



# FOCUS

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## HEALTHCARE REFORM

### LOOKING TO DISRUPTIVE TECHNOLOGIES

Contributors describe their vision for a new age of healthcare and how disruptive technologies could help mitigate the ageing population crisis in healthcare provision

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Photo: iStockphoto



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# FOCUS

ATSE *Focus* is produced to stimulate discussion and public policy initiatives on key topics of interest to the Academy and the nation. Many articles are contributed by ATSE Fellows with expertise in these areas. Opinion pieces on topics of national interest, particularly the Academy's key interest areas – climate change impact, water, energy and education – will be considered for publication. Items between 800 and 1500 words are preferred. Please address comments, suggested topics and article for publication to [editor@atse.org.au](mailto:editor@atse.org.au).

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# The biotechnology revolution – delivering personalised medicine

Whole genome sequencing has the potential to become a disruptive technology, in the same way that the steam engine replaced the horse



By Susan Pond

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**T**he history of mankind has been one of technological change. Initially, each age spanned a very long time but the rate of change has been exponential.

Currently we are in the information age that began around about the mid-20th century. Since then we have seen incredible convergence of discoveries in biotechnology and information technology.

This convergence is leading the biotechnology revolution and sets the scene for technologies that could disrupt healthcare within the next 10 to 20 years – with major implications for individuals and the healthcare system.

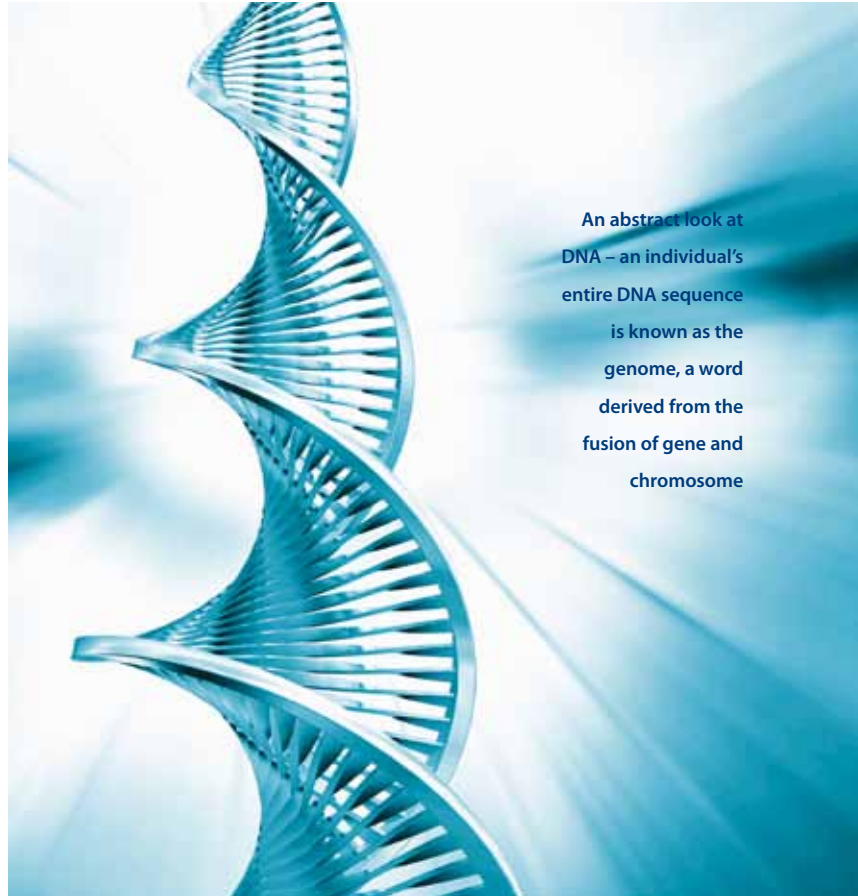
This revolution is a subject being raised and discussed by futurists such as Ray Kurzweil, Chancellor of the newly founded Singularity University (SU) – “an interdisciplinary university in California with the mission to assemble, educate and inspire a cadre of leaders who strive to understand and facilitate the development of exponentially advancing technologies in order to address humanity’s grand challenges”.

The information age has transformed our daily lives through the internet, our computers, iPods, mobile phones, global positioning systems, smart cards and a myriad of devices using microchips.

Kurzweil refers to these devices as androids. He predicts that by the mid-21st century our androids will rival our full range of human intelligence and that we will be an era in which our intelligence becomes increasingly non-biological, embodied in our androids. We will be at a point of Singularity.

Within the biotechnology revolution is our capacity to sequence the entire genome of an individual and understand what it means for our current and future health, with the promise of complete genome sequencing, raising questions such as:

- can we sequence the complete genome easily and cheaply (\$1000 per genome or less)?
- what will the data reveal about our biology, our diseases, their diagnosis, prevention and treatment?
- how should we use them?



An abstract look at DNA – an individual’s entire DNA sequence is known as the genome, a word derived from the fusion of gene and chromosome

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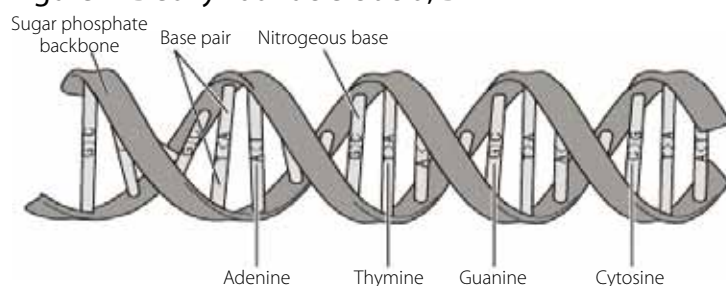
- what are the implications of direct to consumer marketing of complete genome sequencing?

