INSTITUTES IN ACTION

THE UNIVERSITY OF MELBOURNE

Research Institutes

A Global Research Powerhouse

Contents

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Cover depicts Newton's eggs cradle and the concept of 'action-reaction'.

Further information about the institutes can be found at:
www.ri.unimelb.edu.au
www.ni.unimelb.edu.au
www.bio21.unimelb.edu.au
www.melbourneinstitute.com

Foreword

The University of Melbourne aspires to being a publicly spirited institution. What does this mean in terms of its research agenda? One answer lies in harnessing the University's great research strengths in pursuit of pressing societal problems.

To facilitate this, the University has established the Melbourne Research Institutes to complement its already established research centres and institutes. There are currently five University-level interdisciplinary Melbourne Research Institutes: Melbourne Energy Institute; Melbourne Materials Institute; Melbourne Neuroscience Institute; Melbourne Sustainable Society Institute; and the Institute for a Broadband-Enabled Society. The intent is to develop a portfolio of eight to ten Melbourne Research Institutes that exemplify the breadth of the University's research activity without attempting to cover all University research strengths. Unlike the long-established institutes, such as Bio21, the Nossal Institute for Global Health and the Melbourne Institute of Applied Economic and Social Research, the Melbourne Research Institutes are sometimes referred to as 'virtual institutes' as they do not employ staff directly, and they do not have dedicated locations (other than the office of the Director and support staff).

The Institutes provide powerful ways of articulating our research to the external world. The University of Melbourne is a large and complex organisation, and it can be a challenge for us to explain what we do and for others to find avenues to access our expertise. The Institutes enhance the research profile of the University, seek significant new partnerships and increase the University's responsiveness to external priorities.

From left to right: Professor Steven Prawer, Melbourne Materials Institute Director; Professor Craig Pearson, Melbourne Sustainable Society Institute Director; Professor Mike Sandiford, Melbourne Energy Institute Director; Professor Trevor Kilpatrick, Melbourne Neuroscience Institute Director; Professor Liz Sonenberg Pro Vice-Chancellor (Research Collaboration); Laureate Professor Rod Tucker, Institute for a Broadband-Enabled Society Director.

The Institutes help make connections where none exist, enhance fledgling connections, support already valuable connections, and provide University leadership and coordination when responding to challenges that draw on research expertise from across the University.

The Melbourne Research Institutes complement and enhance the ongoing research efforts of faculties. University investment in the Melbourne Research Institutes supports the Director and seeds collaboration enabling activities.

All staff on Institute-aligned projects are employed through faculties and are expected to contribute to the discipline depth and strategic directions of their faculty. Research income generated via Institute projects flows back to the relevant faculties.

This inaugural edition of *Institutes in Action* celebrates the key achievements of the Melbourne Research Institutes as well as Bio21, the Nossal Institute for Global Health, and the Melbourne Institute of Applied Economic and Social Research.

The Bio21 Institute, established in 2005, is a multidisciplinary research centre specialising in medical, agricultural and environmental biotechnology.

The Nossal Institute for Global Health, established in 2006 and named in honour of Professor Emeritus Sir Gustav Nossal, works with partners locally and internationally to generate knowledge and translate it into policies for the improvement of health in areas of greatest need.

The Melbourne Institute of Applied Economic and Social Research, established in 1962, enhances the wellbeing of all Australians through its sustained contribution to economic and social policy development.

In the pages ahead I invite you to observe how we at the University of Melbourne, through our Institutes, have been engaging with some of the major challenges facing the world today.

Professor Liz Sonenberg
Pro Vice-Chancellor (Research Collaboration)

Planting the seed

Interact 2010

The Interact 2010 showcase consisted of 24 projects supported by Melbourne Research through the Interdisciplinary Seed Funding Grants scheme offered for the first time in 2010. Each project is consistent with the broad research objectives of one or more of the Melbourne Research Institutes or designated emerging areas of focus. Together these 24 projects involve over 100 contributing researchers.

FOCUS AREA KEY, PAGES 3 & 4:

MNI Melbourne Neurosciences Institute
MEI Melbourne Energy Institute
MSSI Melbourne Sustainable Society Institute
IBES Institute for a Broadband-Enabled Society
Bio21 Bio21 Institute
MMI Melbourne Materials Institute
SE Social Equity
VLSCI Victorian Life Sciences Computation Initiative

A snapshot of the research is provided below. For full details of all projects and contributing researchers see: www.research.unimelb.edu.au/rgc/grants/find/schemes/uom/idseed/interact2010

Health

Membrane recognition of antimicrobial peptides (Bio21)

SNAPSHOT:
In the face of increasing clinical resistance to existing antibiotics, antimicrobial peptides (AMPs) are seen as a source of new antibiotics. Bio21 has characterised the structure and activity of several AMPs from the skin glands of Australian amphibians.

AMPs satisfy two primary design principles for development of successful antimicrobial agents: a limited capacity of the microbial targets to acquire and spread resistance; and non-toxicity toward the host cell at concentrations lethal for the target. We are studying the activity of AMPs *in situ* to determine what are the bacterial membrane features required for AMPs to specifically kill pathogenic bacteria.

Nanoparticle mucosal vaccines (MNI)

SNAPSHOT:
Periodontitis is a pathogen-associated inflammatory mucosal disease leading to the destruction of the tooth's supporting tissues and ultimately to tooth loss. The disease is a major public health problem in all societies and has been linked with cardiovascular diseases and certain cancers. It is estimated to affect at least 30 per cent of the adult dentate population, with severe forms affecting up to 15 per cent.

This project aims to combine the nanoparticle, vaccine and mucosal immunology knowledge of the Melbourne Dental School (MDS) and the Department of Chemical and Biomolecular Engineering (CBE) to construct and formulate novel protein/peptide nanoparticle vaccines that (i) induce an antigen specific immune response after mucosal administration; and (ii) provide protection against the bacterial-induced oral disease chronic periodontitis.

Environment

Rapid environmental detection of legionella (MMI)

SNAPSHOT:
Legionnaires' disease is a life-threatening form of acute pneumonia caused by inhaling the environmental bacterium, Legionella. Identification of Legionella in contaminated water relies on bacteriological culture, which is not only slow but also insensitive.

The broad aim of this interdisciplinary project is to develop an *in situ* test for the rapid detection of live Legionella in water, based on detecting the activity of the major Legionella-secreted protease. The specific aims of this project are to identify peptide sequences cleaved by the protease and to develop a polymer film/matrix system to detect protease activity. Ultimately the aim is to build the detection polymer into a filter-based system for on-site detection of live Legionella in water samples.

Limits of resilience: integrating empirical research with theory (MSSI)

SNAPSHOT:
Resilience is a concept used widely in both the ecological and social sciences, and, although the respective meanings differ widely, common to both fields is a lack of evidence about the characteristics of systems that make them resilient. Drawing these two diverse fields together into a collective endeavour requires an understanding and respect for the ontological and epistemological bases of the ecological and social sciences.

This project will investigate the linkages between the theory of resilience and its empirical basis in each discipline. The aim is to develop an approach to studying resilience that can produce meaningful insights when applied to both ecological and social systems.

Research Institutes
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Technology

Chemical, biological and quantum optical approaches for interfacing with neuronal cultures and brain slices (MNI, MMI, VLSCI)

SNAPSHOT:
During the past century brain research has relied on metal electrodes to capture the local electrical activity of the brain and its neurons. Unfortunately, such electrodes do not work in the appropriate time and space scales needed for detailed understanding of neural networks. To overcome this limitation, this project will exploit radical research spearheaded by physicist Professor Lloyd Hollenberg at the Centre for Quantum Computer Technology.

The new method will rely on nanoscale quantum sensing by special diamond crystals to transduce cellular electrical activity into a readily observable optical readout. Successful deployment will significantly enhance our ability to understand brain function in both health and disease.

Multi-spectral adaptive optics retinal imaging using super-continuum laser light and novel nanocrystalline materials (MNI, MMI, Bio21)

SNAPSHOT:
Super-continuum laser light is now an affordable reality. Picosecond pulses of high energy infra-red laser light are passed through specially designed photonic crystal fibre to produce bright 'white' light spanning the visible spectrum to the far infra-red (450–2400 nm).

This project unites hitherto disparate groups across the University in a collaborative effort to improve our understanding of basic biochemical and neurophysiological processes of vision and address issues of significant and broad societal import including failing eyesight due to neurological and vascular retinal disease.

Society

Mobile and broadband technologies for ameliorating social isolation in older people (IBES)

SNAPSHOT:
Social isolation is not limited to old age, but it is exacerbated by it. Growing old makes people more vulnerable to diminished social networks, bereavement, and health problems, all of which contribute to social isolation. While the incidence of social isolation is growing, so too is the use of broadband by older Australians. This project aims to investigate the use of mobile and broadband technologies that can ameliorate the social isolation of older people.

The project will draw upon knowledge about older people and knowledge about the design of interactive technologies to build a prototype that addresses key aspects of social isolation. The prototype will be tested with a small group of older people.

Living poor in contemporary Australia: the social recognition of poverty and disadvantaged neighbourhoods (SE)

SNAPSHOT:
Dominant approaches to research and practice that focus on individual-level inequalities and risk factors also reinforce stigmatising images that are already associated with socioeconomic disadvantage and, largely unintentionally, contribute to the reproduction of the conditions in which inequalities are generated, and risk further stigmatising and marginalising those experiencing disadvantage.

There is an urgent need to develop improved theoretical frameworks that account for the transforming conditions in which poverty, socioeconomic disadvantage and inequalities are generated. The pilot project will translate these theoretical issues for an empirical study; it will inform the development of a program of innovative cross-disciplinary research that seeks to develop new ways of understanding and responding to contemporary and complex conditions of social inequality in post-industrial Australia.

Inspiring the next generation

Australia's biotechnology sector is a vibrant community of dedicated and passionate scientists.

However, its future growth and sustainability depends on our ability to attract the brightest young minds into science and engineering, and this will require a transformation at the most fundamental level.

The 'Science Sub-School' is a new education initiative announced by the Victorian Government which brings together a unique and innovative approach to science education and the interaction between the secondary school and university.

Purpose-built science teaching and learning facilities will connect science teachers and students to the science and research community and industry, enabling developments in science to be seamlessly integrated into the education system. In addition Master of Teaching students will also be co-located to support the development of teacher training.

"The Bio21 Institute has a vision to develop a unique 'school-to-bench-to-workplace' environment, bringing together school, research and industry," explains Bio21 Institute Director, Professor Tony Bacic.

"By establishing the Science Sub-School, we are taking the first steps in the continuum, with the aim of transforming the science education experience and increasing the number and quality of people in science."

The initiative is a collaboration between the Bio21 Institute and the University of Melbourne Faculties of Education; Science; Engineering; Medicine, Dentistry & Health Sciences; and Veterinary Science; the Melbourne School of Land & Environment; the Victorian Government Department of Education and Early Childhood Development; University High School; and Debney Park Secondary College.

The Science Sub-School will be co-located alongside the Bio21 Institute on the grounds of the University of Melbourne's Western Precinct, adjacent to University High School, in the heart of the Parkville Precinct.

"The benefits of co-location provide an opportunity to develop programs that will expose students and their teachers to cutting-edge scientific research and innovation, technology platforms and world-class expertise," says Professor Bacic.

Programs will be designed to support advancements in the development and delivery of the science curriculum and will be supported by robust pedagogical research by the Melbourne Graduate School of Education.

The importance of inspiring and nurturing students via mentors is also a critical element of the program.

"Developing enduring mentoring relationships with a scientist will increase the likelihood that students will continue in a career in science," says Professor Bacic.

