CSIRO SOLVE
A CSIRO review of scientific innovations for Australian industry

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Hope for a World Without Dementia

The dementia epidemic has arrived. There are an estimated 24 million people with dementia worldwide, and by 2040 it is estimated that this number will rise to 81 million. The impact of dementia on public health systems, which is already acute, will become extreme.

In recognition of this, the Australian Government has recognised dementia as a National Health Priority; the first government to do so.

Worldwide, the direct and indirect cost of dementia is about US$48 billion (A$333 billion). With an increasing number of cases, these costs will rise dramatically.

There is a small window of opportunity to find solutions to the dementia epidemic, building on the progress made by medical researchers in the past 25 years. We now know a great deal about the pathology of dementia and that it can develop decades before symptoms show.

Evidence from research suggests that the most promising strategies will be based on identifying those most at risk of dementia and developing treatments that may delay its onset. A study by Access Economics has demonstrated that even a five-year delay in the average age of onset would reduce the number of people with dementia by half by 2040. This would result in significant

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WATER: Greener Pipelines

CSIRO scientists are examining how mining companies can cut water use without compromising efficiency
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FOOD INDUSTRY: Efficiency Drive*

Food industry logistics are being examined to see how Australian producers can become more competitive
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*National Research Flagships
The National Research Flagship program – one of the largest scientific initiatives ever mounted in Australia – is specifically designed to integrate and focus our national scientific resources on challenges of the utmost importance to Australia.The Flagships are large (100 or more) multidisciplinary research teams that focus the best of Australia's scientific resources on the most critical challenges we face as a nation. These teams combine the best talent from CSIRO, universities and other research bodies, business and industry. The Australian Government has made this possible through the investment of an additional $305 million in CSIRO over seven years..

savings to health systems, as well as improvements in quality of life for sufferers and their carers.

It is encouraging that much research worldwide is focused on dementia prevention and risk reduction. The Australian Preventative Health Flagship's imaging biomarker and lifestyle aging study is an exciting reminder of the contribution that Australian researchers can make to the international research effort.

Australia spends less than 0.4 per cent of the total direct and indirect cost of dementia on dementia research. An annual investment of 1 per cent of the annual cost of dementia – $50 million – would be a small price to pay for the hope of a world without dementia.

Glenn Rees
National Executive Director
Alzheimer's Australia

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COVER STORY

VIEWPOINT: The Big Challenge

By Brad Collis

Time to unleash the power of science

As Australia's economic landscape is increasingly buffeted by global economic forces, one of the country's premier research bodies, CSIRO, has restructured its research management and reviewed the way it engages with industry. As she nears the end of her tenure as Board chairman, Catherine Livingstone explains why change within CSIRO is vital to Australia's capacity to ride increasingly rapid and pervasive global economic movements. In an interview with science writer Brad Collis, Catherine Livingstone outlines core issues and opportunities facing Australian industry. She warns against any temptation to simply hope the global economic dice will fall Australia's way, saying a capacity to trade aggressively in the new 'knowledge economy' is vital.

In a recent poll conducted for the Lowy Institute, the Sydney-based independent international policy think-tank, global warming rated ahead of international terrorism as the primary threat to Australia's vital interest.

The poll indicated that improving the global environment should be Australia's top foreign policy goal. Two-thirds of respondents wanted steps taken immediately to tackle global warming, even if the cost is high.

The Lowy Institute poll is just part of the growing public debate on climate change, fuelled again in recent months by the documentary *An Inconvenient Truth*, presented by former US vice-president Al Gore. The documentary portrays a planet in environmental crisis, but reaction continues to range from alarm and frustration to scepticism or denial. Few, if any, have stood up to suggest that global warming could potentially also be an extraordinary technological opportunity.

It is a viewpoint brimming with latent potential, which is why it is being raised by one of Australia's leading R&D figures. Catherine Livingstone, Chair of CSIRO and a Board Member of Telstra and Macquarie Bank, believes global warming could be one of the biggest opportunities this country has ever had.

Her point is that global warming needs an unprecedented technological assault and as has been proven time and again, large-scale scientific programs tend to unearth a wealth of knowledge and industry potential.

"The world is looking for solutions and technologies," she says. "It is an area in which Australia could take a lead with enormous economic rewards, if we are able to make it our knowledge and technologies that are sought out.

"It would produce an innovation yield the likes of which we have never seen before. But it needs to be articulated at the national leadership level, and there needs to be a greater alertness in government and boardrooms to the power of science."

Catherine Livingstone's determination to try to raise the profile of a technological response to climate change with both government and industry stems from her view that it transcends all other issues: "It affects everything and everyone."

Part of the challenge, however, in bringing enough science to bear on issues as pervasive as climate change is finding a way to engender public debate that takes its cue from science.

Catherine Livingstone still believes that CSIRO's reputation as a trusted organisation that is able to impartially inform the community is intact, even though recent restructuring and shifts in focus have met at times with an antagonistic response.

She suggests that it may be time for a change in approach for science communication, because the hard reality today is that science is presenting people with increasing ambiguity.

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"Less and less are we able to give clear answers. With regard to global warming, for example, unequivocal answers to every question are just not possible because there is still so much more to know.

"So the task is to communicate ambiguity scientifically; in a manner that makes the range of opinion itself understood and less easily seized on by vested interests."

She says one obvious example of a debate that has slipped away from science is GM (genetically modified) crops, and she wonders if it can ever be brought back to the facts, despite the increasingly urgent need for crops that are tolerant to drought, or crops that can confer direct community health benefits.

"CSIRO is well advanced with the technology that would allow plant breeders to give certain land crops the same genetic capability that makes marine plants (phytoplankton) produce long-chain omega-3 fatty acids. These are vital to healthy cell function in people and are only available at the moment by eating fish that have fed on phytoplankton. As a consequence we are depleting fish stocks all around the world.

"We have the technology to redress this and to create important new agricultural and food industries, but the science and all potential commercial development have been hamstrung by a protracted and at times ill-informed debate."

The CSIRO Chair says she has similar concerns for the fate of nanotechnology, a science that could underpin the next generation of manufacturing, but which is already being misconstrued in some of the early media coverage and debate.

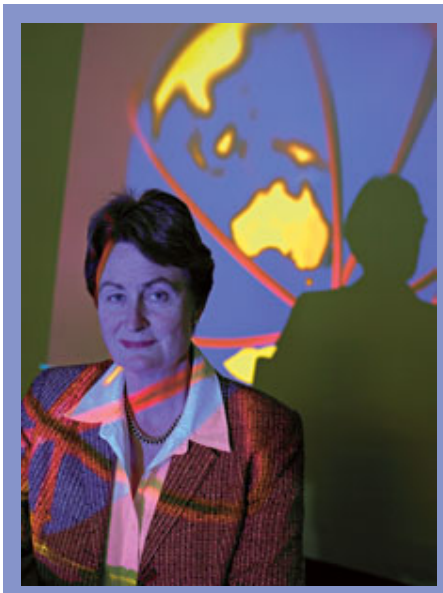
She says that with all these there is still a bottom-line choice. You can grow GM crops or not grow them: "Climate change is not a matter of choice; that's why the first country that really starts to apply itself to developing solutions is going to harvest an unprecedented innovation yield."

This, by default, means a much higher level of engagement between science and industry than has been the norm in Australia. It is likely to require them to be more willing to initiate R&D relationships, rather than scientists simply taking to the hustings to hawk their technologies and ideas to the highest (or least uninterested) bidder.

Catherine Livingstone hopes that an imminent Productivity Commission report into science and innovation will trigger an extensive national debate on Australia's commitment to R&D – and be the catalyst for a more proactive approach to using science that can anchor economic and industry development in this country.

"It comes back to the question: 'What are we trying to achieve…just commercialisation or real knowledge transfer?' If it is knowledge transfer then I think we can start to have a more productive conversation," she says. "To seek the benefit of intellectual property from its point of departure from a research institution is extraordinarily difficult, as evidenced by the fact that even in best-practice cases, barely two or three per cent of a research institution's income is derived from commercialisation or a royalty stream.