The biotechnology revolution will lead to what is called “personalised medicine”, which has long been the holy grail of physicians. We are reaching the point of being able to decode our individual “Rosetta Stone” of life which has three languages: our personal history and medical record; our personal biological material, which includes our DNA sequence; and our personal information in the context of the population or as a participant in a clinical research cohort.

When we have unlocked all of these three languages, we will be at the point of delivering truly personalised medicine.

## We have come a long way

We have made great advances already in genetic testing of discrete variations in single genes. Such testing has trans-

**Figure 1 Deoxyribonucleic acid, DNA**

Software on which biology is based

formed medical practice in a number of ways. We use it for prenatal testing, for examination of single gene variations that lead to abnormalities before or after birth. We use it for the diagnosis and management of infectious diseases, some forms of leukaemia and other forms of cancer. We use it to predict response and side effects to certain drugs. There are even some tests on the market that enable us to identify genetic subtypes of common diseases such as diabetes that are due to single gene defects.

It is clear that we have come a long way already in the use of genetics in healthcare.

What is this concept of whole genome sequencing? At our core is the genetic information encoded by four nucleotides – adenine, thymine, guanine and cytosine. DNA consists of two long chains of these nucleotides twisted into a double helix and joined by hydrogen bonds between the complementary bases adenine and thymine, cytosine and guanine.

An individual's entire DNA sequence is known as the genome, a word derived from the fusion of gene and chromosome. In humans, the genome is packaged very tightly into 23 pairs of chromosomes. The Nobel Prize recently awarded to Elizabeth Blackburn relates to how these chromosomes stop themselves from unwinding by being capped at the end by a series of repeating nucleotides put in place by an enzyme known as telomerase.

If we stretched out the DNA found in human chromosomes, it would be two metres long. We have six billion nucleotides which, if written down, would fill 200 telephone directories. You can appreciate why we have such a huge amount of information packaged packed into each and every cell.

The Archon X Prize in Genomics is a \$10 million prize announced in 2007 for the first team to successfully sequence a hundred human genomes in 10 days for less than US\$10,000 per genome. It is expected that the prize will be awarded by 2014 or earlier.

A number of public genome sequencing consortia have been announced. In January 2008 an international research consortium named the Thousand Genomes Project

([www.1000genomes.org](http://www.1000genomes.org)) launched a three-year program to create a more detailed map of human genetic variation by deep sequencing of the genome of 1200 people around the world. It is receiving major support from organisations in the UK, China and the US and will generate 64 times more sequence data in public data bases than have been generated during the past 25 years. The first data were released in December 2008. The group has proposed the launch of the next phase, the Million Genomes Project.

The private sector is also accelerating its productivity. Complete Genomics ([www.completegenomics.com](http://www.completegenomics.com)) is a third-generation methodology human genome sequencing company. In September 2009, it announced that it had sequenced, analysed and delivered 14 human genomes to customers since May 2009.

In 2010, the company plans to sequence 10,000 human genomes at a cost of US\$5000 per genome for customers ordering more than 40 genomes. It markets its services direct to biotechnology and pharmaceutical companies, and institutions undertaking large-scale genome research. The operations centre has 192 sequencing instruments and, importantly, a data centre which contains 60,000 processors with 30 petabytes of secure storage.

In summary, 2009 was the year in which we reached a tipping point in sequencing technology and capacity. The number of genomes entered into databases will rise and the costs will decline exponentially during the next few years enabling us to reach the goal of the \$1000 complete human genome.

## Potential to disrupt medicine

Does this present the potential to disrupt the practice of medicine? How will we interpret and use an individual's whole genome sequence? What if the technology becomes so commoditised that it is available to the population as a whole?

Whole genome sequencing has the potential to become a disruptive technology, in the same way that the steam engine replaced the horse, telephones replaced the telegraph, and digital photography replaced film. Could whole genome sequencing combined with 'instructions' in the form of risks and what to do about them disrupt current healthcare systems and practices, displace healthcare practitioners?

This is not a fanciful notion. More than 80 companies are marketing genome sequencing products. Amongst them are companies such as 23andMe (named for our 23 pairs of chromosomes), which markets its services directly to consumers ([www.23andme.com](http://www.23andme.com)). Their service "starts with us mailing you a saliva collection kit". Other companies in the same space include Navigenics, deCODEme, Pathway Genomics and YiGene.

23andMe currently charges customers around \$400 to learn if they harbour certain genetic mutations that place them at higher risk for developing certain diseases and impact their response to certain drug treatments. Google is an investor.

What issues are raised by these direct to consumer services? In order to offer meaningful interpretations, we will need to study large cohorts to find the small genetic effects on susceptibility to common diseases. Take bipolar disorder as an example. A genome wide association study to discern genetic variations associated with this disorder needs to enrol 10,000 patients and 100,000 controls. The only way that these studies will be possible is through the use of linked electronic health records of patients already diagnosed and entered into a linked database. Our current lack of capacity in bio-informatics is another rate-limiting step.

