms Alexander worked as an accountant and became the first woman to be admitted to partnership in any of the so-called "big six" Australian accounting firms. She is a specialist in Risk Management and Corporate Governance, and has served on numerous public and private sector boards and committees and recently retired as chair of CSL.



Elizabeth Alexander

Do it smart, do it digital

National ICT Australia Ltd will receive \$1.9 million from the **Australian Centre for Renewable Energy (ACRE)** for a project aimed at providing enhanced data for targeted geothermal exploration. The grant, which is the first awarded under the \$126 million ACRE initiative, will contribute to the overall \$5 million the project is expected to cost over the next two years.

As reviewed in our ARDR Sep-Dec 2011 issue, Australia's potentially vast geothermal resource in the form of 'hot rocks'



located several kilometres underground still remains to be unlocked. The industry is struggling with the very high costs associated with the earlier stages of projects, while there is limited investment capital available.

NICTA's project will tackle the hurdle of exploring suitable resources that can be used for energy production, which still is a manual and expensive exercise. Together with experts from universities (**University of Sydney, Australian National University, University of Melbourne and University of Adelaide**), NICTA is developing automated ways to define geothermal targets, using machine learning techniques and advanced data analytics instead of drills. Also involved in the project are **GeoDynamics** and **Petratherm**, as well as **GeoScience Australia** and the South Australian **Department of Manufacturing, Innovation Trade Resources and Energy**.

► **More information:** <http://minister.ret.gov.au>

Cashed up explorers

Spending on Australian mineral exploration has continued at high levels during 2010/2011, according to a review released by **Geoscience Australia**. The *Australian Mineral Exploration Review 2011* shows that all jurisdictions, except for Victoria, experienced increased investments totalling almost \$3 billion. The increased exploration was across most commodities, with exploration for coal (up 62% to \$520 million) and copper (up 60% to \$323 million) showing the largest increases in percentage terms. Exploration spending for lead, zinc and silver

was up 46% to \$76 million), followed by nickel and cobalt (up 33% to \$271 million), iron ore (up 27% to \$665 million), uranium (up 27% to \$214 million) and gold (up 13% to \$652 million). Decreased exploration spending was seen for diamond (down 14% to \$9 million) and mineral sands (down 8% to \$26 million).

Western Australia took the lion's share of the increased spending with \$1.6 billion, up by 28% on the previous year, followed by Queensland with \$664 million and South Australia \$225 million, which both were up by 52%.

Next in line were the Northern Territory with \$195 million, up by 31%, and New South Wales with \$153 million, up by 17%.

Tasmania with \$37 million had the largest percentage increase, up by 80%.

► **More information:** <http://minister.ret.gov.au>



Realising piped dreams

China's **Sinopec Group** has increased its existing purchase commitment with **Australia Pacific LNG**, which already was the largest LNG supply agreement in Australia's history, from 4.3 million tonnes per annum (mtpa) to 7.6 mtpa.

The company also increased its stake in the Gladstone venture, from 15% to 25%, after having joined the project as a partner in April 2011. The move reduced the share of the other two venture partners, US firm **ConocoPhillips** and **Origin Energy**, to each to 37.5%.

Commenting on the deal, Minister for Resources and Energy **Martin Ferguson** said that it would emphasise Australia's link into the Asia Pacific Region and in particular with China, with which Australia has now contracts for the delivery of 18 mtpa of LNG.

With the Sinopec commitment, a final investment decision on adding a second train to the \$14 billion APLNG project is now within reach.

To date, \$45 billion have been committed to Queensland's burgeoning coal seam gas (CSG) to LNG industry, which is based on CSG recovered from Queensland's Surat and Bowen Basin and processed and exported around the coal port of Gladstone. Other advanced projects under construction include the \$15 billion **Queensland Curtis LNG** project (QGC), the



\$16 billion Gladstone LNG project (Santos/Petronas/Total/Kogas). Another proposed project by Shell Australia/Arrow has been declared a 'significant project' by the Queensland Government and if realised could produce a further 18 mtpa of LNG with up to four trains on Curtis Island.