"And it is not a matter of telling scientists to be more commercial. To a business, ideas at the point they leave a research institution have little value because until you put in the 400-times investment to develop and market the product, you don't have anything. So pushing the research sector to 'commercialise' runs the risk of merely perpetuating a tense relationship between industry and researchers.



Catherine Livingstone has been on the CSIRO Board for six years; five as Chair. She is also on the Boards of Macquarie Bank Ltd and Telstra Corporation.

In the early 1990s, Catherine Livingstone held senior positions with Nucleus Limited, which later became a division of Pacific Dunlop Limited. In 1994, she was appointed to head Cochlear Pty Ltd, a subsidiary of Nucleus, and 18 months later Cochlear was floated on the ASX for $125 million.

By the time Catherine Livingstone stood down from Cochlear in late 2000, the company was exporting the 'bionic ear' to more than 50 countries, and had revenue of A$150 million and a market capitalisation of $1.5 billion.

"But neither is it appropriate in a global context to simply say here is the IP, anyone can have it. It is public money that has been invested and we must have regard for the national interest."

Catherine Livingstone says this whole issue is in fact an area that CSIRO is now exploring – different industry engagement models, that maximise the impact of its research in industry while also securing enough of a return flow of resources to make the business (of research) sustainable.

She says different approaches will be needed according to the circumstances: "Where benefits are localised, then it might be in the best interests of the country to transfer the IP at no cost. Conversely, where an industry is mature and highly profitable, then that might be a different basis for engagement.

"The question to be asked is what will maximise the national benefit?"

She feels the impact of globalisation is still only partially understood, such has been the pace of change, but says it has enormous ramifications for Australian science and industry and their capacity to give a national economy enough resilience to withstand, or ride with, powerful global movements.

Globalisation, in the modern sense, is considered by students of global affairs to have arrived in the mid-1990s on the back if what Thomas Friedman in *The World Is Flat* attributed to the lightning-swift advances in technology and communications.

Within a very short period a large number of people had access to the internet and its information resources – a broadband pipe that is allowing enormous amounts of data to move almost instantaneously around the world – and mobile telephony.

As Friedman describes it, globalisation has shifted from 'corporate' to 'individual', and Catherine Livingstone believes the central issue facing Australian industry is how it participates in the global economy: "It is a huge question that needs more conscious thought, public discussion and science–industry coordination than we ever previously had.

"It is the global market now that allocates resources and it has no regard for Australia's national interest. And the more that our industry is globally oriented or organised, the less it too will be concerned with the national interest. This is a big change that has taken place, because it means government can no longer rely on market forces for the resource allocation that ensures the social and economic wellbeing of its citizens.

"National governments, particularly in small, open economies such as Australia's, need to be thinking very hard about the consequences of a global market working its efficiency factors on a national environment."

For the CSIRO Chair, these are huge issues and are already being manifested in skills shortages and increasing competition for students and researchers in higher education facilities.

'To seek the benefit of intellectual property from its point of departure from a research institution is extraordinarily difficult'

To meet this competition, she is urging new and long-term government, industry and research sector partnerships: "We have to think together and the outcome must be the development of globally relevant research and knowledge that makes certain that Australia keeps its seat at the global table.

"If we don't have technologies to trade, we will be forced to buy…what we probably won't be able to afford."

Catherine Livingstone is quick to remind that for the moment Australia does have a research organisation, CSIRO, with a global reach.

"For example, one of the emerging sectors of significance is the bio-economy and the OECD is in the process of establishing a governance framework. CSIRO is representing Australia in that process because of its internationally recognised capabilities."

It is these capabilities that she wants industry and government to better understand and build on: "If not, economic gravity will drain Australia."

The developments driving globalisation since the mid to late 1990s have changed the way people live, work, run industries and do research, and it was the perceived need to bring CSIRO's inner workings up to speed that prompted the restructuring that has taken place over the past few years.

There was a sudden discontinuity with previous business systems and CSIRO was not alone in being caught lagging, particularly when its core business, research, has long lead times. There was a sense by the turn of the century, certainly in industry, that CSIRO was not aligning itself to the new environment.

It was during this hiatus that Catherine Livingstone joined the CSIRO Board and in many ways her perspective on challenges like economic globalisation has come to reflect the way CSIRO's Board and management have redirected the organisation, which she says was only just starting to realise the need for some clear enunciation or 'meeting of minds' on its role in this new globalised world.

"Like many in industry, I regarded CSIRO as having a virtuous approach to research and I was certainly mindful of all the anecdotal stories about 'he ones that got away'.

"It was soon clear why that was the case. CSIRO comprised many disparate divisions working within, but not for, CSIRO. This was not sustainable at a time of mounting pressure on CSIRO to demonstrate what the government was getting for its investment – especially given that CSIRO was also no longer the only major research centre available.

"But to be accountable you have to know, clearly, what your role is and reflect this to people you engage with, be they in government or industry. There was also not a great deal of understanding in government or industry about the value and role of CSIRO."

She says the Board considered it CSIRO's responsibility to change this by developing and articulating a clear direction. It began by initiating a five-year (2003–07) strategic plan based on six overarching goals to:

- focus our science investment;
- deliver world-class science;
- partner with others for maximum community impact;
- serve as a catalyst for industry innovation;
- build CSIRO's capabilities and commitment; and
- secure a financial foundation for forward growth.

"These goals required hard decisions about what we were doing, and also what we were not doing or would no longer do."

CSIRO's research has become theme-based – with a focus on 'big picture' objectives from which flow research streams comprising specific research projects.

"Organising CSIRO's research under 'themes' is a fundamental transformation for the organisation because they are making it more transparent, accountable, flexible and relevant."

Investment is at the theme-level based on a Science Investment Planning (SIP) process, which involves a systematic whole-of-organisation review of the science being done and the 'path to market' potential. The new approach seeks to harness and deploy CSIRO's multidisciplinary capacity onto national research priorities by making it flexible enough to respond quickly to community or industry needs, by increasing its global reach, and also by clarifying its fundamental reason for existing.

"The theme approach improves our flexibility and responsiveness because it allows CSIRO to form multidisciplinary teams to respond rapidly and with enormous capacity," Catherine Livingstone says.

'These goals required hard decisions about what we were doing, and also what we were not doing or would no longer do'

The National Research Flagships initiative has become the expression of this new approach, with considerable Australian Government backing. Flagships are research partnerships with industry, governments and other research bodies, tackling large-scale national objectives in health, water, energy, food, light metals and oceans.

"As part of our response to climate change, for example, the Energy Transformed Flagship research program is developing clean affordable energy and transport technologies to try to help halve Australia's greenhouse gas emissions by 2050. The Light Metals Flagship is exploring new ways to produce alumina, aluminium, magnesium and titanium, and the products made from them, so that manufacturers can reduce costs and pollution, plus lift their competitive performance."

The CSIRO Board has also sought to make the organisation's own performance more transparent under the themes approach, because they have clear output goals against which every downstream research project can be monitored: "If a particular project hits a dead end, you stop it and redeploy the money and knowledge gained to that point into other parts of the stream that are contributing to the theme's goals."

However, in the course of developing a new management model and with talk of becoming more commercial, CSIRO has been criticised in some quarters for moving away from 'public good' and 'blue sky' research in favour of contract research that is industry problem-solving rather than knowledge-building.

Catherine Livingstone argues, however, that defining its role strengthens CSIRO's long-term commitment to pure research: "The difference between now and five years ago is that at any given moment we can actually say how much of a theme's research streams are being directed to short- or long-term goals, or to public good research versus specific industry support.

"And CSIRO still has the same mandate to take risks for Australian society and industry – it just can't have all of its research directed at high-risk horizons."

As for industry-oriented research, she says the objective continues to be the development of long-term relationships with industry sectors. "Having a good understanding of where an industry is going, and the challenges it is likely to face, puts us in a position where we can help both the sector and individual

businesses within it. There are already very good examples of this in CSIRO's long-term relationships with the mining and agricultural sectors.