The House of Lords Science and Technology Committee released an excellent report on Genomic Medicine. It recognised that clinical health records and sequence information will need to be merged on secure platforms and that a whole workforce in medical informatics will need to be trained. It will be difficult to gain an understanding of the genetic basis of some diseases. We have a long way to go.

Other issues raised in the House of Lords report relate to implementation of service delivery – public engagement, the ethical, social and legal issues and education and workforce planning. Philosophical issues such as genetic determinism need to be considered. Reproduction is another area for discussion as well as questions related to commercialisation of products including intellectual property rights and security of data.

What happens if one of the companies providing services folds or merges? What happens to the genome sequences left by that company in the 'cloud'?

Despite all of these unanswered questions, we are making very rapid progress particularly in the field of cancer. We recognise that every tumour is different and every cancer patient is different. Consortia such as the International Cancer Genome Consortium are being established to undertake comprehensive whole genome sequencing of the tumour as well as the background DNA from a large number of patients with different types of cancer.

Australia is participating. The NHMRC has awarded this project \$27.5million, the biggest grant that it has ever awarded, to a team in Queensland and Sydney that is studying pancreatic cancer, one of the most severe cancers for which treatment is usually ineffective.

Ray Kurzweil has portrayed the future as "The Web within us: When minds and machines become one". We need to be prepared for the day, within the next 20 years, when the 'Web within us and Medicine' become one. ◀

**DR SUSAN POND AM FTSE has a strong scientific and commercial background having held executive positions in the biotechnology and pharmaceutical industry. She is a Director of Commercialisation Australia and has held several Board positions including as Chairman of the Australian Drug Evaluation Committee (ADEC), Executive Director of Johnson & Johnson Pty Ltd and non-executive Director and Chair of AusBiotech Ltd. Dr Pond has specialist clinical credentials in internal medicine, clinical pharmacology and clinical toxicology and was a faculty member of the Department of Medicine at the University of California San Francisco for six years and later at the University of Queensland.**

## Re-engineering Australia's healthcare system

The need to re-engineer Australia's healthcare system is high on the political agenda, as evidenced by the Health and Hospitals Reform Commission June 2009 report *A Healthier Future for all Australians*.

The reform agenda proposed in this report includes the need to take action to "redesign our health system to meet emerging challenges and create an agile and responsive and self improving health system for future generations". Three levers are proposed: strengthened consumer engagement and voice; a modern, learning and supported workforce; and smart use of data, information and communication, particularly via an e-health agenda.

While identifying problems in the healthcare system, the report did not look at the full potential of disruptive technologies and disruptive innovations as a mechanism for fundamental improvement in Australia's health system.

('Disruptive technology' and 'disruptive innovation' are terms coined by Clayton M Christensen of the Harvard Business School and used in business and technology to describe innovations that improve or replace a product or service in ways that the market does not expect, typically by being lower priced or designed for a different set of consumers.)

In response to this challenge, ATSE held a seminar in October 2009 in Sydney – supported by the NSW Government – at which experts in the field of healthcare policy discussed the impact of disruptive technologies on this sector with healthcare practitioners, health workforce planning experts, biotechnology industry leaders and government representatives.

The seminar was opened by the New South Wales Minister for Science and Medical Research, Hon Jody McKay and the keynote address was delivered by Dr Susan Pond AM FTSE, former Chair and MD of J&J Research. Dr Margaret Hartley, ATSE's CEO, was the rapporteur.

Speakers included: Dr Vaughan Beck FTSE, ATSE Executive Director – Technical; Dr Vitali Sintchenko, Senior Research Fellow, UNSW Centre for Health Informatics; Dr Shane Brown, Medical Director, Pacific Knowledge Systems; Professor Branko Celler, CEO, Telemedcare; and Professor Philip Davies, Director Australian Health Workforce Institute, the University of Melbourne and the University of Queensland.

**Articles developed from their presentations provide the theme material for this edition of ATSE Focus. The presentations made at the seminar are available at [www.atse.org.au/index.php?sectionid=17](http://www.atse.org.au/index.php?sectionid=17)**

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Nanomedicine, the medical application of nanotechnology, is driving a new generation of medical diagnostic and therapeutic products. The University of South Australia is helping lead the way with a current research income of \$A2.5 million for nanomedicine projects involving collaboration between the Ian Wark Research Institute and the Sansom Institute for Health Research. Taking advantage of the unique properties of materials at the nano size, this cross-disciplinary research aims to design more efficient and less invasive diagnostic and therapeutic anti-cancer agents, and to assess the safety of nanomaterials and establish their toxicological profile.

Nanomedicine research is being led by a team of world-class researchers at UniSA, collaborating across these leading Institutes. Professor Michael Roberts, an NH&MRC Senior Principal Research Fellow and Director of the Therapeutics Research Group at UniSA's Sansom Institute, is Australia's foremost expert in drug delivery systems and nanotoxicology. At the Wark, Professor Clive Prestidge, recently appointed as Associate Director for Nanomedicine, Dr. Benjamin Thierry, Senior Research Fellow, and Professor Hans Griesser, Deputy Director, lead large and successful research programs dedicated to nanotechnology in medicine including drug delivery, biomedical devices, and cancer diagnostics and therapeutics.