► **More information:** <http://minister.ret.gov.au>

Doing the dance with Chinese giants...

China and Australia are increasingly joining forces in their mining interests, beyond the growing producer/buyer relationship. In January, The University of Western Australia announced that three major Chinese companies – coal miner and power generator **Huainan Mining Corporation**, coal and construction giant **Yancon Group Co., Ltd.**, and the world's biggest coal producer **Shenhua Corporation** – have joined a group of 16 Chinese and Australian science and industry

partners to develop new international collaborative approaches to energy and mining research.

Together with four leading Chinese universities and two Chinese Academy of Sciences' institutes, the Chinese enterprises will

work with seven Australian universities, **CSIRO**, **BHP Billiton Iron Ore Pty Ltd**, low-emission energy developer **Ceramic Fuel Cells Ltd.**, thermal processing and biomass technology company **Ansac Pty Ltd**, and **Umwelt (Australia) Pty Limited**, a highly regarded environmental consulting firm providing services to Australian and international mining industries.

With an eye firmly on the newly-created \$18 million **Australia-China Science and Research Fund**, the five year partnership will include the exchange of research staff and students, joint conferences and other academic activities, and the sharing of research findings. UWA's acting vice-chancellor **Professor Bill Loudon** said the collaboration between Australian and Chinese business and researchers would benefit science and technology, and long-term economic cooperation between the two countries.

► **More information:** www.news.uwa.edu.au

...as the party continues...

The **Bureau of Resources and Energy Economics (BREE)**,

a statistical research unit within the federal **Department of Resources, Energy and Tourism**, has [released](#) an updated reference of Australian energy statistics and analysis, *Energy in Australia 2012*. Major points of the publication include:

- Australia maintained its position as the world's ninth-largest energy producer, increasing its share of world energy production from 2.4% to 2.5% between 2008-09 and 2009-10;
- Australia represents 5% of world energy exports, with net energy exports representing 68% of total energy production;
- Earnings from energy exports were around \$70 billion in 2010-11, accounting for 33% of the total value of Australia's commodity exports; and
- Renewable energy increased its contribution from 7% to 8% of Australia's electricity generation.

In 2009-10, coal accounted for 37% of Australia's total primary energy supply, followed by oil (35%), gas (23%) and renewable energy sources (5%). Energy consumption increased at an average annual rate of 1.8% over the ten years from 1999-2000 to 2009-10.

Coal accounted for 75% of Australia's electricity generation in 2009-10, followed by gas (15%) and renewable energy sources (8%), with hydro (5%) and wind (2%) the major components.

BREE has also [released](#) new data on resources and energy investments in 2011, which totalled a record \$190 billion, up 15% from the previous year. In addition, the researchers [forecast](#) that despite a predicted fall in commodity prices over the medium term, increased export volumes will lead to record earnings reaching \$225 billion (in 2011-12 dollars) in 2016-17.

► **More information:** www.bree.gov.au

...on sound advice

The Australian Government has established an interim Independent Expert Scientific Committee in the lead up to the formal establishment of an **Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining**



Development, which requires legislative amendment to the *Environment Protection and Biodiversity Conservation Act 1999*.

The Committee, for which the Government has set aside \$150 million, is part of a new science-based framework to provide more certainty for regional communities around coal seam gas and large coal mining developments, jobs and

investment and the protection of water resources.

The interim committee will be chaired by *Professor Craig Simmons*, who is director of the **National Centre for Groundwater Research and Training** at **Flinders University**, and also includes:

- *Professor John Langford*, former chief executive of the **Rural Water Commission**;
- *Jane Coram*, currently with **Geoscience Australia** and a member of the **Expert Panel on Coal Seam Gas**;
- *Associate Professor David Laurence*, the inaugural director of the **Australian Centre for Sustainable Mining Practices**;
- *Professor Chris Moran*, the current director of the **Sustainable Minerals Institute** at the **University of Queensland**;
- *Emeritus Professor Peter Flood*, retired deputy vice-chancellor at the **University of New England**.