"However, new or emerging sectors require even more of an effort to build these relationships. The biotechnology sector is a case in point, and is probably an area where CSIRO needs to go much further than halfway to engage with the industry and businesses and encourage people to ask us the questions that will prepare us for a supporting role.

"The other opportunity that is presenting itself is to identify areas in which CSIRO can develop competencies that are anchored in Australia and that create a whole new space in which Australian industry can grow. This is behind the work being done, for example, in the Light Metals Flagship, and is starting to give shape to what could become a whole new industry.

"This is where we want to be; in a position to deploy good science that builds industry, strengthens our environment and creates the economic vigour that ensures the wellbeing of the community as a whole."

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ARTICLE

AGRIBUSINESS: Insect Sharpshooter

By Gio Braidotti

A technique to create chemicals that selectively kill only some types of insects is the platform for the development of high-performance agriculture.

The ability to kill any creepy-crawly fast is a key selling point for a household pesticide, given the panicky response aroused by cockroaches, centipedes and spiders.

But when it comes to genuine pestilence and the need to control insect-borne diseases (such as malaria) or agricultural pests, many chemicals hit insects indiscriminately, potentially creating long-term environmental imbalances that outweigh the immediate triumph.

Such unwanted impacts make up a list of health and environmental issues:

- the evolution of insecticide-resistant pests that erode hard-won advances in disease and pest control measures;
- health impacts from chemicals that have accumulated in the food chain;
- damage to biodiversity and the environment;
- the loss of beneficial insects that prey on pests; and
- the loss of pollinating insects such as bees, leading to massive crop failures.

To Dr Ron Hill and his team at CSIRO Molecular and Health Technologies, the unintended side effects all point to the same, basic design fault. Insecticides generally fail to distinguish different insect subtypes. It is a problem, but like many problems, it also becomes a potential opportunity.

"We have known for years that more than 99 per cent of insect species are innocuous or even useful to humans," Dr Hill says. "It is just 0.1 per cent that require control measures."

For this reason, scientists are working on the next generation of high-performance insecticide that can chemically 'see' what kind of animal it has come into contact with and spare mammals, birds, fish, reptiles, bees, ladybugs and other insects that are not the intended target.

"Target-specificity is a fascinating challenge," Dr Hill says. "It requires integrating molecular biology and protein-structure analysis into the synthetic chemical process of designing insecticides. At the same time, you don't want to have to solve the specificity problem from scratch for every situation.

"In other words, the insecticide needs to be insect-specific, but the method we use to develop that specificity needs to be universally applicable – otherwise the R&D effort would be enormous."

APPLICATION A new class of insecticides promises to control pests without unwanted health and environmental effects

BENEFIT The process enabling researchers to identify and target specific insects has generated interest across agriculture

As paradoxical as that requirement sounds, it has been met. Dr Lloyd Graham and Dr Noni Johnson from the CSIRO team, with support from a $1 million Start grant, have developed a screening method for a new type of insecticide.

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"This new system is based on the hormone receptor that triggers moulting of an insect's hard outer skeleton," Dr Hill says. "The use of chemicals that mimic the hormone ecdysone allows us to activate moulting inappropriately, causing the insect to die. Best of all, ecdysone mimics are innocuous to most other animal groups."

To achieve the desired target-specificity, Dr Mike Lawrence is examining the three-dimensional structure of the hormone receptor, looking at the way it binds the hormone, to identify differences among insect types.

"These variations are the key to discovering hormone-like chemicals that are active in a selected subtype of insect only," Dr Hill says. "But to realise that potential, we had to invent a way to mass-screen the hormone mimics."

The result is a patented, automated, high-throughput assay performed in standard laboratory equipment. To set the assay against a particular insect, the ecdysone-receptor gene from the target insect is cloned and expressed in a cell line to make the receptor protein used in the automated assay.

Industry is already expressing interest in the new assay, with Australian Wool Innovation (AWI) investing in the technology to target the blowfly, which costs the sheep industry $280 million a year in fly-strike. Fly-strike is the reason for the controversial mulesing procedure, which cuts away the loose skin where flies lay maggots.

AWI is also supporting Dr Matt Pollard to clone the ecdysone receptor from the sheep body louse as another target for insecticide development.

In freezers in the CSIRO laboratories, genes for ecdysone receptors from other pest species – cloned under the direction of Dr Garry Hannan – are also available, with the team eager for investment to pursue other economic pests such as aphids and whiteflies.

CSIRO business development manager Dr Tim O'Meara estimates that it has been a decade since the last development of a new class of insecticides, and the sheep industry is not the only sector in need of new, high-performance compounds.

With chemical treatment still one of the most effective ways of maximising crop yields – and crops finding new uses as sources of fuel and 'biofactories' – the worldwide sale of agrichemicals is exceeding $20 billion a year.

However, as population growth continues to put pressure on arable land, the need for sustainable agricultural practices is lifting the demand for selective, environmentally friendly insecticides.

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ARTICLE

TEXTILES:
Shirts Fashioned for Rockin' Science

By Rebecca Thyer

CSIRO has developed an air guitar – a wearable instrument shirt. It embodies some of the technology mix that textile researchers hope will eventually become the basis for new textile industries.

Some day soon CSIRO research engineer Dr Richard Helmer hopes to walk into a meeting in a new business shirt and as eyes turn his way, jump and gyrate with a virtuoso 'air guitar' performance. But he won't be ripping off his shirt – he will be playing it. Dr Helmer and his team at CSIRO Textile and Fibre Technology (CTFT) at Geelong have developed an air guitar shirt. It is what they have dubbed an invisible wearable instrument shirt (WISH) that allows the user to play air instruments and make real sounds.

The WISH works by recognising and interpreting arm movements and relaying the information wirelessly to a computer for audio generation. Textile motion sensors embedded in the sleeves detect motion when the arms bend – in most cases, the left arm chooses a sample and the right arm plays it.

Using very fine conductive fibres in the body of the shirt, sensor signals are bused to a common wireless connection and from there to a computer for gesture analysis and audio generation, using CSIRO-developed software. The software can be customised for different instruments and skill levels…including drummers.

Because the shirt responds in milliseconds, the user knows instantly when they have struck the right chord, so to speak.

"It has to be faster than 20 milliseconds because the ear is very fast at recognising sound," Dr Helmer says. "And people playing it [the shirt] need to know that the moves they make will indeed make music."

This said, the WISH is not intended to be played as a conventional instrument; in other words, it is not necessary to play note by note. Instead the device uses everyday audio samples to make authentic sounds based on simple movements.

APPLICATION Louder than a Hawaiian shirt, WISH could act as a musical instrument, gaming device or for rehabilitation and exercise

BENEFIT WISH shows how different technologies can combine, in this case computing, chemistry, electronics, music and textiles

"We realised people don't want to play it as a real instrument; they want to make some moves that correspond to a hero and a song," Dr Helmer says.

The all-singing, all-dancing shirt is the latest piece of textile wizardry to emerge from CTFT and encompasses textiles, music and computing know-how.

Dr Helmer says CSIRO's textile work is about embracing knowledge from many disciplines to create textiles of the future. "It took a merger of skills in computing, chemistry, electronics, music composition and textiles to get the air guitar right. In the same way, the next generation of textile development will demand cross-discipline research and development."

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The range of products that could be based on this development is limited only by imagination.

Dr Helmer says the technology takes clothing beyond its traditional role of protection and fashion into computer gaming (requiring children playing games to aerobically exercise as part of the playing) and areas such as occupational therapy. The clothing can act as a remote nurse, making sure exercises are being done correctly.

"With our intelligent textiles work, we are trying to demonstrate our ability to do exciting things with sensors, batteries, antennas and indicators, among other things."

Dr Helmer set himself the task of creating an air guitar a few years ago, when he became aware of the new directions and technologies at CTFT. "The first thing I thought of was an air guitar," he says. "Developing it was a technical challenge for precision textile-based sensing."

The project not only combines his expertise in fibre technology, chemistry and electronics, but also his love for and aptitude in music (Dr Helmer plays in six bands). The team that has taken rocket science to rockin' science has developed a prototype air guitar, air tambourine and air guiro (a percussion instrument). CSIRO is discussing the concept with the gaming and sports industries, which will help determine how the technology might be taken to the next stage.