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*Nanotechnology offers unprecedented possibilities towards the design of novel anti-cancer therapeutics: Nanoparticles (red) mediate simultaneous delivery of active genetic material (green) and drugs. (Thierry et al., Chem Comm 47; 7348-7350; 2009)*



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# Knowledge management contributes to disruptive technology in healthcare

Disruptive technology in healthcare has to shift a locus in which the healthcare is delivered by capturing knowledge and making it freely available in different sites



By Shane Brown

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Clayton Christensen, in his book *The Innovators Prescription*, looks at disruptive innovation as a way of improving healthcare in the future. He defines disruptive technology as an innovation that makes things simpler and more affordable by combining different inputs to those traditionally used to deliver outputs of greater value. He uses the PC as a good example of disruptive technology.

In the late 1950s to early 1960s there were three big computer companies. They were CDC (Computer Data Corporation), DEC, and IBM. CDC disappeared into UNYSIS. DEC was subsumed by Compaq and then by Hewlett Packard and they now make PCs.

IBM actually survived very successfully because when the Apple II was starting to appear on the desks of students in primary schools, IBM created a strategic business unit that worked independently of IBM's mainframes and also started making PCs.

Since PCs were not the best type of computer around, CDC and DEC continued making bigger, better, faster mainframes and mini computers. Over time however, these disappeared because the PC got better and better

and was affordable. The disruptive technology of the PC eclipsed the mainframe market.

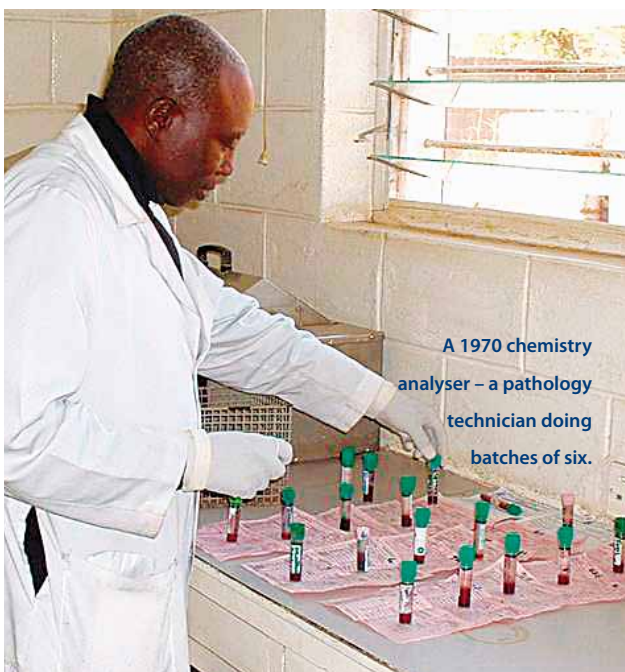
Why, Christensen argues, does this have any relevance to healthcare? The answer comes from the US, which says that by 2020 its entire budget at its current growth rate could be consumed by defence and healthcare.

There has been no move to reduce the defence budget but the US Government does recognise that it is an issue for their healthcare budget. For governments around the world, the increase in health costs is clearly posing a major problem.

The population, in Western and developing countries, is becoming more educated. People have greater access to the internet, they know more about their diseases, they are much more involved in the way that they want their diseases to be diagnosed and treated – all factors which put further pressure on governments to spend more and more on healthcare.

At the same time, there has been little or no change in the way that medicine is practised – we still rely on the 'bedside' clinician to make the diagnosis and arrange for appropriate treatment. In order to be more cost effective, we need to start looking at a different paradigm.

With respect to diagnostic tests, one of the major is-

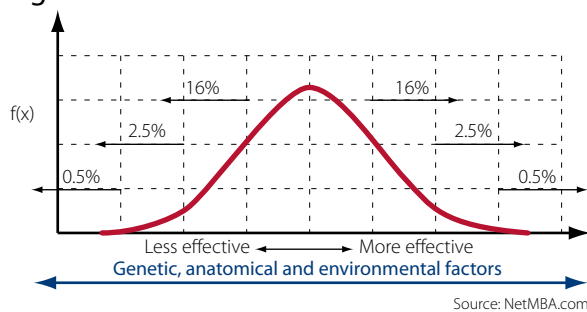


A 1970 chemistry analyser – a pathology technician doing batches of six.



The current generation of modular devices with a capacity of up to 5000 tests an hour.

Figure 1 Normal distribution



sues is that they have been totally commoditised. There has been an enormous input from the private sector into selling a product, namely diagnostic medicine. At the same time, there have been issues with the way the funding models have dealt with that commoditisation.

A 1970 chemistry analyser (a pathology technician) was a very friendly instrument – capable of changing its plan with a simple direction from a supervisor.

However, he/she did tests in batches of six and was very inefficient. Ten years later, the automated next generation of analysers came along – not so user-friendly but they could perform 60 tests an hour. They were followed by the start of the current generation of modular devices with a capacity of up to 5000 tests an hour.

If your laboratory needs to do more than this number of tests an hour, then you buy another machine. If you have the money, you can also put a track between them so that your throughput of data can be increased even further based on the commoditisation of this type of instrument and driven totally by the commercial market.

While I have focused on chemistry in particular, the same trend has occurred in every discipline within pathology – it happened in imaging, it happened in radiology. There was an enormous surge over that 30-year period in the range of instrumentation available and diagnostic medicine could be practiced very cheaply and very efficiently.