In addition to students' access to scientists, the Science Sub-School will have access to leading-edge facilities within state-of-the-art dedicated classrooms and exposure to an environment that inspires interest in science among school-age students.

"The Science Sub-School will provide broad community benefit, transforming the future of science education that ultimately underpins our approach to science innovation and the sustainability of our industry," says Professor Bacic.

For further information
www.bio21.unimelb.edu.au

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A global health initiative in India

The Nossal Institute has an established presence in India, with substantial growth in its program in the past decade.

Importantly, the Nossal Institute provides a legal presence with a registered branch office in New Delhi. Current work supported by the Bill and Melinda Gates Foundation includes a 10-year program in partnership with the Emmanuel Hospital Association addressing the challenges of the HIV/AIDS epidemic in northeast India and researching its social impact.

The partnership with the Public Health Foundation of India (PHFI) is expressed specifically through support to one of its eight Indian Institutes of Public Health (IIPH), IIPH-New Delhi.

The Nossal Institute provided a fee remission scholarship to IIPH-New Delhi to support its future faculty program and thereafter secured Australian Government support to assist IIPH-New Delhi to develop a centre for higher education as it gears up to offer its own graduate studies program in 2011. This initiative will greatly contribute to the accelerated development of a qualified public health workforce to meet the needs of India.

More recently, on behalf of the University of Melbourne and in collaboration with the Australia India Institute, the Nossal Institute has initiated a program in urban health and equity in partnership with the ASHA Project, New Delhi.

Today one billion people live in urban slums, where the consequences of poverty and ill health are magnified by overcrowding, social unrest, mental illness, and outbreaks of disease. The ASHA Project is one of the few examples of successful urban development at significant scale.


PHOTO: KATHRYN HOWDEN

Established by Dr Kiran Martin in Delhi more than 20 years ago, it has improved the lives and health of 400,000 people by addressing health and its broader determinants and now provides a model for the Government of India to expand its impact across the burgeoning cities of India.

At the invitation of the ASHA Project the Nossal Institute will engage in a multidisciplinary partnership to support and critically evaluate the ASHA's success to inform this expansion, this will engage senior academics across the University.

Research will focus on the social determinants that impact vulnerable and poor communities within Delhi and evaluate the health impact resulting from the multidisciplinary interventions of the ASHA model.

The findings will influence a multi-year prospective investigation of the implementation of the ASHA model in new slum settlements to study the impact of the early introduction of all major elements of the model on the scale, pace and nature of community development.

For further information
www.ni.unimelb.edu.au

THE UNIVERSITY OF MELBOURNE

THE NOSSAL INSTITUTE FOR GLOBAL HEALTH

Female GPs earn 25 per cent less than male counterparts

Female GPs earn an average 25 per cent less than their male counterparts, according to the first study into doctors' earnings released recently by the Melbourne Institute and Monash University.

The surprise finding reveals that the gender income gap is greater for those at the front line of the medical profession than it is for all of the nation's full-time adult workers, where average total earnings for women are 20.7 per cent lower than men according to the latest figures from the Australian Bureau of Statistics.

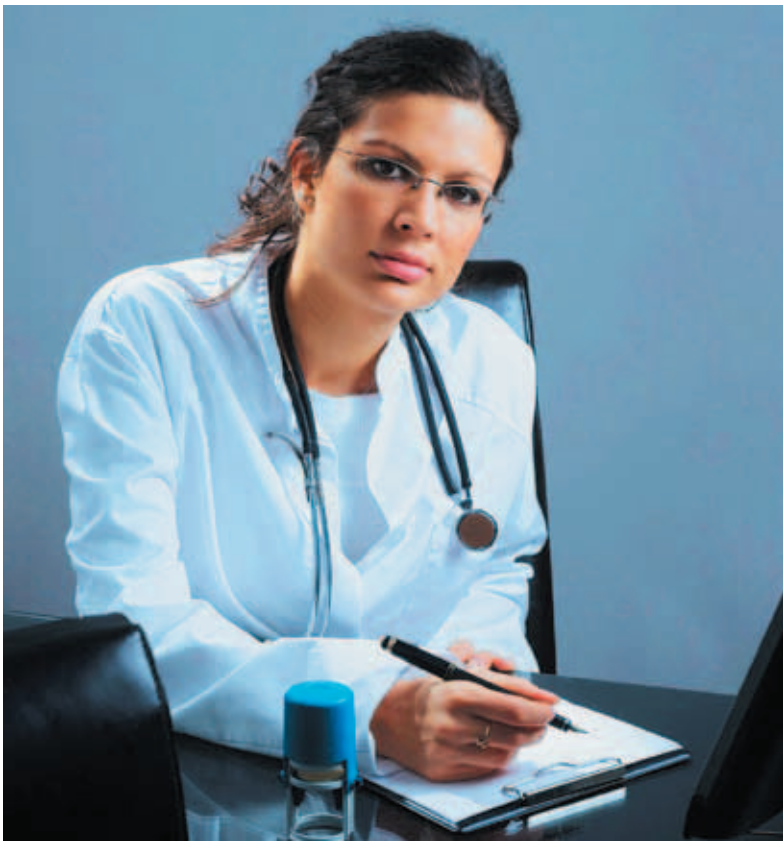
"This is something of a mystery," says Professor Tony Scott, principal investigator for the research project. "While such differences persist in other occupations, this is particularly difficult to understand in an occupation where men and women have the same high level of education."

"Our results have adjusted for differences in hours worked, years of experience, and a host of other factors. It could be that female doctors see a different mix of patients than male doctors. We are puzzled and are continuing to look into this."

The study also found that female specialists were at an earnings disadvantage when compared with males, but the difference was smaller at 16.6 per cent.

The main findings show that the average annual pre-tax personal earnings of GPs and specialists were $177,883 and $316,570 respectively. This was based on the responses of 2,619 GPs and 3,018 specialists. They include salaried GPs, and specialists working in both the public and private sectors. Females comprised 44.4 per cent of GPs and 27.5 per cent of specialists. The average weekly hours worked were 39.4 for GPs and 45.1 for specialists, and both worked on average 51.6 weeks each year.

The groundbreaking paper – *What Factors Influence the Earnings of GPs and Medical Specialists in Australia?* – is based on analysis of data collected through a comprehensive national longitudinal survey of doctors called *Medicine in Australia: Balancing Employment and Life* (MABEL). Responses were received from 10,498 doctors. The Wave 1 of the MABEL survey was undertaken between June and December 2008, and the Wave 3 survey has just been sent out. Other results from MABEL are available on the website www.mabel.org.au



The study was undertaken to provide detailed empirical research on the factors that determine doctors' earnings because of the important role that earnings have in influencing the overall cost of health care, decisions on workforce participation and labour supply.

Other highlights of the study were that country doctors earned 11.5 per cent more than GPs in major cities, despite the fact that there was often a doctor shortage in those areas. It was also found that GPs on average earned 31.7 per cent less than specialists.

For further information www.melbourneinstitute.com

MELBOURNE INSTITUTE®
of Applied Economic and Social Research

Energy

“How much can we reduce carbon emissions while we still provide enough energy for people?”

PHOTO: FRED KOW

MUREIL: the future of energy

In Australia, per capita carbon emissions are the highest in the world because we use a lot of energy, and our electrical energy production is very carbon-intensive.

"We're running at over 20 tonnes of carbon dioxide per person, compared with a global average of five tonnes," says climate change, carbon cycle and energy analyst, Dr Roger Dargaville (pictured left).

"We need to reduce that global average by about 50 per cent by 2050 if we want to avoid the two degree climate warming projected by the Intergovernmental Panel on Climate Change (IPCC)," he explains.

"So that's a global average of two-and-a-half tonnes per person by 2050. For Australia we would need to reduce our emissions by about 90 per cent to meet that target.

"That's a massive challenge."

Dr Dargaville leads the Melbourne Energy Institute's (MEI) Energy Futures Group, a group of active researchers with interests in energy technologies and the economic and legal aspects of the energy system.

One of his current research themes is modelling of energy systems, looking particularly at optimisation of renewable energy systems under Australian conditions.

This work will help find ways to achieve the maximum reduction in carbon emissions at the lowest cost, and will reduce uncertainty in renewable energy output estimations. Researchers are working to build the computer modelling tools necessary to deliver advice on the optimal network design.

"We need to start reducing our emissions very quickly to have any chance of hitting the 2050 reduction target," says Dr Dargaville.

The model that Dr Dargaville and his team are working on is called the Melbourne University Renewable Energy Integration Laboratory or MUREIL. Its goal is to look at how to design a system of renewable energy made up of wind, solar and other technologies that gives the best mix, because every renewable energy technology has a different characteristic.

Solar will produce energy during the day, wind will produce it during windy periods, geothermal can produce base load, while tidal is far more predictable than wind but tends to be more expensive.

"You have all these different characteristics with different costs, and also the geographical placement of your energy technology stations greatly impacts when and how much power they can produce," says Dr Dargaville.

"The logic is that we're trying to work out what is the optimal mix of wind and solar, and where do you put them?

"How does that interact with demand?

"We have our highest demand during the day, and solar is able to produce highest supply during the day so that's an obvious marriage.

"But then solar can't produce power at night.

"Wind does but of course it's not always blowing.

"The question is what mix of those two is optimal."

The electricity market is highly variable with prices fluctuating between $0 and $10,000 a MWh when demand peaks (the average is around $50 a MWh), meaning the economic viability is not simply proportional to the amount of power produced, but also the value of the power at the time it is produced.

The way in which electricity is moved around the country also needs to be considered given the high cost of power transmission lines.

Combining models of the weather, demand, economics and transmission allows a comprehensive view of the energy system.

"The question is how much can we reduce carbon emissions while we still provide enough energy for people," says Dr Dargaville.

"It's a decoupling of the carbon industry from the economy," he explains.

"We can still very happily produce enough energy for everybody even in a growing population, but by moving away from heavily polluting fossil fuel technologies for producing our electricity we can produce the energy without the carbon emissions."

Dr Dargaville is a research fellow with Federation Fellow Professor David Karoly in the School of Earth Sciences.

He completed his PhD at the University of Melbourne, and has worked at the University of Alaska, Fairbanks; National Center for Atmospheric Research in the USA; CNRS; UNESCO; and the International Energy Agency in France.

For further information
www.energy.unimelb.edu.au

ENERGY
Research Institute

Energy Futures seminar series

The Energy Futures public seminar series provides a forum for industry leaders, decision makers and the general public to learn about current research in energy-related issues.

The seminars proceed with panel presentations, followed by mediated discussion. This format gives audiences a broad insight into the impact that current research might have on Australia's energy future, as well as an opportunity to have their own questions and input considered.

The seminars have brought together experts from diverse research areas to explore the topics of carbon trading, integrating the grid, renewable energy, cities in a low carbon future, and nuclear power in Australia.

At the Future of Carbon Trading seminar the University of Melbourne's Vice-Chancellor's Fellow and Professor of Economics, Ross Garnaut, presented his latest research on carbon trading, including an outlook for a carbon trading scheme and what it would mean for Australian business, individuals and contributions to greenhouse gas emissions.

The public response to the seminars has been excellent, with large numbers attending each event. The Future of Renewable Energy in Australia seminar demonstrated the extraordinary interest in this field, with The Spot (Economics) filled to capacity, as industry experts and researchers provided valuable insights into the potential of renewable technologies in Australia. The seminar went some way to breaking down commonly held myths about renewable energy, showing how solar power with storage can meet the nation's power demand, both day and night.