Dr Helmer says there is also potential for the technology to encourage exercise. "Imagine a computer game where instead of sitting back and twiddling controls to jump over obstacles or whatever the game demands, you physically have to perform that task?"

However, he sees computer gaming as just the beginning; a starting point that allows people to become comfortable with the technology. "The system could ultimately be used in sports training and rehabilitation. For example, it could work as a remote physiotherapist. You would know you were getting your exercises right because the sensors would feed into a system to coach you."

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ARTICLE

LIGHT METALS: Cooler Future for Smelting

By Bianca Nogrady

The Light Metals Flagship is working with the minerals group Rio Tinto to lower the energy costs of producing aluminium.

Aluminium producers, who consume as much as 15 per cent of Australia's electricity, are keenly watching research between the Light Metals Flagship and industry partner Rio Tinto on a new method for producing aluminium that could cut energy consumption and greenhouse gas emissions.

The research involves the use of ionic liquids as 'designer solvents' that could reduce the high temperatures needed for aluminium smelting.

Designer solvents or ionic liquids could also be used as alternative media for reprocessing nuclear fuel and waste in the nuclear power industry, and as catalysts or solvents in a host of other industrial processes.

CSIRO is also exploring their use as electrolytes in lithium batteries, because the organic solvents used in lithium battery manufacture are volatile and flammable. Other potential uses include carbon dioxide recapture in power plants, desulfurisation of fuels and even perfume production.

The key to ionic liquids is their low melting point. Aluminium is currently produced through electrodeposition, where the alumina is dissolved in a molten cryolite bath at 1000°C and an electric current is applied to separate aluminium from oxygen. The high temperature needed to keep the cryolite in liquid form is the reason for the high energy consumption.

By contrast, ionic liquids typically melt below 100°C. If they can be used instead of molten cryolite, they could dramatically reduce a smelter's energy needs.

Rio Tinto's technology support general manager, Dr Ray Shaw, says that although research on ionic liquids is still in its early days, it is a novel approach that the company is monitoring closely. He says ionic liquids could reduce by 20–30 per cent the electricity used in aluminium production, based on the expectations of researchers in America.

"Whether that's achievable or not is uncertain at this early stage. But if there's an opportunity to improve, then we're interested in exploring it."

The Flagship's ionic liquids research project leader, Dr Theo Rodopoulos, believes ionic liquids have significant commercial potential. "Their negligible vapour pressure eliminates the release of atmospheric pollutants, and because less of the solvent is lost to evaporation during processing, ionic liquids are more recyclable and economical than conventional industrial solvents," he says.

Their capacity to remain liquid over a wide temperature range and their high thermal

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stability also allow chemical processes to operate at higher temperatures to improve reaction kinetics, without actually boiling or decomposing the solvent.

Ionic liquids' electrochemical stability gives them a significant edge over conventional aqueous and organic electrochemistry in the electrodeposition of certain metals, Dr Rodopoulos says. "For example, aluminium electrodeposition is not possible in water due to the reduction of water to hydrogen at the cathode."

Know your ions
IONIC liquids are a form of molten salt, but differ from traditional molten salts in ion size. Traditional salts such as sodium chloride consist of a small cation and a small anion, which pack neatly together and form a solid. However, in an ionic liquid, the cation is generally large and the anion is either large or small, resulting in poorer packing of the larger ions with weaker attraction, so the compound tends to remain liquid. It is this liquid state that is the key to ionic liquids' useful properties, which include high thermal stability, negligible vapour pressure and good electrochemical stability – making them attractive to any industry using solvents.

They are often called designer solvents because they can be tailored to meet the needs of specific applications. Dr Rodopoulos says it all depends on the type of positively and negatively charged ionic components selected, with an almost infinite number of combinations possible.

"You really need to consider the sort of application you're interested in and choose your cations and anions accordingly, to give you the desired properties such as lower viscosity, lower melting point or a particular solvation characteristic."

However, there are still issues to be resolved with ionic liquids – such as cost. Rio Tinto's Dr Shaw says the challenge is one of scale. "Until significant quantities are used, the cost will remain high. So they need to end up with a use that's sufficiently compelling to drive large-scale use."

Dr Rodopoulos says that although ionic liquids are relatively easy to produce, they can vary in their purity. "They can be anything from colourless, which is typically what they are, to pale yellow and brown, which is usually an indication of impurities."

However, this may not be an issue if the impurities do not interfere in the ultimate application, he says.

APPLICATION Aluminium production accounts for about 15 per cent of Australia's energy consumption. compared to solvents currently used to produce aluminium from alumina, ionic liquids could reduce the industry's energy use by up to 30 per cent.

BENEFIT With their low melting point, ionic liquids offer a more energy-efficient and safer alternative to high-temperature or volatile or flammable industrial solvents.

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CSIRO SOLVE
A CSIRO review of scientific innovations for Australian industry
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ARTICLE

SOLID FUELS:
Fuel Solution Out of the Box

By Sue Neales

One man's waste is another's treasure on King Island in Bass Strait, where some clever engineering has closed an environmental loop

King Island has two problems – a future shortage of wood and mountains of cardboard. Now a joint effort between its main industries – kelp and dairy – has seen the two problems merge and a possible solution take shape.

John Hiscock, the general manager of Kelp Industries on King Island, recalls the day 16 months ago that a plausible answer was found: "It wasn't like a light bulb popped, it happened slowly, more like a fluorescent light," laughs Mr Hiscock, "…because it evolved as a joint idea within these industries.

"The [King Island] dairy had mentioned how much waste cardboard they had and that it was too expensive to ship back to the mainland. They were wondering how they could use it on the island. Then I remembered the briquettes made from cardboard I'd seen for sale in a shop somewhere…"

Coincidentally, Kelp Industries was looking for an alternative fuel for drying its seaweed. The wood it has always used to fire its furnaces may be in short supply on the island one day, and importing gas or diesel is too expensive.

The kelp industry on the 60-kilometre-long King Island, off the north-west coast of Tasmania, employs 45 of the 1600 locals and earns about $2.5 million a year for the remote economy. Extracts from the dried seaweed are used as thickening agents in food and industrial products worldwide.

"So it occurred to me that using this waste cardboard as a fuel source – if it was at all feasible – might solve a few problems for us and the dairy, and maybe for the island as well," Mr Hiscock says.

The King Island Dairy (National Foods), which sends three 400-litre bins of waste cardboard packaging to the local tip every week, agreed enthusiastically, as did the King Island Council. Council general manager Andrew Wardlaw says reducing landfill and improving waste recycling is a hot topic for the island, with the old tip full and a new one just opened. The proposal also fitted neatly with the council's commitment to clean, green and sustainable principles, and the island's reputation as a producer of fresh and pure gourmet foods.

To turn the idea into reality, CSIRO was approached. That was when the phone first rang in the laboratory of Bob Flann, principal research scientist with CSIRO Minerals in Melbourne. An expert in furnaces and briquetting, Mr Flann relished the challenge to help the King Island community solve its problems – and to neatly close a processing loop. "It was a project from 'left field' with what looked like a natty solution, and I really liked the idea that CSIRO could help the island people in facilitating a good outcome," he says.

The first step was to fly to King Island to inspect the furnaces being used by Kelp Industries, and the type of cardboard available. Key scientific elements that CSIRO needed to resolve were the correct density of the cardboard briquettes for use in the furnace, the optimal ratio of cardboard to wood burning to sustain the process, and ash analysis to ensure impurities from the cardboard did not contaminate the drying seaweed.

One year later, after a trial of 300 kilograms of briquettes made by CSIRO Minerals in Melbourne and shipped to Kelp Industries

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on King Island, the results are scientifically clear. Solid briquettes made from shredded cardboard waste and about the size of a house brick work well in the Kelp Industries furnace as a 30–50 per cent component of the total fuel mix.

Extensive analysis established that potential contaminants such as arsenic, lead, cadmium and mercury in the dried seaweed were negligible, although Mr Flann recommends that only plain cardboard with minimal colour is used. A spin-off benefit is that the briquettes are also suitable for home use.