The Australian Government will provide a further \$50 million for a new **National Partnership Agreement**, under which the Commonwealth and states agree to take the Committee's advice into account in their assessment and approvals decisions.

Killing it softly, not selectively

In a contribution to the Policy Forum of the journal *Science*, a team of scientists, led by experts from Belgium and Norway and *Dr Shijie Zhou* from the **CSIRO Wealth from Oceans Flagship**, have reviewed how the current conservation paradigm of increased selective fishing impacts on ecosystems and fisheries production. The growing body of evidence suggests that selection for small groups of species, sizes or sexes neither maximises production nor minimises ecological impacts. By contrast, the authors write that at commercially sustainable fishing levels "selective removals will inevitably alter the

composition of a population or community and, consequently, ecosystem structure and biodiversity".

Regulations in place in many jurisdictions intentionally promote selectivity but are often at odds with the goal of maintaining biodiversity as well as fish yield.

Instead, the scientists propose moving towards a balanced harvesting approach, which distributes a moderate mortality from fishing across the widest possible range of species, stocks, and sizes in an ecosystem. They acknowledge that there remain issues regarding the potential benefits and implementation of balanced harvesting, but they argue that the time has come for action to address food security while minimising ecosystem impacts.

The approach will require coordinated management at an ecosystem level across all fisheries in a region, and in some regions, markets and the processing sector will need encouragement to accommodate sizes and species not traditionally utilised. They also suggest the use of ecosystem modelling as a way to determine appropriate patterns of fishing.

► [More information: www.csiro.au](http://www.csiro.au)

connected benefit

In Marine reserves, the connectivity between mangroves and reefs that are close together can help increase fish numbers, according to a study by researchers from **Griffith University**, the **Queensland Department of Environment and Resource Management** and **CSIRO**.

The study results, recently presented in *Conservation*



*Letters**, revealed that in the Moreton Bay Marine Park, Queensland fish numbers – especially of yellowfin bream, moses perch and black rabbitfish – were found greater when both habitats were in close proximity..

The research, which was supported through an **ARC Linkage** grant and led by *Professor Rod Connolly* and *Dr Kylie Pitt*, also suggests that protected reefs close to mangroves may be better placed to recover from major disturbances such as

the flooding of the Brisbane River that was seen over the 2010-2011 summer. Marine park areas with well-connected reefs and mangroves were also found to support more herbivorous fish, which graze on algae competing with coral for living space.

► **More information:** www.griffith.edu.au; *<http://doi.wiley.com/10.1111/j.1755-263X.2011.00204.x>

Captive progress with caveats

CSIRO has released the latest findings from a \$21 million research program, which is funded under the **Asia-Pacific Partnership (APP) on Clean Development and Climate** to

assess the agency's carbon dioxide capture (PCC) technology fitted at coal fired power stations.

Munmorah Power Station, and below the Post combustion capture (PCC) pilot plant built by Delta Electricity and CSIRO.
image: air shot by Delta Electricity; image of pilot below by CSIRO



According to a statement summarising the experience with two Australian pilot plants run under the program, the technology was found to operate effectively under Australian conditions and is now technically available to the industry as the first stage in the carbon dioxide capture and storage (CCS) chain.

PCC entails a process under which flue gases that leave power stations either

through a chimney or a flue stack are cooled and then fed into a CO₂ absorber containing ammonia or an amine suitable for absorbing the gas. The CO₂ is removed from the absorbing solution by steam, and then compressed and cooled to a storable liquid.

The APP funded program includes three pilots of the technology, of which two projects are in Australia, at **Delta Electricity's** Munmorah power station in NSW and at **Stanwell Corp's** Tarong power station in Queensland. (A demonstration project based on the Munmorah pilot is currently in the planning stage). A third pilot CSIRO is **engaged** in under the program is a project in China with China's **Huaneng Group**. In addition to the APP funded pilots, CSIRO has a transportable plant running at the Loy Yang Power station in Victoria's LaTrobe Valley, which was established in 2008 and was

the first pilot of PCC technology in the Southern Hemisphere.