At this seminar, John Daley, CEO of the Grattan Institute, proposed that the single greatest challenge facing renewable energy scale-up is the human barrier: "To ask people to spend a lot of money up front to get a return in the future is psychologically one of the hardest decisions you can ask anyone to make."

The seminars were chaired by prominent members of Australia's media community. ABC Radio's Robin Williams and Peter Mares, *Lateline's* Quentin Dempster, and *The Age's* environment writer, Adam Morton, have each provided stimulating leadership at these events.

Audio recordings of all seminars are available at the Energy Institute website see: http://energy.unimelb.edu.au/index.php?page=energy-futures-seminar-series-2010

Australian Sustainable Energy publication series

In 2010 the Melbourne Energy Institute released two 'energy roadmaps' through its Australian Sustainable Energy publication series.

The Institute's first publication, *Australian Sustainable Energy – By the Numbers*, was written by Melbourne Energy Institute Honorary Professor Peter Seligman, and inspired by David MacKay's *Sustainable Energy–Without the Hot Air*. It provides a clear account of Australia's renewable energy potential as well as a blueprint for a nationwide renewable energy system based on the most efficient mix of technological, societal and habitual changes.

Australia Sustainable Energy – By the Numbers shows that, unlike many countries, Australia could comfortably supply all of its energy requirements from renewable resources including solar, wind and geothermal energy, backed by pumped hydro storage systems.

Dr Seligman also identifies situations in which energy efficiency measures represent a cheaper option in terms of immediate cost of abatement, and quantifies these strategies accordingly.

The second Melbourne Energy Institute publication was the *Zero Carbon Australia Stationary Energy Plan* – the first report in a bold collaborative project that maps a national-scale transformation to 100 per cent renewable energy.

The Stationary Energy Plan confirms not only the technical feasibility of achieving 100 per cent renewable energy in Australia, but presents a strategy for achieving it without sacrificing any of the benefits of our present energy system.

The Plan shows that provision of baseload power through renewable sources can be achieved through solar thermal technologies that include molten-salt storage. Industrial-scale solar power plants, like those currently operating overseas in Spain and the US, would replace baseload power currently sourced from fossil fuels, with a significant contribution also from wind power.

The Plan has prompted considerable public engagement, and recently was awarded a Banksia Prize (Mercedes-Benz Australian Environmental Research Award). The Zero Carbon Australia Project is an ongoing research collaboration between the climate change think tank Beyond Zero Emissions and the Melbourne Energy Institute.

Carbon Capture and Storage Flagships Program

The CO2CRC is a collaboration between universities, industry and federal and state governments, conducting research into carbon capture and storage (CCS). The CO2CRC is seeking new and efficient ways to capture CO2 from fossil fuel power plants, and to transport and safely store the CO2 in geological reservoirs.

The University of Melbourne leads the CO2 capture research within the CO2CRC, with the research teams led by the Melbourne Energy Institute Deputy Director Associate Professor Sandra Kentish and Professor Geoff Stevens.

The success of recent proposals submitted to the Australian Government's CCS Flagships program and the Australian Government Education Investment Fund (EIF) will allow the University to further establish its research profile in this area, facilitated by the movement of a number of key researchers from the CO2CRC organisation onto the University site. New laboratory facilities will allow the University to cement its world-leading research in this field.

The CCS Flagships program is designed to accelerate the development and demonstration of CCS technologies. The program aims to promote the wider dissemination of CCS technologies by supporting a small number of demonstration projects that capture CO2 emissions from industrial processes and safely store CO2 underground in stable geological formations to mitigate global warming.

If the Flagship proposal is successful it will lead to the construction of CarbonNet, a multi-user capture, transport and storage infrastructure project in the Latrobe Valley. CarbonNet aims to capture between three and five Mt of CO2 per annum from a number of high emissions sources and transport the gas via common user infrastructure for storage in suitable geological formations. The proposal has been shortlisted by the Federal Minister for Resources, Energy and Tourism.

The University of Melbourne has provided input to an EIF bid led by the CO2CRC to access research infrastructure funding. If successful, this will provide high quality chemical engineering and geological/petrophysical laboratory space at the University to support CarbonNet research. EIF funds will also be directed to improving existing pilot-scale capture facilities within the Latrobe Valley and to drilling a new experimental well for carbon storage research.

Energy in East Timor

Responding to climate change while providing for growing energy needs is a core policy challenge for countries in the Asia-Pacific region.

In the rugged mountainous areas of East Timor where the majority of the population lives, only five per cent of households are connected to the electricity grid. Those that are connected face inordinate prices. Retail electricity prices in East Timor are broadly similar to Australian prices despite per capita GDP being 100 times lower.

There is a clear need for the construction of reliable and affordable energy infrastructure in regional East Timor. But with energy infrastructure contributing substantially to greenhouse gas emissions, the potential impact on climate change must be carefully considered. This is especially so given that many developing countries in the Asia-Pacific region are particularly vulnerable to the impacts of climate change.

On the other hand, demanding that the energy needs are met through the construction of sustainable infrastructure may increase the cost of providing for the energy needs of people in developing countries, potentially pricing energy beyond their means. This raises the question of how these additional costs are to be distributed in and between developed and developing countries and what the role of intellectual and technology transfers ought to be.

In response to these challenges, the Melbourne Energy Institute East Timor research project will analyse the energy needs of people living in East Timor's rural region Ainaro, including a survey of the opportunities available in the region for utilising sustainable generation and transmission infrastructure, including the use of distributed systems.

The project will also study the environmental impacts and costs of alternative models of electricity generation and transmission infrastructure suited to rural areas of East Timor, and study the existing regulatory framework governing access to energy in East Timor and the equity challenges facing this framework.

In the context of a global response to climate change the project will also explore how the costs of providing sustainable energy infrastructure and securing universal access to energy ought to be distributed equitably in and between developed and developing countries.

While the project focuses on East Timor, it has wider significance because the technological and policy challenges facing the provision of energy infrastructure in regional East Timor are similar to those faced by many other developing countries in the Asia-Pacific. The analysis of the role of developed countries in contributing to mitigation efforts in East Timor also has wide applicability to the global debate concerning socially just responses to climate change.

Materials

“The force between bubbles during collision was previously too small to measure.”

PHOTO: FRED KOHN

The delicate science of bubbles

The mystery surrounding what happens when bubbles collide has finally been busted. And knowing how bubbles bounce apart and fuse together could improve the quality of ice-cream and champagne as well as increase efficiency in the mining industry.

In research led by the University of Melbourne, and published recently in the Proceedings of the National Academy of Sciences (PNAS), a team of chemical engineers, chemists and mathematicians have united to measure the force between bubbles during a collision.

Associate Professor Raymond Dagastine from the Particulate Fluids Processing Centre (PFPC) in the Department of Chemical and Biomolecular Engineering at the University of Melbourne says knowledge of how bubbles move and collide will impact numerous industries.

"By understanding how bubbles bounce off each other and mould together, we will be able to improve things like the stability of ice-cream and the stability of bubbles in champagne. The findings could also be used to improve water waste treatment, and increase efficiency in the mining industry," says Associate Professor Dagastine (pictured left), who is also an ARC Future Fellow, and a researcher with the Melbourne Materials Institute.

The force between bubbles during collision was previously too small to measure, however thanks to advances in technology such as nano-fabrication facilities and the Atomic Force Microscope, the team was able to study bubbles colliding at various speeds.

Associate Professor Dagastine's focus area of research is colloid and interfacial science. He has long been interested in understanding how the interactions on the nanoscale between objects (particles, droplets, bubbles and other soft matter materials) mediate or control behaviour on the macroscopic scale in complex fluids (e.g. emulsions, foams and particle suspensions).

This area of research focus has a direct impact on a large range of applications such as microfluidics, mineral and pharmaceutical processing, and product formulation in personal care products, pesticides and foods. The importance of interfacial interactions is exemplified in the broad scope of areas that are unified by their similarities on the nanoscale.

"In many established Australian industry sectors such as pharmaceutical formulations, dairy products and food processing, as well as in the growing high-value sectors of biotechnology and nanotechnology, a key step is the processing and control of emulsion and foams," says Associate Professor Dagastine.

"Emulsions are basically droplets of one liquid dispersed in another liquid and they feature in everyday items such as salad dressing, milk and shampoo, as well as industrial processes such as solvent extraction used for pharmaceutical purification," he explains.

"Equally, foams, or mixtures of bubbles in liquids, form the core in everyday products such as ice-cream, as well as in minerals processing."

In both foams and emulsions, droplets and bubbles are dynamic in nature as they move through the suspending liquid and collide with each other.

During collisions, the droplets or bubbles may bounce off each other so the emulsion or foam remains stable and retains its desired properties. Alternatively, the droplets or bubbles may collide and coalesce, resulting in an unstable emulsion or foam.

In everyday products, stability is commonly desired – one does not want a shampoo that separates into oil and water – but in many industrial processing situations, one may want a stable emulsion or foam during one stage in a process but may subsequently need to destabilise it in a controlled manner.

The objective of Associate Professor Dagastine's research is to develop nanoscale experiments and theories to measure and predict the interactions between droplets and bubbles that underpin the innovative applications of foams and emulsions.

The project includes researchers from the PFPC at the University of Melbourne including Professor Derek Chan from the Department of Mathematics and Statistics; Professor Franz Grieser from the School of Chemistry; and Professor Geoffrey Stevens, another chemical engineer; and international links to three research institutes in Singapore – IMRE, IHPC and ICES.

"We had chemists, chemical engineers and mathematicians all working together, because not only did we have to figure out how to hold and push two tiny droplets together, and how to measure their interaction, but we also needed to interpret the information we collected."

"This was a truly multidisciplinary effort," says Associate Professor Dagastine.

For further information
www.materials.unimelb.edu.au

MATERIALS
Research Institute

PHOTO: PETER CASMENTO

Defensive science

The Melbourne Materials Institute (MMI) has launched the Defence Science Institute (DSI), the new strategic partnership established between the University of Melbourne and the Defence Science and Technology Organisation (DSTO), to tackle the complex challenges faced by the Australian Defence Force (ADF).

"This latest initiative will use cross-disciplinary research to find innovative responses to both current and future challenges so that when the time comes, the DSTO will be able to deploy these technologies in the field for maximum impact and benefit," says Professor Steven Prawer, Director of the MMI and the interim Director of the DSI (pictured above).

"How do you present information to a commander in an optimal way to enable him or her to take the best decision possible in the heat of battle? Could we train a computer system to scan a scene and report to a commander that something was out of place, not quite right, that might alert him to a lurking danger? Could we equip surveillance drones with radars and smart systems to enable them to avoid collisions in a crowded airspace and operate semi-autonomously? These problems are big and complex, but solving them is vital," says Professor Prawer.

The DSI will initially bring together researchers from Bio21, the Parkville Neurosciences Facility, the DSTO, National ICT Australia (NICTA), other Victorian universities and industry partners to work towards futureproofing the nation's defence sciences.

"We welcome participation of other universities, small and medium enterprises, defence primes and others who share our vision and progress through partnership for the betterment of Australian defence," adds Professor Prawer.