APPLICATION Briquettes made from cardboard waste from King Island Dairy will help fuel the island's kelp drying kilns

BENEFIT Both sides win – the dairy gets rid of its waste and the kilns have the prospect of cheaper fuel

"But we're not quite there yet," admits King Island Dairy's environmental coordinator, Steve Newham. "The big question now is who makes the briquettes, who buys the briquette machine (which can cost between $70,000 and $150,000), where we locate the cardboard depot and who operates the facility," he says.

Mr Wardlaw says the council supports the concept, "But we are only a small community. It has to make sense financially as well as environmentally and that's what we need to resolve at the moment."

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CSIRO SOLVE
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ARTICLE

PRECISION OPTICS: Mapping the Milky Way Opens Doors

By Rebecca Thyer

Australian-built retro-reflectors will help NASA chart the Milky Way and look for new planets

Using the most sensitive instruments ever built, NASA plans to accurately map the Milky Way and help astronomers find new planets. Central to this space odyssey are Australian-built retro-reflectors made by the Australian Centre for Precision Optics (ACPO), based at CSIRO Industrial Physics in Lindfield, Sydney. They reflect light back precisely to where it came from – regardless of incidence angle.

Dubbed 'double corner cubes', the reflectors have been fitted to a prototype on NASA's PlanetQuest demonstrator spacecraft and may prove central to NASA and its Jet Propulsion Laboratory's 2011 Space Interferometer Mission. The mission aims to detect new planets by accurately mapping the stars and looking for any signs of 'wobble' in their positions. (Wobbling stars often indicate that gravity from orbiting planets is tugging at them.)

The reflectors' geometry – accurate to within five-thousands of a millimetre – will enable precise relative positions of far-off stars to be measured by bouncing lasers between telescopes.

Although other corner cubes exist, NASA needed precision and resilience in the harsh operating environments of both deep space and the initial launch. These requirements are where ACPO's skills in precision optics fabrication, coating, measurement and assembly make the difference.

Where the white things are

Measuring accurate distances of stars throughout the Milky Way is very different from measuring distances on earth. To measure the immense distances between stars to any accuracy, tiny angular changes over very long baselines must be calculated. So, to detect these subtle changes, NASA will measure the position of stars with far greater precision; its new mission will have an accuracy of more than several hundred times compared to what is possible today.

ACPO director Manfred Claasz says it was his team's 'intellectual horsepower' that helped to deliver on NASA's demanding requirements: "The value of the group is in its people. They are a considerable asset."

It is an asset that Mr Claasz and the centre wish to share a lot more with private industry. Precision optical components, systems and underpinning research services are used in astronomy, space exploration, semiconductors and photolithography, fibre optics and photonics, research, education and instrumentation.

Industry alliances would bring the group recognition, help expand its work and allow others to take advantage of its creativity, Mr Claasz says.

"We are often perceived as a group in the fabrication industry, rather than a research unit that has consummated the value of its research in the delivery of a product to the client's satisfaction. An industry alliance would boost knowledge of the team's work, especially in the US, Europe and Japan, where precision optical know-how is in high demand. Raising the visibility of what we do would also allow our team's creativity to be more readily perceived and demonstrated."

Mr Claasz is actively engaging organisations in Australia, the US and Europe.

"We have been building custom-made optical components and systems for the world's most demanding clients for more than 50 years. Our small group has made such an impact on NASA's work that we want to expand our business," he says.

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WEB SEARCH:
Software Heralds Searchable Web Videos

By Jason Major

Open-source technology will significantly reduce web audio / visual download time

Internet search engines have opened a whole new world of information access, but as rapid as the phenomenon has been, such text-based searching is already not up to the needs of a worldwide web in which video and audio are becoming increasingly predominant. Two of the frustrations users face are the large size of video files and the need to search for and download a whole file, such as a current affairs interview, when they might only want a snippet.

This challenge has been taken up by a team from the CSIRO ICT Centre, which has developed open-source technology that allows indexed searching of video and audio on the web. This means that instead of having to download an entire file, a web user can find and hyperlink to a point of interest within a video or audio file, saving significantly on download time.

The ICT Centre team has developed a file format called Annodex, a new mark-up language called CMML and a form of Universal Resource Identifier (URI) that together allow audio and video to be accessed as hyperlinkable and searchable web resources.

"The explosion of audio and video in the past five years has created a need for more advanced and efficient tools to search these types of web data," says Conrad Parker, CSIRO lead developer on the project. "Apart from users, others to benefit will be media companies and anyone who owns large archives of audio and video."

CSIRO and the Centre for Networking Technologies for the Information Economy (CeNTIE) jointly developed Annodex and are now working to have Annodex and its associated tools accepted as an international standard.

Just as HTML has become the international standard code for writing web pages, CMML could easily become the international standard for indexing and annotating continuous media.

"One reason HTML became the standard was because it was universally available and people could experiment with it and expand on the creative capability of the code to the benefit of all," says Mr Parker. "Acceptance of Annodex as a standard is a matter of uptake. If uptake is sufficient, standardisation will usually follow."

Industry is showing increasing interest in CSIRO's research in this field. The Australian Broadcasting Corporation (ABC) has run a trial with the software to index and annotate its news bulletins. CSIRO is also negotiating with Wikipedia and has conducted trials with US research teams to index US senate proceedings.

CSIRO is developing proprietary technologies to capitalise on this open source software.

One of these is an interface and browser for smart mobile phones such as those with 3G technology. Phone users with CSIRO's technology can search video and audio the same as any web user, but because they can select and download just the interesting bits, download time is quick and bandwidth use is minimised.

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ARTICLE

NANOTECHNOLOGY: Light Fantastic

By Gio Braidotti

In building the world's smallest electrical circuits, CSIRO has created a material with unusual optical effects capable of tuning and controlling visible light

Somewhat gingerly, Dr Tim Davis removes the glass disk housing the world's smallest electrical circuits from a protective case and holds it in the palm of his hand. Casually he mentions that each fingernail-sized unit etched into the glass contains a staggering 32 billion circuits.

He then holds the disc up to the light to demonstrate its orange glow, which is at the heart of the innovation. Dr Davis's nanocircuits are resonating at the same frequency as visible light.

That resonance means his circuits can interact with light in much the same way that electrical circuits in radios and mobile phones are able to tune radio waves. Dr Davis then points out the other significant aspect – his electrical circuits are powered by light.

He explains that these nanocircuits represent a convergence of different ideas from physics, optics and material science: "Obviously there is a lot of interest in shrinking electronics to make them go faster. But this is also a way to potentially make components for high-speed electronics that are powered by light. There are also novel optical effects that come into play."

Dr Tim Davis with his nanocircuits

The nanocircuits can behave like a lens, bending and focusing light, depending on the way the circuit is designed. Dr Davis offers the example of a unit that behaves like a mirror, but with the circuits redirecting the reflected light to the viewer, irrespective of the angle at which the reflecting surface is held. One early application being mooted is the development of extremely high-resolution microscopes.

Dr Davis says that shrinking the circuits was instrumental in achieving the optical effects: "Theoretical physics has long proposed that shrinking capacitors and inductors should produce circuits where the electric current is oscillating at ever higher frequencies, much higher than radio waves," he says.

But the circuits required to resonate with visible light have to be truly miniscule. "Each circuit is about 130 nanometres (or billionths of a metre) high and 160 nanometres in diameter."

By comparison, human hair is a massive 100,000 nanometres thick, although Dr Davis prefers a different comparison: "One circuit is actually smaller than the wavelength of visible light, which is about 600 nanometres."

To build the tiny resonant circuits, Dr Davis made use of the electron beam lithography facilities at CSIRO Manufacturing and Materials Technology in Melbourne, and adapted a printing process that CSIRO uses to stamp images with advanced optical properties.