Interestingly however, we did not see governments changing the way they were funding diagnostic testing. They continued to fund a chemistry test, for example, based on the assumption that someone was sitting at the bench taking samples and processing them manually.

Despite these advances in instrumentation, there was a substantial lag time before the Health Insurance Commission started to appreciate that technology had moved the costs significantly away from the way we used to practise. Now, the advances in instrumentation are being rapidly superseded by those in proteomics and genomics.

But now we can examine the RNA (Ribonucleic acid) and DNA directly. The amount of information that we can now apply to making a provisional or a definitive diagnosis has dramatically increased.

Despite the whole advent of molecular diagnostics and the quantum leap in the amount of data that is available, we have not yet seen the basic model of healthcare change. If you are sick, you go to the GP, who does some preliminary tests – some of them make sense, some of them do not. He or she may actually order more and then send you to a specialist or send you to a specialist immediately. The specialist then repeats some of the tests because the original ones may not have been appropriate.

This approach means that we are actually using an iterative process to reach a final decision whereas, today, the information can be immediately available if we can access it.

Let me focus on the concept of personalised medicine and how the information generated from it should be used in a positive way.

By definition, 62 per cent of a normally distributed population will lie between  $-1$  and  $+1$  standard deviations and this forms the basis on which we do clinical trials and build a framework of evidence-based medicine. We put something in or we take something out and we measure its impact on a specific disease entity. At the same time, we monitor general wellbeing to ensure that whatever we are putting in or taking out does not do excessive harm to the patients while remaining focused on the impact of our treatment on one particular aspect of the disease.

Now, if you happen to be the person three standard deviations to the right of the mean, you are responding better to that treatment than 99.5 per cent of the rest of the population. If you happen to be the individual the same distance away on the left, you are actually getting a worse outcome than 99.5 per cent of the population. The key question is what is the reason for such a difference? The answer lies (see Figure 1) in the wide variation in genetic, anatomical and environmental factors present in an outbred population like humans that can influence our response to treatment.

The emerging molecular technologies, to which we now actually have access, to put them in the clinical context, have the potential to tell us where individuals lie on that spectrum in the normal curve. Consequently, patients and funding bodies are starting to say that they actually want to see personalised medicine and interpretative diagnosis applied to the way that healthcare is delivered.

Given the enormous amount of data being generated however, we now have the problem of how to manage this knowledge in a way that will benefit the patients.

The Pacific Knowledge Systems (PKS) product, Lab Wizard, like other decision-support tools on the market, is a case-based system and can be applied widely – to lymphoma, cystic fibrosis, breast cancer and range of other dis-

eases. Using Lab Wizard a clinician can analyse test results and build a set of flags which allows him or her to pull together the vast amount of information acquired and start to make sense of it.

Having done that, the clinician can construct a very personalised, very directed interpretation of the results. At present, the exercise of capturing the relevant knowledge takes a great deal of time but, once that is done, the report is generated automatically as the data comes in. One of the major advances of such an approach is that it gives us the rules needed to capture the knowledge.

By using such an approach, the patient, by the time he or she goes to the specialist, has had the appropriate testing

done which means that the whole diagnostic process happens much more quickly.

Clayton Christensen says that for a disruptive technology to have a serious impact on healthcare, it has to be able to do three things:

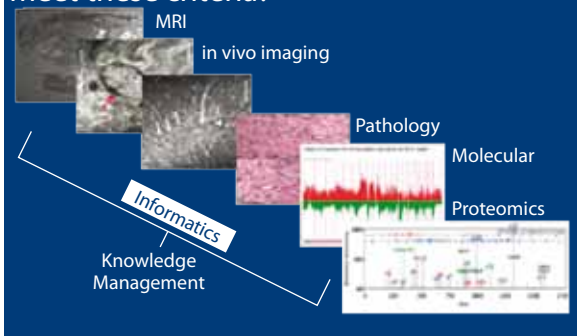
- first, it has to be able to shift a locus in which the healthcare is delivered by capturing knowledge and making it freely available in different sites;
- secondly, in order to do that one needs to support an inter-operable medical record; and
- finally, a disruptive technology must be simple and affordable.

Does knowledge management meet these criteria? If you look at the spectrum of what we are doing in terms of medical diagnostics, I think the answer is yes, provided we apply informatics at each of the levels shown in Figure 2.

In that way, data can be aggregated and sent to a knowledge management system so efficiently that there is now the real potential to alter the way we practise medicine and make it sustainable into the future and affordable. ◀

DR SHANE BROWN is the Medical Director of Pacific Knowledge Systems (PKS). He is a highly experienced senior management consultant in the Australian public and private health sector. He is a pathologist by training, with a long career in NSW health.

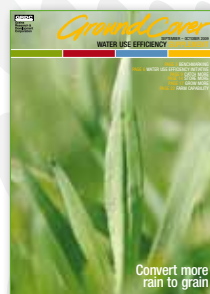
Figure 2 Does knowledge management meet these criteria?



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# Forecasting health futures and health costs

We need to recognise that our forecasts, whether they are optimistic or pessimistic, are vulnerable to a great deal of uncertainty



By Philip Davies

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PHOTO: iSTOCKPHOTO

In most areas of life, particularly in consumer goods, as technology develops the cost of goods goes down. So either we get the same functionality for a reduced cost or we pay about the same and get a lot more functionality. Motor cars, mobile phones and personal computers would be good examples.