Initial research will focus on:

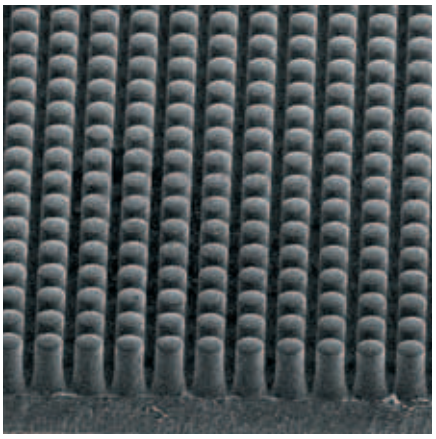
+ biological systems, including how to prepare for and recover from biological and chemical attack
+ human protection and performance, including the use of advanced imaging tools to study and mitigate neuro-trauma
+ the study of active materials, or smart materials that change their properties in response to changing environments
+ energy systems that will develop battery technology and renewable energy sources
+ micro-radars for use in unmanned aircraft and submersibles
+ intelligent information systems, including how to best manage and present the huge quantities of data bombarding commanders so they can make the best possible decisions in the heat of battle.

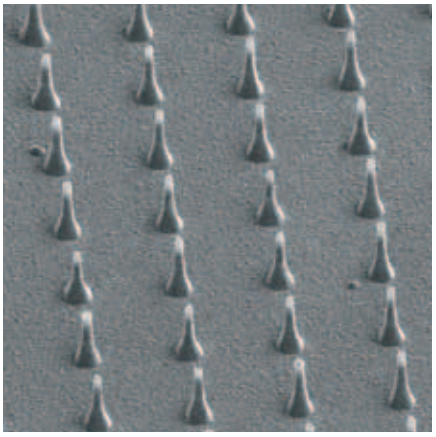
The University of Melbourne's Deputy Vice-Chancellor for Research, Professor Peter Rathjen, says: "Partnerships are core to the University of Melbourne's Research Institutes. The close relationship between the University of Melbourne and DSTO has been made possible by the Melbourne Materials Institute and the leadership and commitment of the MMI Director, Professor Steven Prawer".

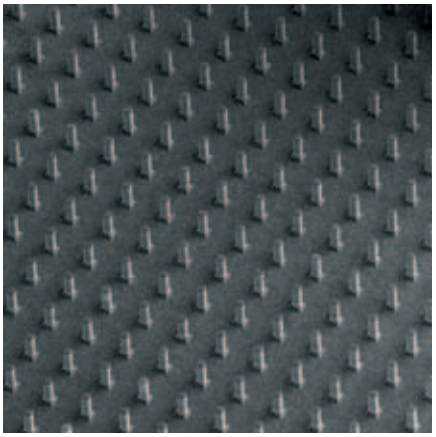
Professor Prawer explains: "The partnership has now turned from an idea into reality. The DSI is open for business, and it will be an exciting and important adventure."

A sparkle in the eye

People with degenerative or inherited retinal disease may have their sense of vision restored, thanks to the latest success at Melbourne Materials Institute (MMI) in achieving excellent preliminary results that indicate material biocompatibility with boron-doped diamonds. The MMI has also developed the first prototype of all-diamond electrode arrays using nitrogen-doped diamond.







This groundbreaking study is part of the collaborative Bionic Vision Australia project to develop a retinal prosthesis, or bionic eye, capable of restoring the sense of vision to people with vision impairment. This has recently been made a national priority by the Federal Government and the Australian Research Council.

"MMI offers cutting-edge diamond technology to deliver light signals to the brain, which will be instrumental in the bionic eye prosthesis and the next generation of bionic devices," says Professor Steven Prawer, Director of the MMI.

Bringing together world-leading research organisations such as the Bionic Ear Institute, the Centre for Eye Research Australia, NICTA, the Centre for Nanoscience and Nanotechnology based at the University of Melbourne, and the University of New South Wales, MMI offers novel materials processing.

"Diamond has an outstanding reputation for being chemically inert and uniquely biocompatible, and MMI has the world-class expertise in how to optimise this diamond interface for effective development of a functioning retinal prosthesis," Professor Prawer says.

"The development of new biocompatible materials will ensure that our device can safely stay in a patient over many years. The diamond coating on the implantable chip will not only deliver electrical stimulation to the light-sensitive cells in the eye, but also create a protective barrier between the electronics and the patient's body," Professor Anthony Burkitt, Director of Bionic Vision Australia says.

MMI will create a suitable coating for the microchip that will ensure its longevity and safety once implanted into the retina.

"We have successfully fabricated an all-diamond conducting penetrating electrodes array and this device is currently being tested," says Dr Kumar Ganesan, a Research Fellow at the School of Physics.

"The next step is to test whether the retina can be stimulated electrically in a safe way," says Dr Hamish Meffin, a Senior Research at the National Information & Communication Technology Australia (NICTA).

This will be a key milestone in preparing for pre-clinical and clinical tests to be submitted to the US Food and Drug Administration and the Therapeutic Goods Administration of Australia.

The bionic eye project aims to deliver improved quality of life for patients by enabling them to distinguish light from dark and regain their mobility, independence and functioning central vision.

Generous MMI and CSIRO postgraduate scholarships

The best and brightest students are invited to embark upon interdisciplinary research in materials science and work alongside leading experts at the CSIRO and the University of Melbourne.

The Melbourne Materials Institute (MMI) in partnership with the CSIRO will offer six competitive tax-free PhD scholarships of $30,000 p.a. and fee remission for the duration of three-and-a-half years to outstanding local and international students pursuing doctorate research in materials science from January 2011.

"This unique opportunity allows prospective students to not only join research teams conducting cutting-edge materials science research, but also access the rich networks and cutting-edge facilities of the University of Melbourne and the CSIRO across the nation," Professor Prawer says.

Under this innovative scheme, the successful applicants are invited to solve major national and global challenges in areas such as health, energy, water, transport and communications by partaking in sophisticated scientific dialogue among leading established researchers, industries and the government linked through the MMI and the CSIRO Division of Materials Science and Engineering.

"This program supports PhD candidates to embark upon research in areas related to the joint objectives of the MMI and the CSIRO, with an emphasis on working at the interface between biology, chemistry and physics within an engineering framework and a focus on nano-medicine, energy, quantum technology and photonics," explains Professor Prawer.

"We facilitate dynamic knowledge transfer not only across various disciplines in sciences and major sectors, but also to the brightest young minds of the next generation so the fundamental advances in materials sciences will continue to progress in the future," says Professor Prawer.

Under the scholarship program, the MMI and the CSIRO will match the research interests and skills of prospective students with their supervisors. This is unlike the conventional PhD scholarship application, which requires the prospective students to decide on the supervisors and research project prior to application.

"This is a rare and precious opportunity," says Professor Prawer.

"From the very beginning, the prospective student will be able to brainstorm their research project with internationally respected experts in the field.

"Ideal candidates will hold a First Class Honours or Masters degree in the fields of sciences and demonstrate strong interest in conducting interdisciplinary research to solve the large and complex problems of our age," Professor Prawer comments.

For more information, contact Professor Steven Prawer, Director of the Melbourne Materials Institute (MMI), on P: +61 3 8344 6415 or visit: www.materials.unimelb.edu.au

PHOTO: JOE VITTORIO

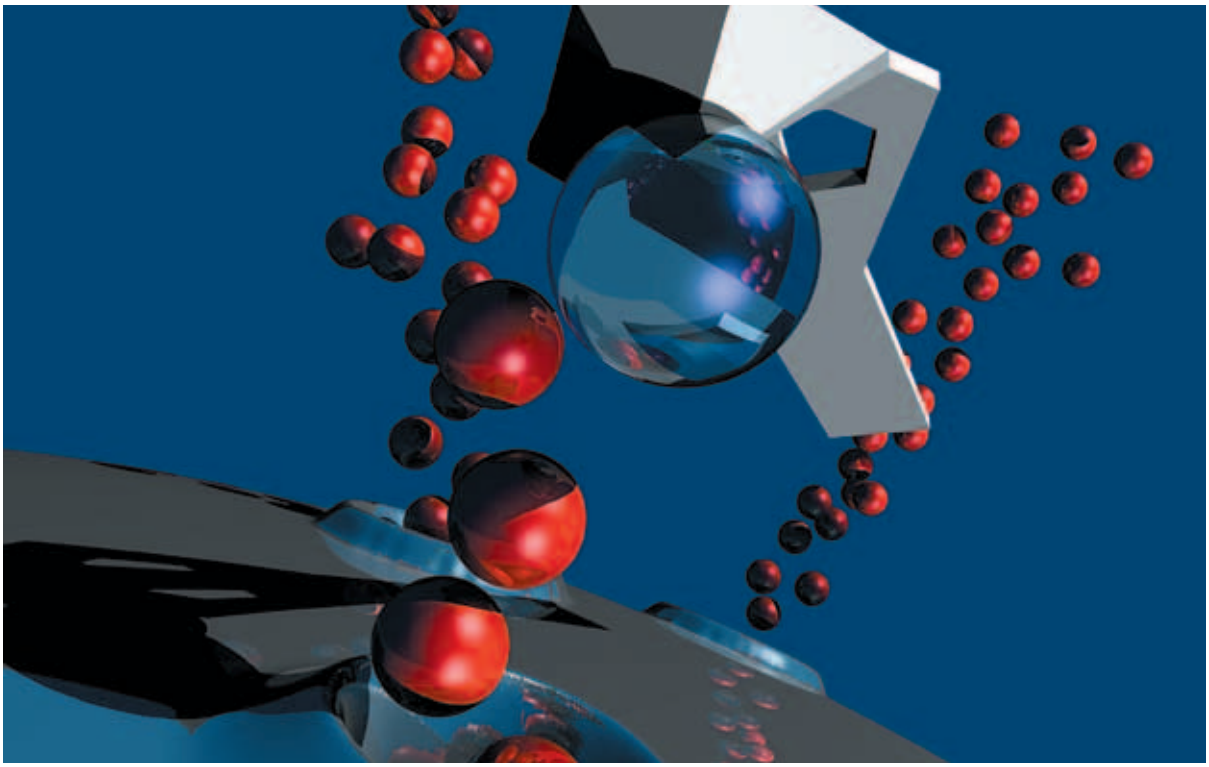


ILLUSTRATION: LIAM HALL

Quantum measurements in a living cell: life and death at the quantum–classical interface

The quantum properties of nanodiamonds have the potential to shed new light on complex biological processes, according to the latest research in a MMI seed-funded project led by Professor Lloyd Hollenberg from the School of Physics at the University of Melbourne.

In this groundbreaking research the first series of quantum measurements have been conducted on nanodiamonds inside living cells. The cross-disciplinary team comprised PhD students, postdoctoral fellows and senior staff from the departments of Physics, Chemistry, and Chemical and Biomolecular Engineering.

"The significance of the work is that an individual quantum system like an atom is extremely sensitive to magnetic fields and can be used as a unique nanoscale sensor in biological applications," says Professor Hollenberg, who is also Deputy Director of the ARC Centre for Quantum Computer Technology.

School of Physics PhD student, Liam McGuinness, explains: "This successful demonstration proves that such a quantum sensor can be controlled and measured in the cellular environment."

According to Physics PhD student, Alastair Stacey, "The ability to perform quantum measurements non-invasively is potentially game-changing, with researchers suggesting that such systems could be used to monitor protein gateways and aid drug delivery and discovery."

Liam Hall, School of Physics PhD student, worked on the theoretical analysis of the measurement, and observes that the nitrogen-vacancy (NV) nanodiamond probe should be sufficiently sensitive to identify 'on' and 'off' states in a single ion channel, despite the influences of background effects.

This research points the way towards a radically new class of biological probes based on quantum de-coherence sensing, bringing quantum technology into the biological realm.

Another project collaborator, Dr Yan Yan, from the Department of Chemical and Biomolecular Engineering, says the quantum sensor has the potential to provide new information to biologists of particular interest to particle tracking in nanomedicine.

The implementation of this detection mechanism may have profound implications for the testing and discovery of new drugs.