"We coat a glass disk with an electron-sensitive polymer before passing a beam of electrons over the surface in a specific

APPLICATION Physics, optics and material science have been combined to create tiny circuits powered by light

BENEFIT The nanocircuits are a big step towards light-powered nano-machines

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pattern," says Dr Davis. "The electrons expose the surface, producing an array of little holes that go down to the surface of the glass. We use a thin-film evaporator to add sequential coatings of silver, magnesium fluoride and more silver. We then lift off the polymer which removes all the layers except for the three tiers of materials in the etched holes."

Each stack constitutes a circuit with a capacitor and an inductor separated by a magnesium fluoride dielectric (or non-conductive) layer.

"Because the nanocircuits resonate at the frequency of light, we can design the electrical properties to control how light reflects off the circuits," says Dr Davis. "That's what I was originally attempting to do – build an unusual optical material that interacts with light in ways that you can't otherwise find in nature."

Physicists refer to artificial materials with novel optical properties as 'metamaterials', and there is growing worldwide interest in learning how to fabricate them, says Professor Yuri Kivshar, who is a world leader in the study of the behaviour of light and the head of the Nonlinear Physics Centre at the Australian National University.

"Metamaterials display amazing properties that can reverse fundamental principles of physics," says Professor Kivshar. "It would be great to use the opportunity to downscale optical devices, taking advantage of a metamaterial's unusual properties for novel imaging and sensing technology."

"What makes Tim Davis's work so interesting is the leap in scale: from microwaves, which is what most researchers are working on, to optical wavelengths. It's an impressive achievement."

Keen to collaborate with Dr Davis, the ANU physicists are preparing to do some numerical simulations that could provide new designs for the nanocircuits.

Given that nanocircuits were purely theoretical only a year ago, Dr Davis estimates that second- and third-generation prototypes are at least 10 years down the track. Nonetheless, with each translation of theory into practice, science steadily progresses towards the sci-fi scenario of nano-machines and components powered by light and running on tiny electronic circuit boards.

Towards that goal, there are two innovations that Dr Davis would like to build into the world's fastest resonant electrical circuits: "The first is diode that would allow the circuits to pump energy from light, like a solar cell does, but using different mechanism. The other is a transistor that would allow the circuit to mimic a computer chip."

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ARTICLE

PREVENTATIVE HEALTH: Early Warnings Examined

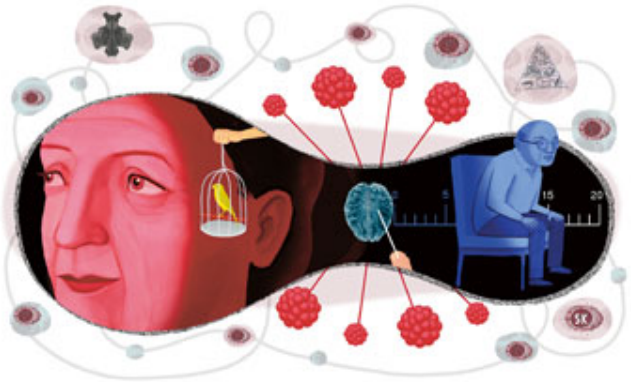
By Bianca Nogrady

A research 'cluster' will study 1000 Australians in a bid to identify the early warning signs of Alzheimer's disease

Alzheimer's disease is a devastating condition; still largely unexplained and becoming more common. As the population ages, more Australians will be affected by this degenerative condition and so far medical science has been unable to prevent or cure it.

Alzheimer's disease costs the Australian health system $3.2 billion a year in direct costs, a figure expected to reach $6 billion within five years. Indirect costs are also considerable. However, positively, if lifestyle or other interventions can delay the onset of the disease by even five months, there would be a five per cent reduction in the cost of Alzheimer's disease to the economy.

This has prompted CSIRO researchers to turn their attention to the disease's early detection and prevention. The Preventative Health Flagship has established a research 'cluster' for Alzheimer's, which brings together some of Australia's leading specialists in psychiatry, neuroscience, nuclear medicine, pathology, epidemiology and nutrition. Their focus will be a three-year study of 1000 Australians in Melbourne and Perth, with the hope of identifying reliable early warning signs. The next step will be to see whether diet and lifestyle interventions can be brought to bear on the disease.



The $10 million cluster, which will undertake the Australian Imaging Biomarker and Lifestyle (AIBL) Flagship Study of Ageing, was created under the auspices of the Preventative Health Flagship in partnership with NeuroSciences Australia (NSA), a national consortium of neuroscience research bodies. The study is led by Professor David Ames, Professor of Psychiatry of Old Age at the University of Melbourne, and comprises researchers drawn from NSA members, including the University of Melbourne, the Mental Health Research Institute, Edith Cowan University and the University of Western Australia.

The director of the Preventative Health Flagship, Dr Richard Head, says Alzheimer's disease was identified as an area of national need because of Australia's changing demographics. "With an aging population you want people to have healthier years with their longevity," he says.

"You need to give people the ability to participate in community life in whatever way they want – volunteer work, continued employment – but you'll only get that if you've got healthy years, and you'll only have healthy years if you can reduce the burden of these chronic disorders."

Professor Ashley Bush, a well-respected senior researcher at the Mental Health Research Institute of Victoria, says the cluster approach means no stone will be left unturned. "We've got a piece of everything, and that's very important," Professor Bush says. "We might be able to find that there is a lifestyle issue that stands out if you have a certain biochemical profile."

In 2003, 162,000 people in Australia were diagnosed with Alzheimer's disease, representing 0.8 per cent of the population. By the time they turn 85, one in five Australians could have the disease. What begins as occasional forgetfulness slowly degenerates into a state where a person no longer recognises close friends and family, and requires constant, attentive care. Unfortunately, by the time any symptoms are noticed, the

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disease process in the brain is well advanced. Alzheimer's disease is characterised by the build-up in the brain of plaques of a protein called amyloid, and when disease is diagnosed these plaques are rife.

A key research leader in the cluster will be Professor Colin Masters, whose co-discovery of the structure of amyloid in Alzheimer's disease plaques has enabled many advances understanding the disease over the past 20 years.

Alzheimer's begins as forgetfulness… by the time symptoms are noticed, the disease is well advanced

One approach to early diagnosis of the disease may be to look for the first signs of these plaques. Nuclear medicine physician and neurologist Associate Professor Christopher Rowe, who heads the neuroimaging arm of the cluster, is evaluating a new imaging agent called Pittsburgh Compound-B (PIB) for brain scans. "It's derived from a chemical dye that pathologists have been using for decades to stain amyloid in post-mortem brains," says Professor Rowe, director of Nuclear Medicine and the Centre for PET at Melbourne's Austin Health. The AIBL study will be the world's largest of its type using PIB.

Increasing evidence suggests these scans will enable the researchers to detect the very early signs of amyloid accumulation in the brain. "That will enable us to relate diet and lifestyle factors to amyloid accumulation, which may turn out to be more sensitive than waiting for people to show Alzheimer's disease symptoms," Professor Rowe says. "Obviously if you can treat something before it has done irreversible brain damage then you've got a much greater chance of success."

Taking the same approach but from a different angle, another group of researchers in the cluster are looking for a blood test for early diagnosis. Diagnosis currently relies on psychometric tests such as the Mini Mental State Examination, which assesses cognitive mental state, but by the time clinical symptoms are advanced enough to be picked up by psychometric testing, much of the damage has already been done. Monitoring levels of Alzheimer's biomarkers in the blood will also allow researchers to continuously evaluate the impact of diet and lifestyle interventions on progression of the disease.

Professor Ashley Bush in Melbourne and Professor Ralph Martins in Perth are leading the research on biomarkers for Alzheimer's disease. An obvious first candidate for a biomarker is the plaque-forming ß-amyloid protein, which forms plaques in the brains of people with Alzheimer's, Professor Martins, Foundation Professor of Ageing and Alzheimer's at Edith Cowan University, says.

"Its levels definitely build up in the brain and levels have also been shown to rise in the blood," he says. Current blood tests for amyloid protein are not sensitive enough, and the situation is complicated by the fact that in the blood, ß-amyloid binds to a whole range of other proteins, making it much harder to detect. "There is a hint that there is a large pool of amyloid bound to other proteins, much larger proteins such as albumin, but that has been very poorly investigated."