In healthcare, on the other hand, technological development is generally associated with an increase in costs.

Why do new drugs and new diagnostic technologies tend to cost more? Perhaps because so often the price signals to the end user are concealed – we become more accommodating of cost increases because so much of the healthcare we consume is paid for by public or private insurance schemes.

Perhaps we shouldn't be too surprised that new technologies in healthcare seem generally to increase costs. If we look across the world we discover that richer countries typically spend an increasing proportion of their GDP on healthcare. It's not simply that a given percentage of GDP devoted to health in a rich country amounts to higher spending than the same percentage spent on health in a poorer country. Rather the percentage itself is likely to be higher in countries that are better off.

Healthcare can thus be viewed as what economists call a luxury good. As societies and individuals become wealthier, healthcare is one of the things that they choose to spend their marginal extra income on.

## Problems with forecasting

Perhaps what we are seeing with increasing healthcare costs is not a cause for alarm. It is just the fact that healthcare is something that is a good thing, and if we can afford more of it, we will spend more on it. That calls into question the doom and gloom forecasting about much



future levels of healthcare expenditure.

There are problems when it comes to forecasting in the health area.

**1** Our whole concept of what we mean by 'health' is not set in stone. The World Health Organization defines health as a total state of mental, physical and spiritual well-being. But what is "a total state of well-being"?

Our standards, our expectations change. In the 1960s a hip replacement was seen as last-ditch surgery. Now people have prophylactic hip replacements and many of us will have two or three such procedures in the course of our life. Our views on what it means to be well are very malleable and fungible, which makes forecasting very difficult.

**2** We also have to cope with changes in individual behaviour. Many projections of the burden of coronary heart disease would have told us to expect a much higher prevalence now but, largely because of what we have done in terms of diet, smoking and the availability of medications,

The last 10 years are the expensive years for healthcare.

the epidemic of coronary heart disease certainly isn't growing at the rate that we, at one time, expected it to.

Changes in individual behaviour also impact on the supply side. We see a lot of predictions of doctor shortages and nurse shortages. It is interesting to reflect on the fact that Australia first set up a medical workforce advisory committee to forecast our future need for doctors in the early 1990s. That committee's original plans and deliberations are now coming home to roost. We discover we have shortage of doctors – probably not because those people did their planning badly but because doctors' attitudes have changed. Their attitudes towards work, their willingness to stay in the workforce, their desire to work part-time or to have multiple careers have all changed in that intervening period.

So, both on the supply and demand side of healthcare, we have very unpredictable, unstable changes in behaviour that make forecasting very hazardous.

**3** Finally, we have changes in technology. With a lot of the changes in technology we are projecting smooth growth. But there are also disruptive changes in technology. The discovery of *Helicobacter pylori* as the cause of stomach ulcers was a step change in our understanding of that particular condition. The introduction of a vaccine for cervical cancer is another step change.

It is very difficult to predict when, how and where those step changes are going to occur. So, as we look forward, we need to recognise that our forecasts, whether they are optimistic or pessimistic, are vulnerable to a great deal of uncertainty.

### The last 10 years are expensive

Age is another issue – specifically the burgeoning numbers of people aged over 65. The question we need to consider is whether the growing aged population, expressed simply as the numbers over 65 or over 75, is a valid predictor of the pressures that our healthcare system will face.

There are two ways of looking at age. One is 'years from birth' – the familiar way. The other is 'years to death', which is arguably a better predictor of the demands that we place on the healthcare sector than years since birth. The conventional view, that healthcare spending is going to rise due to the increase in numbers of aged over 65, may not be correct. That view suggests that if people suddenly went from living to be 75 to living to be 85 the pressures on our health system would double simply because the numbers of people aged over 65 have doubled.

Another way of looking at this – the years to death view – is that the last 10 years are expensive. The last 10 years used to be 65 to 75. If we can keep those 65-year-olds as healthy as 55-year-olds are now, then we still have only the expensive last 10 years of life and those years of 65 to 75 are

Hospitals are about economies of scale – places where we can bring together a lot of skilled and talented people – and expensive equipment – and make sure that it is used to the fullest extent and efficiently.

lived in full or close to full health. Then, the simple measure of the number of people or the proportion of people aged over 65 is not necessarily a good predictor of the future costs of our health care system.

That raises the question of whether health spending really is 'out of control'?

We also need to bear in mind that spending on healthcare is typically a mixture of public and private spending and so is, to a degree at least, discretionary expenditure. I suspect if we looked at the growth in spending on aeroplane tickets, and motor cars through the 20th century we would see that that also grew pretty substantially. Likewise, if we look at spending on eating out of the home in the past few years we would see that growing quite substantially. Is that any more of a problem than the increased private spending on healthcare?

Perhaps we should be careful when we say that growing spending on healthcare is a problem. To the extent that it is discretionary spending on the part of individuals, then maybe we are choosing to spend our money on healthcare rather than movies or trips out to the restaurant. Public spending, on the other hand, is more of a problem and obviously for governments who are concerned about the tax burden, about international competitiveness, the growing public costs of healthcare are a concern.