"The big goal is to develop a new detection capability of sub-cellular processes at the atomic level which could in principle lead to improvements in drug testing and delivery," says Dr David Simpson, a Research Fellow at the School of Physics.

Sustainability

“Companies and communities are faced with a new and rather unexpected paradox...”

PHOTO: FREDI KOHI

Digging for a sustainable world

PhD student Sara Bice has seen first hand the deep and abiding impacts mining has on communities.

She has worked with diverse communities in North America, the Asia-Pacific region and West Africa on matters including sustainable development in the mining industry, women's issues and public participation.

She has seen ecological systems and subsistence lifestyles destroyed by mine tailings being dumped directly into a local river system. She has seen indigenous landowners lose access to traditional hunting and fishing grounds, and the struggle of local communities to comprehend the immense changes which will be wrought on their landscapes and lifestyles by proposed mines.

However, she has also seen some mining companies make efforts to mitigate their impacts, with many multinational corporations attempting to integrate corporate social responsibility (CSR) principles and programs into their regular business practice.

This trend is particularly visible amongst major Australian mining companies with many undertaking programs to monitor and mitigate environmental impacts, ensure worker rights and safety, and contribute financially to development programs in the communities in which they operate.

Sara's PhD research investigates the sociological pressures which influence Australian mining companies to adopt CSR (or 'sustainable development') agendas, how these agendas affect communities in practice, and the implications of this for corporations and the communities at which the programs are targeted.

"My initial research findings suggest that while many Australian mining companies are taking great strides towards becoming better corporate citizens, the types of programs they implement may, ironically, be unsustainable," Sara explains.

"In many instances, programs are ad hoc or reactive, which means they cannot meet long-term community needs. In one instance, a group was given hundreds of plastic chairs to help facilitate community meetings. Not only did the chairs quickly break down in the elements, they did not address fundamental community needs. Although the company's intentions to foster dialogue were appropriate, there was little strategy to shape its execution. While this particular company has since taken many steps towards more strategic engagement, these chairs are symbolic of many companies' actions."

Corporate social responsibility, as it is currently being practised, also has the potential to foster strong community dependence upon mining; yet the very nature of mines is that they will eventually close and exit communities, explains Sara.

Furthermore, ad hoc community programming encourages a 'band-aid' approach in which investments may be made and resources allocated to activities which are not well targeted at priority community needs.

Sara is a member of the first cohort of the Melbourne Academy for Sustainability and Society (MASS), an interdisciplinary group of PhD students from across the university which aims to build a critical 'MASS' of researchers able to respond to the emerging challenges of sustainability in Australia and the Asia-Pacific region.

Sara is completing her PhD through the School of Social and Political Sciences at the University of Melbourne.

"Companies and communities are faced with a new and rather unexpected paradox growing primarily out of companies' attempts to be 'good'," says Sara.

"Now that companies make greater efforts to be good corporate citizens, how can they implement programs which are truly helpful and foster sustainability, as opposed to inadvertently undermining it?"

"Current approaches to corporate social responsibility programming must be altered if companies are to achieve meaningful, long-term outcomes and if communities are to be empowered and capable in their own right. In my experience, many companies are strongly committed to mitigating their social and environmental impacts, and we must support them to develop more strategic and sustainable approaches."

Sara's research investigates the social mechanisms which shape CSR programs at industry, organisational and community levels.

Through her investigations she is hoping to be able to provide insights which will shape recommendations for more 'sustainable' CSR.

Sara believes that although focused on the mining industry, the insights gained from her research will inform policy and practice with recommendations applicable to a variety of industries for which strong community engagement and active prevention or mitigation of social impacts is becoming progressively necessary and desirable.

For further information
www.sustainable.unimelb.edu.au

MELBOURNE SUSTAINABLE SOCIETY INSTITUTE

Sustainable themes

The Melbourne Sustainable Society Institute (MSSI) serves as an information 'portal' to sustainability-related research at the University of Melbourne and as a 'platform' for fostering collaborations between researchers and communities. An Executive of academics guides these twin functions, and currently there are 12 members drawn from seven schools and faculties.

MSSI also benefits from the interest and involvement of leading academics, senior bureaucrats, and innovative business people who are striving for a more sustainable society. Currently, we recognise 12 such people as our Associates.

In addition, a cohort of 17 research higher degree students has been selected from across the University to form the Melbourne Academy for Sustainability and Society. This 'critical mass' of future leaders will take the interdisciplinary experience and spread it more widely across our society's sustainability endeavours.

Sustainability research is categorised as located in one of two domains, or in both:
+ Sustainable Cities
+ Regional and Rural Communities

In representing and facilitating this research, MSSI uses a matrix of these two domains and the following themes that cut across them.

People and values
Understanding culture and behaviour is the key to any initiative to make our practices and lifestyles more sustainable. The topics that integrate this broad and searching inquiry are:
+ Changing Population
+ Sustainable Living, Thoughts and Action
+ Cities, Communities and Institutions
+ Law, Justice and Ethics

Climate change
In this pressing global issue three interconnected topics are being explored:
+ Climate Science and Impacts
+ Vulnerability and Adaptation to Climate Change
+ Mitigation of Climate Change

Some of the major groups involved in research on climate change across the University include:
+ ARC Centre of Excellence in Climate System Science
+ Victorian Centre for Climate Change Adaptation Research (VCCCAR)
+ Primary Industry Climate Change Centre (PICCC)
+ nodes of the National Climate Change Adaptation Research Facility (NCCARF)

Health equity
There are three interdisciplinary topics which represent a continuum from promoting community wellbeing to preventing and then treating illness, with sustainability as the overarching principle:
+ Health Promotion
+ Disease Prevention
+ Health Services

Water, food and energy futures, and governance
The most pressing concern in the coming decades is securing sufficient healthy food, clean water and sustainable, affordable energy.

This tripartite theme engages with the following topics:
+ Water Policy, Law, Governance and Culture
+ Water Cycle Management and Environmental Water Research
+ Food Production, Quality and Environmental Impacts
+ Food Policy, Safety, Trade and Culture

The inextricable theme of Energy is elaborated by the Melbourne Energy Institute, with which MSSI is closely aligned.

Planned infrastructure and transport
Our researchers are striving for the safety, integrity, and sustainability of infrastructure. The major research dilemmas often lie at the interface between classes of assets, the economy and social expectations.

This theme is organised into three topics:
+ Built Structures and Information and Communications Technology
+ Water and Waste Management
+ Transport and Infrastructure

Risk, resilience and transformation
We need to develop better understandings of the ways human systems deal with risk situations so that we may address the complexity inherent in the conditions associated with disasters.

Three topics range over the extent of disaster phenomena:
+ Disaster Sources and Impacts
+ Resilient Places and People
+ Processes and Institutions against Disaster

Rainwater: a sustainable harvest

Fahmida Khanom, Bangladeshi bureaucrat and PhD student at the Department of Resource Management and Geography, knows that the lifeblood of a sustainable society is its water supply.

This challenge is acute in so-called 'mega-cities', those urban centres with a population of more than 10 million, and especially in those burgeoning in the developing world, such as Dhaka (whose population is growing by 4.2 per cent per year).

Dhaka suffers from unplanned growth and poor waste management. Many of the water resource measures that are used in the developed world are either not viable or not affordable for Dhaka. Furthermore, Bangladesh is at the mercy of a vital but volatile annual monsoon.

For her part, Fahmida (pictured above) sees a way of turning a threat into an opportunity.

"Despite the perception of rain as a scourge in this urban context, where the impervious surfaces readily become waterlogged and start to flood, if rainwater can be properly harvested it can provide a key alternative source of water," she says.

In the rural context, rooftop rainwater harvesting has proven to be very simple, cheap, and, because it requires very low or zero energy use, genuinely sustainable.

In Dhaka, water harvesting can not only augment the mains supply, it can recharge depleted groundwater with the monsoonal surplus.

"My hypothesis is that this will be feasible in other mega-cities in the developing world too," says Fahmida.

Fahmida began her doctorate at the University of Melbourne in 2008. Her studies build upon an already successful, ongoing career working for the Government of Bangladesh. Since 2005, Fahmida has been in the Economic Relations Division, Ministry of Finance. She has worked with the United Nations Development Programme, the Canadian International Development Agency and USAID on various development projects, especially environmental management, water supply, disaster preparedness and gender issues. Working as a government counterpart to these agencies, she coordinates, monitors and evaluates project proposals and project effectiveness.

Fahmida's current research focuses on technical and social feasibility of rooftop rainwater harvesting in Dhaka, a city which presents something of a worst-case scenario. It is heavily dependent on groundwater resources, and these are depleting at a rate of 2–3 metres each year during the long dry season.

On the positive side, most multi-storied buildings and houses already have both rooftop tanks and underground reservoirs installed to help overcome the intermittent mains supply. These tanks, now mandated by the government, provide the opportunity to strategically harvest rainwater.

Fahmida's interdisciplinary work has both a technical aspect and a social aspect. Interviews with 148 randomly chosen residents offer insights into community views and values with respect to rainwater harvesting technologies.

There are also important health implications of her research: "In a mega-city like Dhaka, harvested rainwater can often be cleaner and safer than the water from the mains," says Fahmida.

Campus sustainability

Property and Campus Services (PCS) has responsibility for transforming our campuses to meet the University's aggressive targets for campus sustainability. The University sponsors the Green Building Council of Australia and will be working with it in the development of the Green Communities rating tool as a collaborative initiative of PCS, the Research Institutes and the Faculty of Architecture, Building and Planning.

The Research Institutes support this transformation and encourage researchers and students to see our campuses as 'living laboratories'. Two examples of putting this approach into practice are:

+ MUtopia, an interactive three-dimensional modelling tool that is under development by Engineering and other Schools, and is being applied to trial a prototype energy model that uses the buildings and environmental characteristics of the Parkville campus
+ a Melbourne School of Land and Environment initiative that is researching and demonstrating at-scale green roofs on buildings at Burnley campus.

MSSI, on behalf of the Research Institutes, is collaborating with PCS to create a small Campus Sustainability Centre. This centre will showcase the problems and opportunities of our campuses, examples of current research directed to transitioning to campus sustainability, and progress in implementing technical and behavioural changes that reduce our energy consumption, carbon footprint and economic efficiency. It is designed as a drop-in centre for students and staff, general public and visitors to the Parkville campus of the University. The Campus Sustainability Centre will host static and interactive displays, and real-time monitoring of building activity and performance. It will open in 2011.

Our achievements

In its portal role, MSSI has organised and facilitated 19 public lectures, seminars and forums, executive round-tables and workshops. Along with news, media items, and research data, these are represented on the MSSI website. MSSI also provides research capacity information for University-wide initiatives, such as identifying researchers relevant to the establishment of the Global IBM Research Lab and the Low Carbon Cities Research Steering Committee.

In the platform role of research facilitation, MSSI has achieved a number of important outcomes.

Australian G100: CFO Sustainability Survey on Influence and Impact of Sustainability on Capital Investment Decisions

MSSI facilitated a partnership between researchers in the Faculty of Business and Economics and CPA (Australia) to survey attitudes of chief financial officers of Australia's top 500 companies. The survey was developed in consultation with IFAC (International Federation of Accountants) and A4S (Accounting for Sustainability, sponsored by HRH Prince of Wales). In addition to sampling Australia's companies, it is intended to use the survey internationally, as sustainability becomes an integral part of corporate attitudes, marketing and governance.