In this study, researchers will take blood samples from participants every 18 months and screen the blood for biochemical and haematological parameters. The study design means they can then compare the changing levels of amyloid and other biomarkers in patients over time. Of the 1000 people involved in the study, 20 per cent will already have been diagnosed with Alzheimer's disease and another 20 per cent will have clinically defined mild cognitive impairment but not diagnosed with Alzheimer's; this group is believed to be at high risk of developing Alzheimer's disease.

Another 20 per cent of participants will have less specific memory problems, 20 per cent will be mentally healthy but have a genetic mutation that predisposes them to Alzheimer's disease, and the last 20 per cent will be completely healthy. This selection of participants will allow the researchers to correlate the biomarker data with data from the neuroimaging and psychometric arms of the study. "Once it's clear which individuals definitely have Alzheimer's disease according to the neuroimaging, we can then look into screening for other markers that might be more sensitive," Professor Martins says.

APPLICATION Researchers will monitor five groups, from healthy people to those with Alzheimer's, to seek early warning markers for the disease

BENEFIT A cure could help reduce the 580,000 expected cases of Alzheimer's by 2050

Once researchers are better able to monitor progression of Alzheimer's disease, they can evaluate the effectiveness of dietary and lifestyle interventions. Little is known about what causes Alzheimer's disease, according to Professor Bush. "Age is the number-one risk factor but Alzheimer's is a disease, it's not simply a variant of normal aging," he says. "We know there's a protein (amyloid) involved, but we're born with that protein, so there's no reason why production of that alone should cause the disease."

One theory the cluster is examining is that Alzheimer's could be triggered by abnormalities in regulation of metals such as copper, zinc and iron in the brain, with evidence suggesting these metals interact with amyloid in the brain and cause plaques to form. One approach to prevention may be to use a drug called chloroquinol, which binds to the metals and deactivates them, preventing the formation of plaques.

The cluster is also focusing on non-pharmaceutical interventions. Research suggests that Alzheimer's shares many risk factors in common with heart disease, such as high cholesterol, smoking, high blood pressure and lack of exercise – all of which can be modified with changes to diet and lifestyle.

Dr Head says CSIRO has particular strengths in the area of nutritional research. "What has really occurred over recent decades as a generality is an understanding that some foods go beyond sustenance, that they actually have a protective role," he says. "CSIRO has the capacity to understand the constituents within food and has the ability to actually fractionate or separate those components." This will allow a new depth of understanding of the health potential of foods in a whole range of chronic conditions.

It will be several years before the first results emerge from the study, but it is already sparking interest from overseas, according to Professor Martins, who says the multifactorial, preventative approach is an important first for Alzheimer's research. "I think we are probably leading the world with the level we're looking at this".

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ARTICLE

WATER USE:
Sparkling Idea for Showers

By Whitney MacDonald

A new device for showerheads can reduce the amount of water used by 30 per cent – saving the average household about 15,000 litres a year

The average Australian household uses about 240,000 litres of water every year – and showers have one of the biggest thirsts, accounting for nearly a third of the average person's water consumption. Well, water shortages are starting to bite and with necessity being the mother of invention, Australian scientists have developed a new showerhead that uses tiny bubbles to increase the volume of the shower stream while reducing the amount of water within the stream.

The 'aerated showerhead', invented by researchers at CSIRO Manufacturing and Materials Technology (CMMT), creates the sensation of having a full and steady stream of water in the shower, while actually using about 30 per cent less water.

This is enough to add up to a savings of about 15,000 litres of water per household each year; across the population, that is more than the amount of water in 45,000 Olympic-sized swimming pools.

Developed by a team led by Dr Jie Wu, the aerated showerhead is a small nozzle that fits inside a standard showerhead. The nozzle uses a small Venturi tube – a tube for which the diameter varies, creating a difference in pressure and fluid speed. Air is sucked into the Venturi tube as a result of the partial vacuum created, causing air and water to mix and, in this case, tiny bubbles are produced within the water stream.

"The nozzle creates a vacuum that sucks in air and forces it into the water stream," explains Dr Wu. "We make the water droplets in the stream hollow and the bubbles expand the volume of the shower stream."

Small-scale experiments using the aeration device found that people detected no difference in water pressure, sensation or overall perception of showering. Dr Wu now hopes to strengthen the data by testing the aerated showerhead on a larger number of people. "We would like to use about 100 volunteers to test the effect of water saving and the shower cleaning quality of the aerated showerhead technology, benchmarking it against commercially available water-saving and non-water-saving showerheads."

While the general concept of using an aerated showerhead to save water is not new, the technology involved with CSIRO's device is. Other attempts at creating aeration in the shower stream have suffered from drawbacks such as insufficient water suction; an 'unpleasant feeling' caused by problems with flow uniformity; and discrepancies between designs and Australian pipe and flow specifications. The end result has often been only minimal water savings – if any at all.

After almost two years of research and development, the CMMT team is ready to take the aerated showerhead technology to commercialisation. CSIRO is seeking commercial partners interested in taking the technology through to product development.

"We have very promising results on the aerated showerhead's

APPLICATION A Venturi tube in the showerhead aerates the water, making the droplets hollow

BENEFIT The showerhead could cut water use by 30 per cent without any noticeable difference to users

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water-saving potential. Now we are looking for commercialisation partners who will be involved in the development needed to turn the technology into a marketable device, a process that we expect to take less than two years," Dr Wu says. He anticipates the nozzle would cost less than $20 and be able to be installed by householders.

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ARTICLE

MEDICAL RESEARCH: Genes Help Tumour Diagnosis

By Jason Major

Advanced statistical tools are being used to identify genetic markers that will allow doctors to more accurately diagnose different types of brain tumour

Statisticians and medical researchers are teaming up to pinpoint genes that can act as diagnostic markers to better distinguish different brain tumour types as the first step in increasing the long- term survival rate of patients.

The Kolling Institute of Medical Research at the University of Sydney is working with CSIRO statisticians who have developed advanced statistics to analyse the activity of tens of thousands of genes placed onto a tiny, wafer-thin chip called a microarray.

Kolling Institute postdoctoral scientist Dr Kerrie McDonald says the use of advanced statistics has helped advance the institute's brain tumour research by up to five years. "By isolating only the genes of interest, we have saved years of additional laboratory analysis," she says.

There are a number of brain tumour types, collectively called gliomas. They range from low grade to aggressive and highly malignant. At the moment, pathologists determine the tumour type with a microscope. They make a diagnosis based on how a cell looks and behaves. "Unfortunately, this technique cannot help us identify useful molecular targets to better understand the mechanisms of brain tumours or guide us when selecting the most appropriate treatment protocol," Dr McDonald says.

Since the institute and CSIRO started this collaborative project, researchers have found three key genes associated with the more aggressive types of brain tumour. These can now be used as accurate diagnostic markers. This in turn should lead to more appropriate and potentially life-saving treatment. The three genes are subject to a patent based on their use in a diagnostic setting.

The advance that has been achieved is that while traditional statistical analyses used for microarrays can identify significant genes, the resulting list can number 100 or more. All of these genes then have to be biologically validated by the medical researcher to ensure that any genetic effect is real and not an artefact of the microarray platform or processing.

APPLICATION Advanced statistical tools enable researchers to sort genes to isolate those of interest

BENEFIT The technique helps better distinguish brain tumour types, and shows promise in other genetic areas

"The problem is choosing which genes to validate as there is neither the time nor money to validate this many," says CSIRO statistician Maree O'Sullivan.

However, CSIRO's microarray analyses identify a small enough number of potentially significant genes to allow all to be validated in the laboratory. "The advantage is the ability to identify small gene subsets," Ms O'Sullivan says. "It is the genes within these subsets that discriminate the different brain tumours.

"And because our analyses can be applied to any microarray platform, it has also proven valuable in other

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research areas such as agriculture. For example, we are now investigating genetic resistance to amoebic gill disease in Atlantic salmon that costs salmon farmers millions of dollars each year," she says.

In 2007, CSIRO and the Kolling Institute will try to find markers that can predict patient survival, and genetic signatures that will predict how a patient might respond to a particular treatment.