According to the CSIRO, the experience at Tarong and Munmorah showed that PCC technology is able to capture more than 85% of carbon dioxide from the power station flue gases along with other gases such as sulphur dioxide. In addition, the technology can be fitted to both new and existing power stations, has flexible application according to changing consumer demand in the electricity market and can use renewable energy such as solar thermal as a power source.

There are caveats, not only posed by the high implementation and running costs but also by a loss of 30% in power station efficiency that occur with the capture of 90% of CO₂. However, according to CSIRO's **Dr Paul Feron**, the costs of implementing and running the PCC will reduce once the technology is established, and CSIRO is hoping that with further improvements of the technology all emissions can be captured without energy penalty.

► **More information:** www.csiro.au

Warm milk

A new \$7 million research centre focussing on subtropical dairy farming has opened at Queensland's Gatton in March. The only facility of its kind in Australia with its focus on a sub-tropical feed base, the centre is a joint undertaking by the **University of Queensland** and the **Queensland Department of Employment, Economic Development and Innovation**.

According to UQ pro-vice-chancellor **Professor Alan Rix**, the research dairy will allow the development of on-farm strategies to assist dairy farmers in Australia's northern areas – particularly in south-east Queensland and northern New South



image: University of Queensland

Wales – to improve their productivity and profitability.

The centre will provide expertise in the areas of nutrition, forage production, business management, reproductive management, animal health and welfare, animal physiology and biochemistry.

Combined with the new \$100 million facilities in Veterinary Science and the \$33 million Centre for Advanced Animal Science, the UQ Gatton is a hub of national importance for research and learning in animal science, Professor Rix said.

► **More information:** <http://www.uq.edu.au/news/index.html?article=24473>

Broad bandits on the roll

At the end of March, NBN Co [released](#) its plan to rollout the **National Broadband Network** (NBN) over the next three years. The Stage 1 plan details the construction of the fibre optic component of the network in areas containing over 3.5 million homes and businesses and covering a third of the country across every state and territory. According to the plan, construction is either underway or set to begin this year for three quarters of a million premises, with eight early locations already having access to services.

As NBN Co announced earlier in the month, Tasmania, the

reach of fibre will be served by satellite or 4G fixed-wireless. Both NBN Co's Long Term Satellite and fixed-wireless services are due for completion in 2015.

The developments follow the [approval](#) of Telstra's application for structural separation, and a related draft migration plan to the NBN, by the **Australian Competition and Consumer Commission** (ACCC). Announced by the ACCC in February, it was a crucial prerequisite for the Definitive Agreements, [signed](#) between NBN Co and Telstra in June 2011, to come into effect, which will provide NBN Co with access to Telstra's existing infrastructure. It also implements structural reform to the telecommunications sector addressing longstanding concerns regarding Telstra's vertical integration. Telstra will progressively cease to use its own fixed line access networks and instead migrate its business to the wholesale-only NBN infrastructure to supply downstream services.

With the plan now at hand showing which areas are going to miss out in the first stage rollout, the selections made by NBN Co have been criticised for being biased. Thus, Victorian Technology Minister **Gordon Rich-Phillips** [said](#) that Labor-held states South Australia and Tasmania were receiving a disproportionately greater share of the funding compared to Victoria, which has a quarter of national population but had only 19.5% of the premises allocated in the plan.

...but why bother?

According to new data by the **Australian Bureau of Statistics**, the use of mobile wireless broadband connections continued to be the fastest growing and the most prevalent type of internet technology – it accounted for 47% of all internet connections at 31 December 2011. These data exclude mobile handsets, though, which were subscribed to by 11 million Australian, an increase of 13.6%

from June 2011.