The Australian Urban Research Infrastructure Network (AURIN)

AURIN is a $20 million initiative funded by the Australian Government's Super Science scheme and for which the University is the lead agent. AURIN will develop national research infrastructure to increase our understanding of urban resources. It will provide built environment and urban researchers, designers and planners with infrastructure to facilitate access to a distributed network of aggregated datasets and information services. These datasets and services are essential to understanding patterns of urban development, and to form and model urban growth for a sustainable future. AURIN will also provide the mechanisms, protocols and tools by which data can be accessed, interrogated, modelled and/or simulated. This will assist improved design and management of our cities, by linking the physical and social aspects of the built environment.

Sir Mark Oliphant International Frontiers of Science and Technology Conference: 'Sustainable Urbanisation: A Resilient Future' (2011)

Co-hosted with Swinburne University of Technology, and supported by RMIT University, the City of Melbourne, the Committee for Melbourne, Australian institute of Landscape Architects and others, this conference will feature international speakers for a TEDx event, workshops and city walks. It is expected to attract early-career professionals from industry and academia and aimed for purposeful outcomes that will inform MSSI Executive Round-Tables in 2011.

Neuroscience

“Epilepsy is a debilitating brain disease that afflicts three per cent of the world’s population.”

PHOTO: FRED KOH

Understanding epilepsy

Dr Steven Petrou is the Group Leader of the Ion Channels and Human Disease Group at the Howard Florey Institute and at the Centre for Neuroscience at the University of Melbourne. He has a keen interest in researching the fundamental basis of epilepsy.

This includes:

+ working with collaborators to identify and analyse the function of genes involved in inherited forms of the disease to understand the process of 'epileptogenesis' that leads to epilepsy
+ quantitative morphological analysis of the brains of human epilepsy mouse models
+ the impact of environmental modifiers of epilepsy such as diet, stress and sensation
+ identification of therapeutics opportunities to treat epilepsy.

Epilepsy is a debilitating brain disease that affects three per cent of the world's population and will, at same stage, afflict one person out of ten.

Anti-epileptic drugs have significant shortcomings, and almost a third of patients are unable to achieve adequate seizure control.

At present, surgery is the main recourse for these patients, who often live for 10 or more years with untreatable epilepsy prior to surgical intervention. New therapeutics are urgently needed not only to treat patients that don't respond to current anti-epileptic drugs but also to reduce the serious side effects of these medications.

The Laboratory led by Dr Petrou (pictured left) has taken the approach that novel opportunities for therapeutic intervention will arise by firstly, the creation of syndrome-specific epilepsy models based on human genetic lesions; and secondly, a detailed analysis of the fundamental mechanisms that underlie disease genesis and progression in these models.

"To achieve these goals we employ a multidisciplinary approach that combines molecular biology, biophysics, computer modelling, single cell and brain slice electrophysiology, macro and micro histological digital imaging, EEG, unit recording and *in vivo* patch clamps in the brains of mice," explains Dr Petrou.

"By studying the effects of epilepsy gene mutations at several levels of functional organisation, we can validate our models against the human conditions and then delve into the mechanisms of seizure genesis," he says.

"We have strong commercial links so that discoveries in the lab can more readily benefit patients."

Dr Petrou is currently focusing on three projects:

+ Creation of syndrome specific models of human familial epilepsy syndromes and exploiting these for drug development.

The goal of this project is to develop genetically modified mouse models of specific human epilepsy syndromes.

"Once disease-causing mutations are identified in human studies, mouse models are created that harbour the identical mutations," explains Dr Petrou.

"Development of new mice is underway based on susceptible genes; to date we have created three mice centred around idiopathic generalised epilepsy, idiopathic partial epilepsy and temporal epilepsy."

"With these models in hand our studies should reveal mechanisms of seizure genesis, thus providing fertile ground for development of novel therapeutics.

+ Perform a detailed investigation into the mechanisms of epileptogenesis in our syndrome-specific models

Validation of syndrome-specific mouse models of epilepsy requires detailed study at the molecular, neuronal, network and whole animal level.

"We search for similarities in cellular behaviour and seizure activity between our mice and the patients with the mutation as this provides us with greater confidence that fundamental mechanisms of seizure genesis may be shared," says Dr Petrou.

"We envisage that a range of different models will have to be created to cover the major refractory epilepsies seen in man."

+ Genomic consequences of epilepsy gene mutations: development of 4D mouse brain gene maps

It is unclear how common single-gene mutations contribute to epileptogenesis, according to Dr Petrou.

This project will use a combination of array analysis and *in situ* hybridisation to examine spatial and temporal changes in gene expression during the epileptogenic process in the single-gene mutant mice, which will aid understanding of the response of the genome to epilepsy mutations and give spatial clues to guide the project's functional studies.

For further information
www.ri.unimelb.edu.au/neuroscience

NEUROSCIENCE
Research Institute

Improving the quality of life of people with spinal cord injuries

Every day, someone in Australia suffers a spinal cord injury (SCI) with most injuries occurring in young people and the highest incidence in males aged 15–24 years.

Currently more than 10,000 people are living with SCI in Australia. The total annual cost in Australia is estimated to be $2 billion. To most observers, the dominant impact of SCI is impaired mobility. However, it is impairment of autonomic nervous system (ANS) function that socially isolates, increases dependence, precipitates hospital re-admission and causes premature death of those affected.

The program, Autonomic Dysfunction in Spinal Cord Injury: A Strategy for Improved Treatment and Understanding of Bowel, Blood Pressure and Bladder Disorders, brings together research scientists and clinicians with a combination of unique clinical and preclinical approaches to develop novel treatments of ANS dysfunction in SCI.

The program commenced in July 2009 with funds from the Victorian Neurotrauma Initiative. The program is led by senior scientist Professor John Furness, and utilises Neurosciences Victoria supported platform facilities in the Department of Anatomy and Cell Biology.

SCI patients cannot empty their bowel at will and they suffer constipation and soiling. For many SCI patients, this is their most disturbing and socially isolating problem. The Bowel Function project aims to develop novel pharmaceutical approaches for emptying the bowel of patients that will allow them to confidently undertake their daily activities without fear of soiling. Proof-of-principle experiments with a lead compound are promising, and preparation for human clinical trials using the lead compound have begun.

Cardiovascular disease is the greatest cause of premature death in SCI. The Blood Pressure project aims to develop therapeutic approaches to control nocturnal hypertension that causes excessive urine at night, nocturnal dehydration and exaggerated hypotension on rising in SCI patients. Human clinical investigations have begun for this project to determine the progression and incidence of blood pressure problems following spinal cord injury. It is intended that treatments will be put in place to reduce cumulative cardiovascular risk in SCI patients.

The greatest cause of rehospitalisation in SCI is bladder infection that is a consequence of bladder lining breakdown when the trophic influences of the innervation are disturbed. The Bladder Function project is investigating the causes of this breakdown, recurrent cystitis and bacteremia. The project aims to identify the mechanisms which give rise to bladder damage, and test therapies to treat SCI patients.

Further information can be found at www.sciautonomic.com

Musical lifeline

How is music central to human life? The recently established Centre of Music, Mind, and Wellbeing (CMMW) is addressing this core question.

Launched by the Australian of the Year, Professor Patrick McGorry, in 2010, the CMMW is the only centre in the world that links neuroscience with music and social wellbeing.

This is made possible by its globally unique set of interdisciplinary collaborations spanning music, science, health, education, and industry. The Centre's bold vision is to promote new public attitudes to foster grassroots participation in music to discover how it can be best used for the wellbeing of individuals and communities.

The CMMW provides a locus through which major research findings are disseminated to the public and the profession. So far, seed funding of the Centre by the University of Melbourne has led to the following major outcomes:

+ The CMMW has attracted two of the world's leading music neuroscientists as well as a senior social scientist to its Public Lecture program. Two of these scholars will undertake sabbatical research programs at the Centre, scheduled to commence in April and October, 2011.
+ The CMMW has showcased its major research findings to the public via a series of local and national radio interviews, as well as participating in the preparation and screening of two music documentaries, one of which has won a Gold REMI Award at 2010 Worldfest Houston, USA.
+ The CMMW has facilitated interdisciplinary workshops on new music technologies and is planning a series of workshops for 2011 that will involve organisations such as the Environmental Protection Authority, Victoria Police, Hearing Victoria, and the City of Melbourne.
+ After a vigorous international search, the Executive has appointed an outstanding postdoctoral scholar. Four PhD scholars (co-supervised by Executive members) have also been identified to complement and extend existing research programs.
+ Recent publications of the CMMW Executive include: revolutionary new perspectives on the auditory system; the neurobiology of singing; the role of music learning in auditory plasticity and music perception; and the social and individual factors that influence the motivation to learn music in developed societies. This research places CMMW at the centre of a global research effort to establish a socio-biological framework for understanding human musical behaviour, which will focus international attention on research at the University of Melbourne.