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ARTICLE

WATER:
Designing Greener Pipelines

By David Adams

With increasing concern over water use, scientists are examining how minerals processing pipelines can use less without compromising efficiency

For decades the mining and minerals processing industries have used massive pipeline networks to flush waste materials to disposal sites. But growing pressure on the industry to reduce its water use is leading scientists to look at how the design of pipelines can reduce the amount of water needed to transport waste materials and, at the same time, actually increase the size of material that can be transported.

CSIRO's Dr Murray Rudman is overseeing a three-year research project that aims to improve pipeline design by providing a fundamental understanding of the way in which solutions containing a high concentration of solids flow along them. "Typically, the kind of flows that we're looking at would be used in things like waste disposal in the mining industry – when they've finished processing and want to get rid of the fine particles left after the processing step, and the coarse rock they don't process at all," he says. "We're interested in understanding how these materials flow when you put them down a pipeline."

The latest project, which ends in May, follows an earlier study that found bigger rocks are not suspended in the slurry, even when common wisdom suggests they should be. Using an inclinable pipeline test facility built at the CSIRO Manufacturing and Materials Technology (CMMT) laboratories in Melbourne, the project is focusing on the effect pipes' angles have on the flow of materials. Dr Rudman says such information allows the development of models that can predict how high-concentration materials flow in a pipeline and what sort of 'pressure gradients' are required to ensure the most efficient movement. "That influences the type and size of pumps you'll need, and how much it's going to cost energy-wise and dollar-wise to move this material down the pipeline to a tailings facility or whatever."

Dr Murray Rudman

One of the drivers for the project is the need for water conservation, with Australia, South Africa and many South American countries pushing strongly for greater efficiency in water use. In mining, this often means reducing the amount of water pumped to waste disposal facilities.

"If you can move materials down at a higher concentration there are advantages purely from the point of view of saving water, let alone the reduction in real estate and the deposit's mobility," says Dr Rudman. "That's one of the key motivating factors."

He says there have already been situations where mines have been forced to shut down their plants due to a lack of water, costing mining companies millions of dollars in lost throughput. Although it is understood that most mining operations in Australia pay for water access and consumption, these charges are generally low.

Shortages may eventually result in the introduction of other fees by governments, as has been the case in South Africa, a move that would further increase the need to reduce water use as much as possible.

Reducing the amount of water in solutions deposited at disposal

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facilities can also reduce the potential for damage to the surrounding environment. The danger 'mobile' mine tailings can pose was illustrated in Romania six years ago, when the wall of a disposal dam owned by Australian and Romanian joint venture Aurul broke open, spilling cyanide-tainted water into the Danube river system.

APPLICATION Pipes are being tested to see how angles affect the flow of water and materials

BENEFIT Maximising pipes' efficiency can reduce cost, water use and environmental impact

If low-concentration material is kept at disposal sites, heavy rain can be calamitous because the material becomes 'just like water', Dr Rudman says. In contrast, the higher the concentration of solid material deposited at tailings sites, the less likely the tailings are to flow away from the disposal site and damage the environment.

One of the project's sponsors, global resources company Rio Tinto, has already employed the research results – and in particular the computer modelling software called Pipe Tools, which has been developed out of the project's findings – to address issues at mine sites in Australia, Chile, the US and Canada. Although it has not been the main focus of the research, the project is also looking at 'vertical hoisting' – lifting material vertically out of mines. The project aims to determine whether transporting material in slurries via pipelines is a more economical way of getting mined materials to processing plants on the surface than traditional methods using haulage buckets or trucks.

"Ultimately, it's going to come down to an economic assessment," Dr Rudman says. "There is not going to be a panacea or a catch-all for everything, but there will be some operations where there will be a clear economic benefit in utilising vertical hoisting and others where it will be more beneficial to use conventional methods."

Dr Mark Coghill, principal adviser within Rio Tinto's Operational and Technical Excellence group, says the company plans to use CSIRO's pipe facility in Melbourne to investigate the possibility of using hydraulic conveying to transport ore from mines and for the disposal of coarse and fine tailings.

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ARTICLE

FOOD INDUSTRY: Efficiency Drive

By David Adams

Researchers are looking at ways to smooth the bumps in the road to market for Australia's agrifoods sector

There was a time when the local produce market was in the town square; a straight cart run from farm to the centre of town. Today a lot of farm produce has to be freighted hundreds of kilometres and involves a vast transport, packaging and storage infrastructure.

The paddock-to-plate logistics in this infrastructure are complex, costly and said to be eroding the value of Australia's $110-billion food industry by as much as 35 per cent.

Now, for the first time, a research team from CSIRO is taking a comprehensive look at Australian food industry logistics to gain a clearer understanding of costs and efficiencies, and to develop innovative solutions to keep the industry globally competitive. It is an opportune time to analyse logistics because rising energy costs will require highly efficient and streamlined processes.

Dr Andrew Higgins, Food Futures Flagship project leader, says the research will be looking at factors that affect logistics costs and whether alternative models would lower them. "It's trying to get a better understanding [of food logistics] to give the Australian Government and also researchers a clearer idea of the key opportunities that need to be addressed in the future [as well as] the inefficiencies," he says. "We'll also be looking to identify some key challenges in achieving more efficient logistics, whether they be social challenges, infrastructure challenges or even political challenges."

The Australian Food and Grocery Council's deputy chief executive, Dr David Roberts, says logistics costs need to be minimised for all parties, from producer to consumer. Dr Roberts, who is also a Flagship Advisory Committee member, says: "Competitiveness is affected when goods are moved inefficiently or ineffectively. Understanding the state of logistics in the Australian food industry is a first step to identifying opportunities to increase efficiency."

The $200,000 'State of Logistics' project started in June and is expected to run until February. It is the first project under the direction of the Food Futures Flagship following the theme of improving and integrating the food product value chain.

Dr David Tanner, who is overseeing projects coming under the value chain theme, says the flagship program's overarching goal is to improve the international competitiveness of Australia's agrifood industry. He says one way this can be done is by improving the value chain with innovative technologies and encouraging more integration between stakeholders.

Dr Tanner describes the State of Logistics project as a 'scene setting' study. "It's really providing a conceptual framework," he says. "And from that we will invest in an impact analysis study…all of which improves our understanding of where we can get the best bang for our buck."

The State of Logistics project, which involves researchers and expert input from three CSIRO divisions, including Sustainable Ecosystems, Mathematical and Information Sciences and Food Science Australia, a joint venture of CSIRO and the Victorian Government, will look at logistics in agriculture and horticulture and will centre on a series of four case studies.

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"It makes it more tangible," says Dr Higgins, explaining the reasoning behind the use of case studies. "It's very hard to dive in and look at all industries and all logistics. It's too broad and complex."

The case studies will focus on Australia's mango, wine, field crops – including grains and sugar – and meat industries. Dr Higgins says these four industry areas were chosen because they represent a mixture of 'today and tomorrow industries'. While some industries, like sugar and grains, are established, others like mangoes and wine are still growing. They also provide a wide representation of the types of logistics that take place in Australia's food industries.

APPLICATION A CSIRO research team is studying the efficiency of Australian food industry logistics

BENEFIT Improving efficiency reduces costs and makes Australian produce more competitive

Information for the study is being obtained through CSIRO's industry partners as well as past research. The latter includes results from a recent comprehensive logistics study conducted in South Africa.

Dr Higgins says the final report will look at cost structures behind the logistics, as well as consider the impacts on logistics from different food value chain drivers, such as business practices and storage infrastructure and practices.

He says that the big surprise of the research so far has been the complicated nature of the food logistics industry in Australia. "You can understand why this hasn't been done before," he says. "It's a very complicated area because it's so broad and there are different ways to look at the costs of logistics."

Dr Higgins says the initial study will be the first step in an ongoing study of food logistics. "The first study is to better understand the costs of food logistics in Australia and identify some priority areas for government and funding bodies to provide further research investment. So we see it as the first step to much bigger analysis and much bigger investment to achieve change to logistics and practice."

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