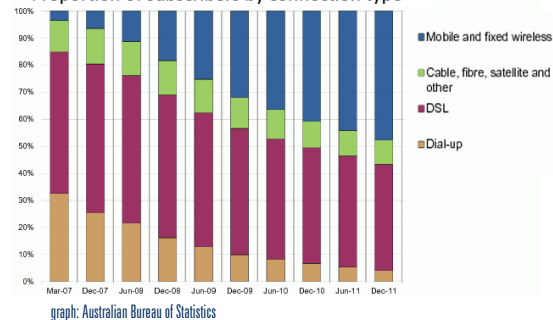
Overall, the number of internet subscribers (which is not equivalent to actual users), rose from 10.9 million in

June 2011 to 11.6 million in December 2011, up 6.3%. Most Australians were subscribing to download speeds of between 1.5 megabytes per second (Mbps) to 8 Mbps, although subscriber numbers to the higher bracket between 24 Mbps and 100 Mbps have increased most in percentage terms.

5.5 million Australians subscribed to mobile wireless

state first connected to the NBN, is also set to be the first state to have its rollout completed. NBN Co locked in a construction contract valued at close to \$300 million with **Visionstream Australia** to replace the existing copper-based telephone infrastructure covering some 200,000 homes and businesses with the fibre optic broadband network. Locations outside the

Proportion of subscribers by connection type



No words needed

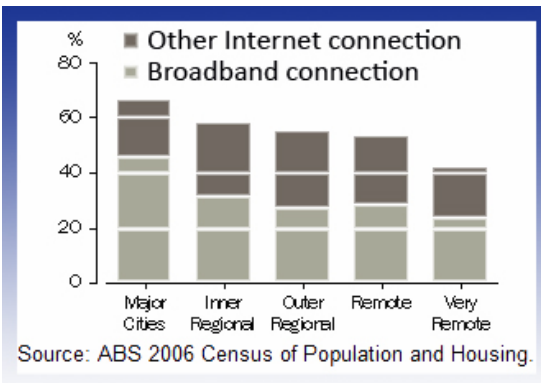
broadband connections, up 14.7% in the six months period, again excluding mobile handsets such as phones. DSL connections increased by 1.3% to 4.6 million.

While this would suggest a trend against fixed-line connections such as the NBN will provide, a totally different picture emerges when looking at the volume of data downloaded (three months to the reference date).

From June 2011, the downloaded data volume rose by 26% to around 345 thousand terrabytes, of which 322 thousand were downloaded through fixed-line connections, and only around 23 thousand through wireless. Even less data was downloaded from mobile handsets, totalling just 5,000 terrabytes in December 2011, although this represented a 35% increase from June 2011 values.

Rural connections...

The ABS data summarised in the previous section do not provide information on the gap in internet access and use between rural and urban Australia. According to census data from 2006, household internet access and broadband



connection decreased significantly with remoteness, with 66% of Australians in cities but only 42% in very remote areas connected (and of this, 45% and

24%, respectively, were broadband connections).

ARDR was unable to obtain recent data on the 'digital divide' but it can be assumed that as access to internet services in Australia has changed dramatically over recent years, the situation in the bush has also improved. The [Australian Broadband Guarantee](#) from 2007 was implemented to help residential and small business premises access high-quality broadband services regardless of where they were located. The program ceased in June 2011.

With the NBN rollout, optic fibre cables will cover around 93% of premises in Australia, and this will include a areas in regional Australia. The Government has just [announced](#) the opening of the a fibre optic link stretching more than 3800 kilometres from Darwin to Toowoomba, which completes the network construction phase of the \$250 million **Regional Backbone Blackspots Program** (RBBP). The network comprises over 6000 kilometres of fibre backbone across regional Australia.

Further links include:

- Gawler in South Australia to Broken Hill, NSW, and Shepparton, Victoria;
- Perth to Geraldton link in WA;
- McLaren Vale to Victor Harbor and Mt Barker (including Adelaide Hills) in SA; and
- through South West Gippsland in Victoria.