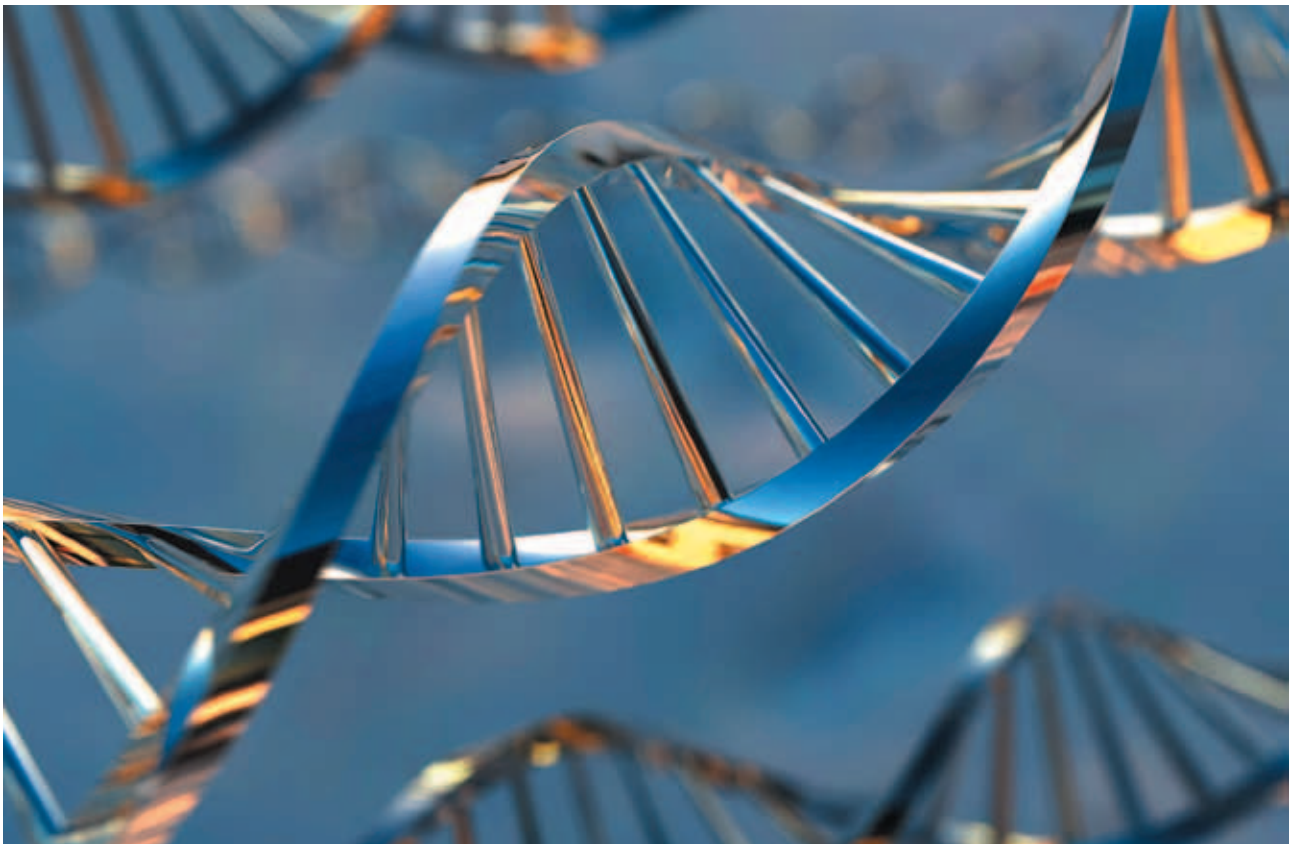


ILLUSTRATION: MARK EVANS

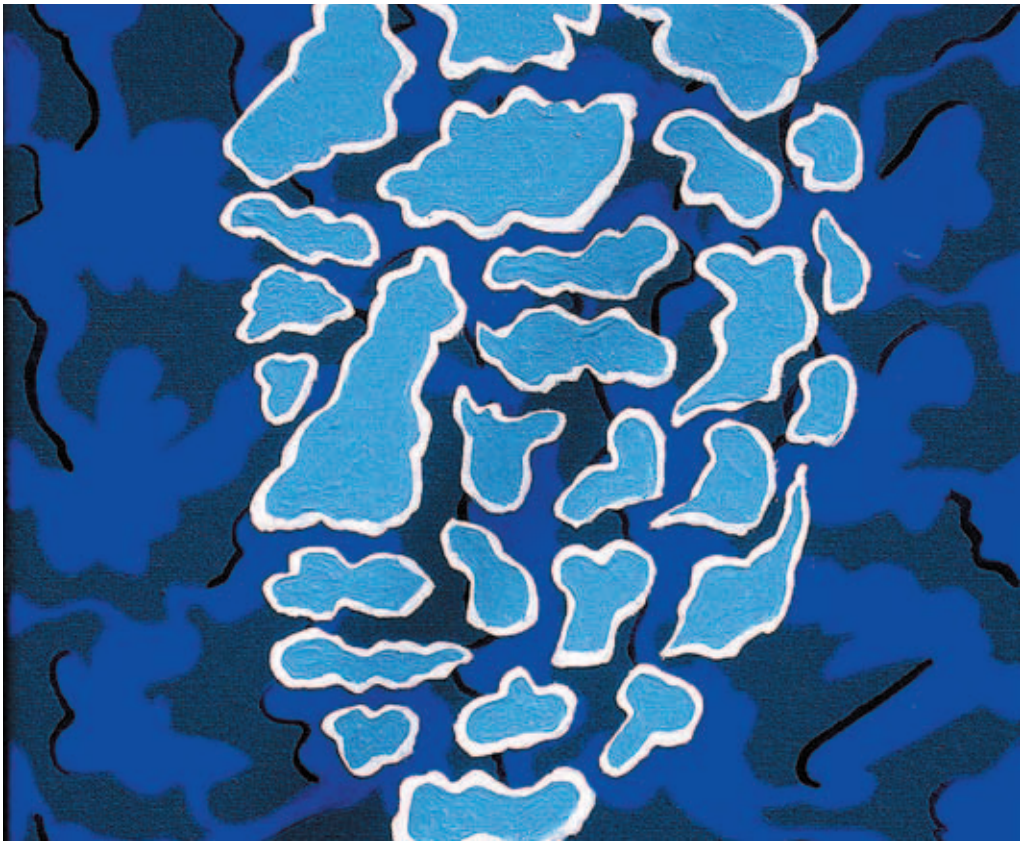


ILLUSTRATION: CHRIS JENSEN

CSIRO Stroke Flagship Program

The CSIRO Stroke Flagship Program is co-chaired by Professors Geoffrey Donnan and Stephen Davis.

Geoffrey Donnan is Professor of Neurology, University of Melbourne and Director of the Florey Neuroscience Institutes. He co-founded the Australian Stroke Trials Network (ASTN) which has numerous investigator-driven and commercially sponsored stroke trials. Subsequently he also co-founded Neuroscience Trials Australia to enhance Australian commercial and investigator-driven clinical trial capability.

Stephen Davis is Professor of Neurology, University of Melbourne, and Divisional Director of Neurosciences, Director of Neurology and Head of the Stroke Service at Royal Melbourne Hospital.

The CSIRO Stroke Flagship Program is a collaborative initiative between the Florey Neuroscience Institutes, CSIRO, the University of Melbourne, Austin Health, Melbourne Health and the National Health and Medical Research Council. The program involves the conduct of a large clinical trial of patients presenting with acute ischaemic stroke in whom the presence of viable tissue has been identified by MR imaging (see figure) as long as 4.5 to 9 hours after stroke onset. The hypothesis being tested is that these patients will respond favourably to the clot dissolving agent tPA and improve clinical outcomes.

Should this hypothesis be substantiated, it will double the very narrow therapeutic time window for which evidence currently exists (up to 4.5 hours) and, importantly, include those patients waking up with stroke in whom the time of onset is uncertain. This group forms almost 20 per cent of the total. Patients will then be followed for a period of 12 months as a cohort in which hypotheses concerning depression and lifestyle factors will also be tested.

There are nearly 60,000 Australians who develop stroke each year and only a small proportion of these (much less than 5 per cent) have access to the thrombolytic agent tPA, largely because of the narrow therapeutic time window for which evidence currently exists.

This $10 million collaboratively funded program will create the opportunity to give patients better access to one of the most powerful biological interventions in medicine.

Understanding the brain

The Centre for Neural Engineering (CfNE) will harness the strengths of the Faculty of Engineering, Faculty of Science and Faculty of Medicine, Dentistry and Health Sciences to take a transdisciplinary approach to research and education focused on understanding the mathematical engineering principles underpinning how a brain works, how to interface to a brain, and how to repair damaged or diseased parts of a brain.

Sixty-five years ago, the need was recognised for understanding the brain in terms of the fundamental engineering principles applicable to any computational device (such as energy, entropy and feedback).

This led to the Macy conferences (1946–1953) which attracted leading scientists from across engineering and the physical and life sciences.

The Macy conferences were one of the earliest organised approaches to transdisciplinarity. They demonstrated the need for, and the initial difficulties in establishing, a common language powerful enough to communicate the intricacies of the relevant fields across the physical and life sciences and engineering.

Insufficient experimental data prevented significant progress being made on understanding the brain, and as time marched on, the barrier to bringing together the ever more specialised disciplines grew larger. With tremendous experimental advances having been made in the past 60 years, it is timely for the CfNE to resume this transdisciplinary quest.

The CfNE uses grand challenges to focus its top-down research programs. Currently, there are two such grand challenges: to build a bionic eye, and to reverse-engineer the brain. Importantly, equal emphasis is placed on transdisciplinary education as on research. New courses are being developed which integrate into each subject elements of mathematics, engineering, physics, neuroscience and scientific computing.

The $34 million infrastructure funding for establishing the CfNE was used to renovate the Boydex building on Bouverie Street and to purchase a data centre and equipment for neuroscientific experiments. This funding will enable the CfNE to play a leading role in transdisciplinary research and education across the physical and life sciences and engineering.

Broadband

> “It’s collaborative time-keeping… the computers talk to each other and adjust their clocks as a result.”

PHOTO: FREDI KRON

All together now

Dr Julien Ridoux is a Senior Research Fellow with the Centre for Ultra Broadband Information Networks (CUBIN). He is researching the construction of a Digital User Guardian through the Institute for a Broadband-Enabled Society (IBES).

Skype, online games, air traffic control, smart energy grids and the Digital User Guardian – all rely on accurate timing across the internet. However, our present computers aren't accurate enough, Dr Ridoux explains.

"They can synchronise with an atomic clock over the internet," he says.

"But even tiny delays across the network introduce errors – your video conversation gets out of sync, you lose your online game or the electricity grid wastes power."

The National Broadband Network promises a much faster internet leading to a new digital age.

But, according to Dr Ridoux (pictured left), as the network accelerates, the time kept by computers has to become more and more accurate.

The solution? The Robust Absolute and Difference clock (RADclock), a novel timing system that is accurate, reliable and inexpensive.

"Spend $50,000 to install an atomic clock in your computer or use RADclock, a free software clock, accurate to within a few millionths of a second," says Dr Ridoux.

RADclock was designed by Dr Ridoux and Professor Darryl Veitch, at the Department of Electrical and Electronic Engineering.

Under good conditions this achieves microsecond accuracy, which is as good as an atomic clock-enhanced computer. And it costs nothing to install.

"The techniques which have been used in the past couple of decades will not be accurate enough to ensure necessary coordination with the diverse range of online services," says Dr Ridoux.

"Installing an atomic clock is not an affordable or a practical solution."

With the introduction of the NBN, computers, modems and set-top boxes will be interconnected at very high speeds, Dr Ridoux explains.

"This army of computers can collaborate to create new services and applications but only if they know who is doing what and, particularly, when," he says.

"With a super-fast network and always faster computers, tasks occur more frequently, and that requires computers to track the passing of time much more accurately."

The software taps into the counting device already installed in each computer to keep track of how fast the quartz crystal timer is vibrating. But because individual counters are unreliable, the program filters and analyses information from time servers across the internet, to construct a robust, precise and accurate picture of the passing of time.

"It's collaborative time-keeping, if you like – the computers talk to each other and adjust their clocks as a result," says Dr Ridoux.

The RADclock is then one of the key components necessary to develop new tools that will potentially benefit all Australians. The Digital User Guardian is one of them, with initial technological improvements having an impact in the regulatory and legal areas.

Developed in collaboration with Drs Zhang and Tune at the Department of Electrical and Electronic Engineering and Professor Gans at the Melbourne Business School, the Digital User Guardian will enable users to collaborate and diagnose their internet connection to preserve privacy, verify that regulatory requirements are met and provide a legal 'paper-trail' of the user's digital life.

"To be effective, the Digital User Guardian will have to accurately monitor events occurring on the network," says Dr Ridoux.

An experimental network of RADclock reference clocks is being established in Australia with the cooperation of the National Measurement Institute (NMI) and Australia's Academic and Research Network (AARNet). This is the first step towards a nationwide high-accuracy infrastructure that will allow any computer and the Digital User Guardian access to accurate time.

The Department of Electrical Engineering at the University of Melbourne is hosting the RADclock testbed, and already runs more than 20 time servers. The team is now deploying 10 more in Melbourne, Sydney and Adelaide, then they plan to expand to other capital cities and possibly also the United States. They're working with the NMI and AARNet, Australia's Academic and Research Network, to test the clock.

The RADclock project is hosted by the ARC Special Research Centre for Broadband Information Networks (CUBIN), and is supported by a Discovery Grant from the Australian Research Council and by a Google Research Award. The Digital User Guardian project is supported by the Institute for a Broadband-Enabled Society.

For further information
www.broadband.unimelb.edu.au

IBES
Institute for a
Broadband-Enabled Society

Being in school, but not at school

Creating a classroom presence for children who are absent due to health conditions

Forty-one per cent of Australian children have at least one chronic health condition.

Annually, approximately 10,700 school-aged children are admitted to the Royal Children's Hospital in Melbourne. These children experience significant barriers for continuity of education: risk of disengagement from school, academic failure and compromised social wellbeing.

Importantly an 'out of sight, out of mind' attitude can contribute to disengagement from school. Broadband-enabled technologies may help connect these children with their schools and contribute to a culture of learning across hospital and school settings.

Broadband-enabled technologies provide an excellent opportunity to connect these children with their schools and contribute to a culture of learning across hospital and school settings.