Such concerns are probably accentuated in Australia by the way that we pay for much of our healthcare. The three big-ticket items on which the Commonwealth government spends health dollars are the Medicare Benefits Schedule, the Pharmaceutical Benefits Scheme and the subsidy for private health insurance. All three of those big-ticket items share one thing in common and that is they are essentially uncapped. People often talk about the MBS budget or the PBS budget. There is no such thing.

### Open-ended subsidy model

There is no figure above which the government will not spend on MBS, on PBS and on private health insurance subsidies. If more people go to the doctor, the government will pay more subsidies. If those doctors write more prescriptions, the government will subsidise more pharmaceuticals. If more people take out private health insurance, or pay higher premiums, the cost of the Commonwealth's subsidy will go up.

Perhaps the question we need to ask in the face of in-

creasing health costs is whether that open-ended subsidy model is sustainable?

We don't have to look too far to see another approach. New Zealand actually capped its national pharmaceutical budget for the past 10 years, under an agency called Pharmac, which is tasked with managing the nation's pharmaceutical use to live within a fixed annual budget, which is currently around NZ\$640 million.

So maybe Australia will see more pressure to contain those open-ended spending commitments, which would create a very interesting and challenging political situation.

What would it mean for technology? I think a lot of today's new technologies are about making services better, increasing coverage, improving quality, ensuring better patient experiences and delivering more effective outcomes – but they do so at an increased cost.

I suspect the technologies that are going to win through as we go into the future are those that can actually improve the quality of the patient experience and deliver better health outcomes, but do so at the same or, preferably, lower cost. If we do move to more constrained funding mechanisms, those are the technologies we need to be looking for.

Health financing does two things:

- first, it covers the costs of rare and costly events. All of us know that if we need heart surgery or if we are involved in a major accident, it would hit us pretty severely in the pocket. So when we pay for healthcare there is an element of insurance to protect us against the costs of rare, unpredictable and often expensive events.
- second, we want to make sure that everyone can get access to it – making health services affordable for the poor who wouldn't be able to afford even the most basic healthcare if and when the need arises.

It is interesting to consider that the funding of healthcare for the poor is actually more of an income supplementation issue than an insurance issue. It is what the economists call a transfer payment where, in common with other elements of social welfare, we transfer cash to people so they can buy essential goods and services.

Unless we are living with a chronic condition how many of us actually need a \$30 subsidy to go and see the GP? It's not very expensive, it's even quite predictable. It happens reasonably regularly. A colleague of mine once said "Insuring to go and see the GP is a little bit like insuring to get your hair cut".

So, once you start to tease apart these two components of health financing and then you project upon that the increasing predictability of health problems through all the gene-based forecasting, it does suggest that we need to start deconstructing and reconsidering the very basis on which we pay for healthcare.

Finally, the institutions – the organisational context in which all of this goes on – deserve some comment.

## Economies of scale

At the moment there are essentially three places where most of us go to get our healthcare – hospital, primary care (GP surgery or a community clinic) or care in the community (in our homes, workplaces and so on). I think the weakest link in that is the hospital.

Hospitals are about economies of scale – places where we can bring together a lot of skilled and talented people – and expensive equipment – and make sure that it is used to the fullest extent and efficiently.

But technologies change the whole basis of economies of scale. We used to go to the telegraph office to send our telegram and shared the telecommunications technology with others from our community. We then got the phone in the hall at home and shared it among our family. We now carry our own individual phones around with us. So the economies of scale in terms of how we communicate have really been transformed by technology.

So, 50 years into the future, there are good grounds to question the need for the conventional hospital, as we know it. Remember, we are talking 50 years into the future here.

The other group that I think may be vulnerable are our traditional primary care practitioners or GPs. As we move into a world where healthcare becomes more technologically dependent and multi-disciplinary, will the small business model of General Practice be viable? Paradoxically the same technologies that may call the business model of the hospital into question could also challenge the business model of general practice.

Looking at the future of healthcare provision, I wonder whether the hospitals and the primary care providers will actually merge and collapse into some new sort of high-tech connected clinic that we can access remotely and that provides the hub for delivering community-based services.

What we spend on healthcare is actually the result of individual choice plus societal views. We live in a democracy and we are not necessarily slaves to demography. We have the power of democracy to help us make decisions about how much we are going to spend on healthcare.

Healthcare expenditure is not out of control. We control healthcare expenditure as individuals or as a society. We have to make those decisions. ◀

**PROFESSOR PHILIP DAVIES** was Deputy Director-General in the Ministry of Health in New Zealand for a number of years before spending more than six years as Deputy Secretary of the Department of Health and Ageing in Canberra. He is now Professor of Health Systems and Policy at the University of Queensland.



# STELR Stage One begins ... Professional Development seminars for 370 teachers from 185 schools in March

## HELPING THE TEACHERS HELP THEIR STUDENTS THROUGH STELR

- In March, two teachers from each participating school will attend a two-day STELR professional development seminar to be held in Melbourne, Brisbane, Sydney and Perth.
- STELR provides teacher release funds and air fares and accommodation where appropriate for teachers to attend these seminars.



## THE STELR PROGRAM

- STELR is an exciting new curriculum program that aims to reverse the low level of interest among students in science courses and careers.
- STELR targets students in Years 9 or 10 – and their science teachers – and will be provided free of charge to 150 secondary schools from across Australia in 2010.
- STELR is a 6-to-10 week package involving inquiry-based activities. It engages students through investigations into global warming, climate change and renewable energy resources.
- STELR operates within the curriculum. It is intended for delivery to all students in the year level.