In addition to the rollout of a fibre network to 93% of Australian

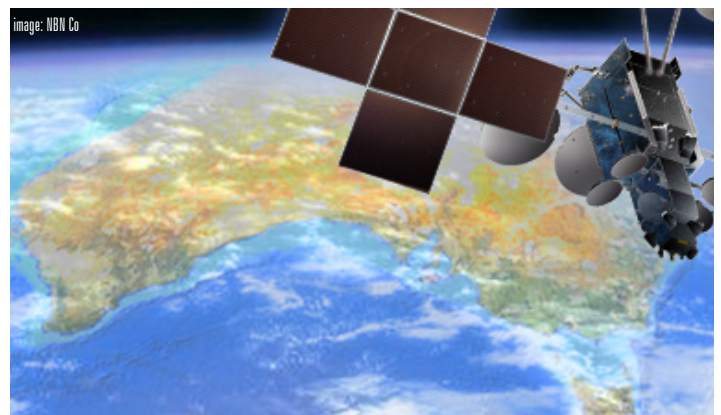


premises, the delivery of universal broadband coverage at peak download speeds of 12 Mbps across the whole of Australia and its external territories will require the use of additional fixed wireless and satellite technology to connect those premises in rural and regional areas that do not fall into the fibre footprint.

In February, the NBN Co [announced](#) a \$620 million agreement with US company **Space Systems/Loral** to design and build two next-generation Ka-band satellites and associated tracking, telemetry and control systems. Launch of the two satellites is planned for 2015.

The existing copper network will continue to be available in the areas outside NBN Co's fibre footprint. That means the Universal Service Obligation, including the availability of a fixed-line voice service, will continue to be provided.

In total, the NBN Long Term Satellite Service will cost approximately \$2 billion over 15 years, which will also include



the ground segment, end-user equipment and the launch vehicles. It will build on the **Interim Satellite Service**, which was launched on 1 July, 2011, and provides around 2500 premises with peak download speeds of up to 6 Mbps.

► [More information: www.nbnco.com.au](http://www.nbnco.com.au)

...to be remotely healthy

Health services is one of the areas which could benefit through improved broadband services in the bush, as recognised through a new \$20.6 million telehealth program announced by the Government. The initiative, which expands an existing telehealth program, will target patients in the NBN rollout areas and provide a testbed for future services on a national scale.

The aim is to deliver access to healthcare services and specialists through measures such as videoconferencing.

► [More information: www.minister.dbcde.gov.au](http://www.minister.dbcde.gov.au)

Supercalculated cures

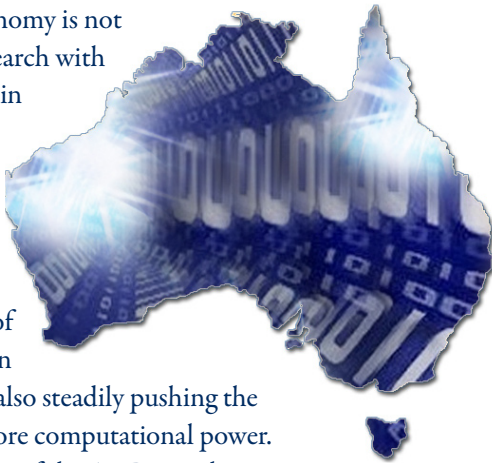
Australia is steadily increasing its supercomputing capacity, also in anticipation of the enormous needs for computing power that could result from a successful bid for the Square Kilometre Array.

In our recent reports we covered investments in the GPU supercomputer for Theoretical Astrophysics Research at **Swinburne University**, and supercomputers installed at the **University of Western Australia** and **Murdoch University** as part of the \$80 million **Pawsey High-Performance Computing Centre for SKA Science**.

However, Astronomy is not the only field of research with enormous increases in data flow. Other areas include, for example, nanoscience and geoscience, and the increasing number of large scale projects in the life sciences are also steadily pushing the requirements for more computational power.

In the last edition of the ARDR we have highlighted the transformation of Melbourne to a hub for ICT research, with the **University of Melbourne** becoming a focal point through its research alliance with global ICT company **IBM**. As a result of this research engagement, Melbourne university is now also home to one of Australia's fastest and, according to a university statement, the world's greenest supercomputer, the **IBM Blue Gene/Q**.