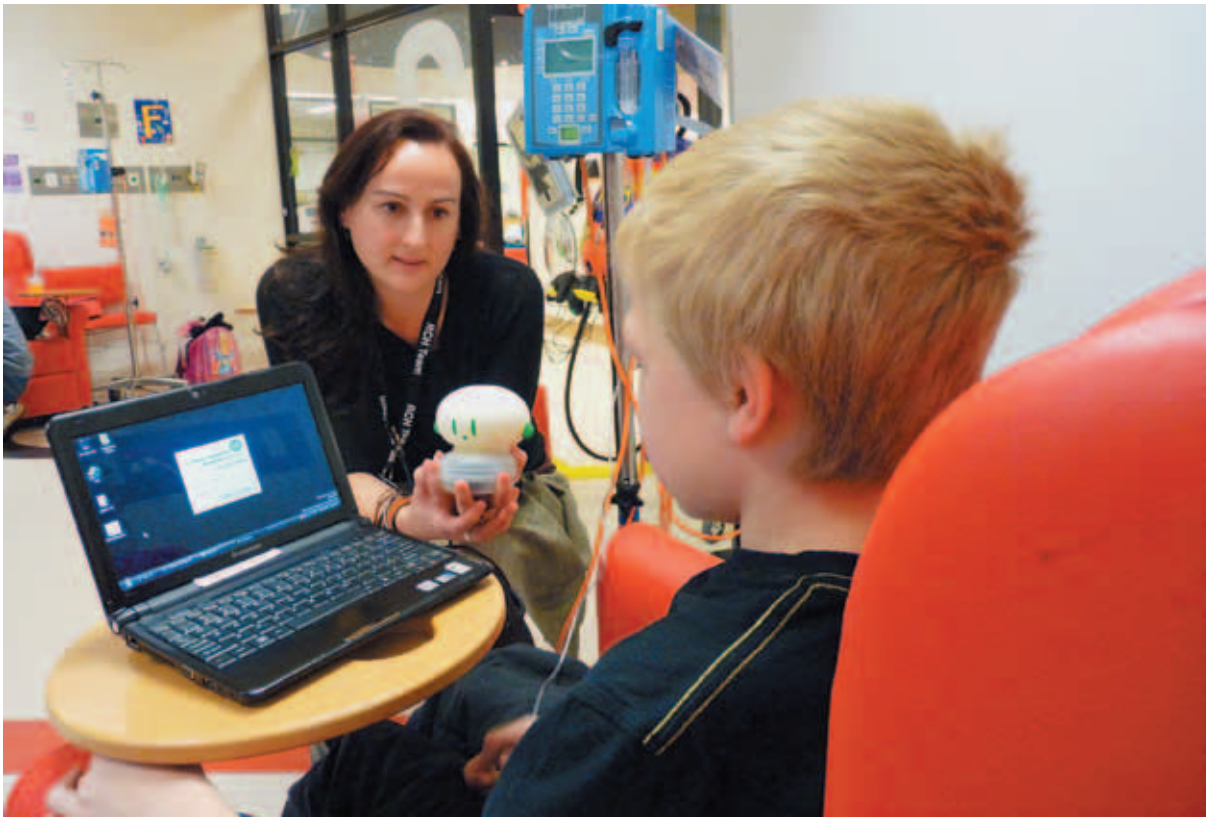
This research is trialling the creation of a presence for hospitalised children in their school classroom through an ambient orb. The ambient orb can alert teachers and schoolmates to a child's desire to connect with their classroom and peers, without requiring the need to establish communication.

The University's Department of Information Systems developed the ambient orb prototype. It consists of an internet-based web application and the orb in the classroom controlled by a wireless sensor connected to a laptop. The hospitalised child controls the orb in the classroom by accessing the web application through a network.

The ambient orb increases presence and enables students to share the sense of being together. Lucy, aged 11 and a long-term patient at the Royal Children's Hospital, said in an interview: "I reckon it was good... some of my friends said when it changed colours it reminded them of me and I liked it' cause everyone would think of me."

The orbs contribute to awareness of each participant's environment, classroom or hospital. The mother of patient Jerry observed: "The [classmates] are more aware, because the orb was there." They also facilitate connectedness and a sense of staying in touch with classmates.

Broadband-enabled technologies such as the orbs bring presence, engagement and connectedness for children suffering chronic conditions. The research being undertaken in this project enables the development of evidence-informed policy ensuring that children with health conditions are able to have continuity in their education.



IBES Director Rod Tucker researching ways to make the internet greener

The Institute for a Broadband-Enabled Society's Director, Laureate Professor Rod Tucker (pictured below), is a founding member of the GreenTouch™ Initiative. GreenTouch is a consortium of leading information and communications technology (ICT) industry players and researchers working to fundamentally re-invent the internet to dramatically increase its energy efficiency.

The evolution of the internet is now intimately entwined with national and international economic growth. New broadband services are continually being developed, driving continued exponential growth of internet traffic for the foreseeable future.

The internet's growth has often been seen as providing multiple avenues for reducing the environmental impact of society. However, this relies on the energy consumption of the internet itself not becoming a problem. If the current rate of growth of the internet continues without due consideration of its energy consumption then several significant constraints to this growth will emerge. In particular, the internet will suffer an 'energy bottleneck,' which refers to problems related to providing the electricity needed to power the equipment used by the internet.

The internet relies on a significant amount of specialised equipment that must be supplied with vast amounts of electrical power. The provision of this energy has already become a major issue for many companies that rely on the internet. If the energy bottleneck is not resolved the future growth of the internet will suffer, creating a significant impact on social and economic development.

The GreenTouch Initiative is stimulated by recent research that identifies a gap between rapid network growth rates and equipment efficiency improvements. The vision of GreenTouch is to create ICT networks and technologies that enable a sustainable internet. Over the next five years, the work of the GreenTouch Initiative expects to deliver demonstrations of key components needed to redesign networks to improve their energy efficiency and reduce their carbon footprint.

PhD top-up scholarships

The Institute for a Broadband-Enabled Society (IBES) supports the next generation of researchers by providing PhD top-up scholarships. The scholarships support research that focuses on new products, services and innovations that maximise the benefit of broadband technologies to society.

There are currently five PhD students who are receiving top-up scholarships:

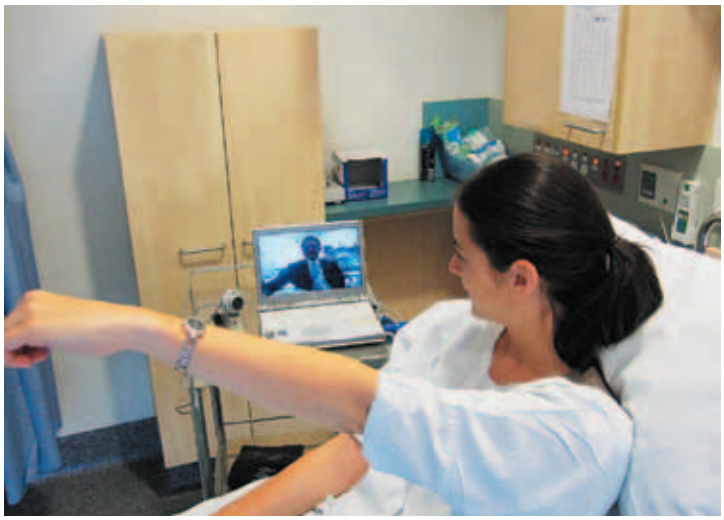
+ **Marcos Dias** (Culture and Communication) is researching the new forms of social interaction that arise from access to broadband-enabled technologies in public spaces.

+ **Michael Feng** (Electrical and Electronic Engineering) is focusing on reducing the energy consumption of the internet through the development of new methods to groom internet traffic. This project is part of a larger IBES research project seeking to make the internet more energy-efficient.

+ **Sung Jun Kim** (Architecture, Building and Planning) is researching 'Smart homes for the elderly: recent developments in Korea'.

+ **Cameryn Garret** (Centre for Women's Health, Gender and Society) is exploring the circumstances that would lead young people in Australia to choose webcam consultations for sexual health. The project is targeting people from rural Victoria.

+ **Parisa Saeedian** (Electrical and Electronic Engineering) is determining the probability of bushfire risk in a given area through data obtained from a sensor network.



Telestroke study

Stroke is a major cause of morbidity and mortality in Australia. There is an annual incidence of 48,000 new strokes and the risk of death is 25 to 30 per cent. Of those who survive, stroke contributes to 25 per cent of all chronic disability in Australia. Acute stroke is caused by a blockage of one of the arteries in the brain, resulting in interrupted blood supply.

In 1997, a landmark 'clot busting' or thrombolytic treatment for ischaemic stroke called tPA was introduced to Australia. It is a powerful treatment, which can unblock the artery and restore blood supply to the brain but has serious side effects with intracerebral haemorrhaging occurring in around 6 per cent of patients. Due to the potential of a serious side effect, the administration of tPA requires patients to be examined by a stroke neurologist.

A significant number of hospitals in rural and regional areas do not have access to a stroke neurologist. A recent survey by the National Stroke Foundation reported that 72 per cent of Australian hospitals were unable to provide acute stroke treatment.

The telestroke study is demonstrating the feasibility and effectiveness of a telestroke system between a comprehensive stroke centre (Royal Melbourne Hospital) and a rural health centre (Wangaratta District Base Hospital)

The telestroke system is a high-speed, high-resolution videoconferencing system that enables a rural stroke patient to be examined by a stroke neurologist who is not on location. The systems include teleconferencing infrastructure installed at the emergency department of the rural hospital and on a laptop computer provided to the stroke neurologist. The system allows stroke neurologists to remotely assess stroke patients presenting to rural hospitals.

To date, 93 patients have been enrolled in the study. Of the 93 patients, 20 were assessed by the telestroke system and nine of these (45 per cent) were administered tPA, with an average time of 82 minutes per treatment.

The Centre for Energy-Efficient Telecommunications

The Centre for Energy-Efficient Telecommunications (CEET) is a new collaboration between the University of Melbourne, Alcatel-Lucent (Australia), Bell Labs (Alcatel-Lucent Global) and the Victoria State Government.

CEET is devoted to innovation in energy-efficient networks and technologies. The Centre will build a research team of 26 over the next three years focusing on embedding energy efficiency into all elements of the telecommunications infrastructure.

There has been exponential growth in the usage of telecommunications networks, resulting in a rapid increase in energy consumption. If left unchecked, energy consumption of telecommunications networks could consume 60 per cent of the world's energy.

CEET brings together research strengths at the Institute for a Broadband-Enabled Society and Bell Labs, both members of the GreenTouch Initiative, where IBES Director Professor Rod Tucker is a founding member. GreenTouch is a global, industry-wide consortium formed to achieve a dramatic improvement in energy efficiency by driving a radical redesign of communications networks.

In achieving its goals, CEET will draw on Bell Labs' decades of achieving breakthrough innovations and its extensive experience in managing collaborative research projects as well as on the University of Melbourne's world-class research in telecommunications network infrastructure.

At the announcement of CEET, the then Victorian State Treasurer John Lenders said that the Centre enables Victoria to position itself as a place for information and communications technology research and a centre for green communications research, development and training. Ben Verwaayen, Alcatel-Lucent CEO, said the Centre has the potential to play a decisive role in meeting this challenge because it has the key ingredients for success: partners with deep research experience and complementary goals.

Finding ways to reduce energy consumption is an important challenge for society, but it is one that the telecommunications sector is well positioned to address. The research conducted at CEET will be used to further the GreenTouch Initiative and its objectives of reducing the energy consumption of the internet.