The new ICT infrastructure will be housed at the \$100 million **Victorian Life Sciences Computation Initiative (VLSCI)**, which was set up by the **Victorian Government**, Melbourne University and the **IBM Research Collaboratory for Life Sciences** to enhance the computation capacity of Victoria's life science research. As part of this initiative, IBM



researchers will work together with university scientists.

The IBM supercomputer is set to significantly enhance the ability of researchers to tackle large-scale and highly complex scientific problems. Expected to be operational by June 2012, it will provide 836 teraflops of processing power – the equivalent computing power of more than 20,000 desktop computers.

► [More information: www.news.uwa.edu.au](http://www.news.uwa.edu.au)

Qualitative data miner

Leximancer Pty Ltd, a spin-off from the **University of Queensland** through its commercial arm **UniQuest**, and US firm **Lexical Edge** have launched a free research and academic portal called **Text Insight**, which supports researchers undertaking qualitative analysis and text analytics. The portal is primarily reaching out to academics but may also benefit commercial users. It provides resources and an active online community for training, discussing research ideas and approaches, and expanding their knowledge of qualitative analysis, text analytics, text mining, big data challenges, and social media analysis.

► [More information: www.leximancer.com](http://www.leximancer.com)

Expected deluge

ICRAR – a joint venture between **Curtin University** and the **University of Western Australia** – has signed an agreement with **DataDirect Networks** to develop high performance data storage capability suitable to cope with the deluge of data that will potentially flow from the Square Kilometre Array (SKA).

With a decision on a definite home for SKA just around the corner, the project, if coming to Western Australia, could pose a major challenge for IT infrastructure. The project is expected to generate around one exabyte of data – a million terabytes (or one quintillion bytes) – every day while it searches the sky with the power to detect airport radars in other solar systems 50 light years away. As outlined on ICRAR's website, DataDirect



Superceded data storage system

Networks' experience will flow into data storage for the SKA through work on the Australian precursor radio telescopes, the **Murchison Widefield Array (MWA)** – due for completion at the end of this year – and the **Australian SKA Pathfinder (ASKAP)** which is due at the end of 2013.

► [More information: www.icrar.org](http://www.icrar.org)

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is the key point of the Victorian Government's submission; without innovative solutions to environmental watering, the outcomes of the Basin Plan will not be met."

Life support

A different perspective emerged at the end of the big tap. In April, the **South Australian Government** [released](#) a statement saying that according to science the proposed 2750 GL water recovery was not enough to return the system to a sustainable level of river health.

The Government refers to an [analysis](#) by the Goyder Institute for Water research, which says that the proposed 2750 GL/y reduction would provide some improvements but not be enough to ensure river health in times of drought.

The Government followed up with a submission to the MDBA, which includes 71 recommendations for how to improve the proposed plan.

Central to the State Government's view is that more water has to be returned to the river system than the proposed 2750 GL/y, that barriers are removed to delivering water to SA, and that the plan should be able to withstand legal challenge.

More information: www.mdba.gov.au

Specific points raised by the South Australian Government include:

- The middle and high elevation areas of the floodplains, where most black box and river red gum woodlands occur, will receive little or no additional water and declining vegetation health is likely to occur;
- In the longer term, the contraction of river red gum and black box distributions on floodplains, with losses of organic carbon production and habitat;
- Ongoing degradation of mid-and high-elevation floodplain wetlands caused by salinity and other factors, with a loss of habitat;
- An accumulation of salt in the lower Murray region during drier periods as a result of insufficient salt export through the Murray mouth;
- Extreme low water levels and salinities may still occur in the Lower Lakes and Coorong under extended drought conditions, which would reduce the habitat available for fish and migratory water birds and may threaten several endangered native fish in the CLLMM region; and
- The likelihood that the Murray Mouth will still require some dredging to be kept open during extended droughts.