## 2010 PARTICIPATING SCHOOLS RECEIVE:

- a comprehensive set of curriculum materials, including teacher and student resources;
- a class set of solar and wind laboratory equipment (yours to keep);
- on-going support throughout the year.

Learn more about STELR at [www.stelr.org.au](http://www.stelr.org.au)  
or contact STELR Project Manager Peter Pentland  
(03) 9864 0906 or [peter.pentland@atse.org.au](mailto:peter.pentland@atse.org.au)

*"The STELR Project  
provides an exciting opportunity  
for schools to engage students'  
interest in science and sustainability  
issues in a practical way."*  
– Andrew Barr MLA, Minister for  
Education and Training, ACT.

The STELR Stage One Project 2009-2010 is supported  
by the Australian Government.

 **ATSE**  
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STELR is a key initiative of the Australian Academy of Technological Sciences and Engineering (ATSE) [www.atse.org.au](http://www.atse.org.au)



# Closing the gap in the skills set in healthcare

Physician assistants don't want to take full responsibility for patient care. They want to work for a 'taskmaster', the physician, and they want to have defined jobs



By Peter Brooks

p.brooks@uq.edu.au

**W**e know what the medical profession of the 21st century is going to have to deal with – chronic disease, ageing, new interventions, cost issues and communications in the context of this information age. Cost issues are really important but so is quality of life and any interventions, whether involving the use of new technology, knowing your genetic code or having health information about yourself on an electronic health record, needs to be looked at in that context.

One of the major problems around the world, until very recently, has been that we have run a medical system, not a health system. Health is much too important to be left solely

to the doctors – they are very conservative and have a very significant conflict of interest in a range of areas.

Robert Fogel, a Nobel Laureate in the late 1990s, predicted that most health systems around the world would be running at between 20 to 25 per cent of GDP by about 2025 and I think we are probably headed for that.

Health expenditure in various countries varies quite significantly and there is not much correlation between health-care costs and clinical outcome. In Australia, the healthcare sector is the second largest part of the workforce and will be the largest part of the workforce relatively soon.

We are also an ageing workforce, so what is the future?

According to the World Health Organisation figures we are 4.3 million health workers short in this decade alone, 2007–17. In Australia, the US and the UK 30 per cent of the medical workforce is overseas-trained. If we think we are going to solve the problem with the number of new medical schools that we have, we are being misled.

## Number of options

There are a number of options for increasing the workforce into the future – we can train more or we can look at role extension of health professionals.

We are seeing a lot more nurse practitioners and nurse-led clinics. In terms of carers, we are going to be 150,000 to 160,000 short by 2030. Now, where are we going to get them from?

It is constraining if we think we are going to get people to do all these tasks. We have to think of some sort of technology, because the people are not going to be there, so it is really important that we look very disruptively at how we are going to tackle this problem.

PHOTO: ISTOCKPHOTO



Physician assistants now number 70,000 in the United States.

## Contributions are welcome

Opinion pieces on topics of national interest will be considered for publication in *ATSE Focus*. Items between 800 and 1500 words are preferred. They must list full name, title/role, organisation (if relevant), city of residence and email address for publication. Please address to [editor@atse.org.au](mailto:editor@atse.org.au)

Extending the role of current workers is important, but we need to create new types of workers and to improve efficiency of those we have.

UK data suggests that a 30 per cent increase in the number of nurses in nursing schools makes about a five per cent impact on the number of nurses required 10 years down the track. If you increase the efficiency of every nurse by one or two per cent, you will decrease the need for those extra nurses by something like 40 per cent.

There are real efficiencies that we can build into the system, but in Australia this is hindered by the fact that there is too much money in the health system.

Running all the services that we run, the major teaching hospitals in London turn in a profit of between \$15 million and \$20 million a year. This indicates we have a real issue regarding a lack of efficiency and good business systems within our health system, whether it is for primary care or in the hospitals.

We spend what most countries spend, which is less than five per cent of our total healthcare budget, on prevention. The Alma Ata declaration of 30 years ago said to run a balanced health system requires about 30 per cent of your health resources to go into prevention, patient education, health promotion and disease prevention. There are only two countries in the world that do that – Vietnam and Cuba – and neither are democracies.

Most countries in the world are calculated to have significant shortages of workers in the 15 to 59 age group by 2020. Australia is about half a million short. China, because of its one-child policy, is 10 million short. The US is 17 million short. India is 47 million positive.

India acknowledges its resource is people and anticipates that is what it will export.

A number of groups are now proposing to some Indian universities that we train health professionals to Australian standards in India, using Indian clinical resources, and then bring them here. The Queensland Government is now looking at this option for nursing.

### Physician assistants

Physician assistants are a delegated healthcare model, which came out of the Vietnam War 'medics'. There are now some 70,000 physician assistants in the US and they contribute significantly to the US healthcare system.

The University of Queensland has just started the first physician assistant program in Australia. Those that want to become physician assistants are a quite different group to those who aspire to be doctors or nurses. They don't want to take full responsibility for patient care. They want to work for a 'taskmaster', the physician, and they want to have defined jobs.

The care provided through medical labour extension has to be comparable, effective and generate reasonable patient satisfaction, but it is important to maintain the medical primacy of diagnosis. What doctors are good at is the uncertainty of medicine. Medicine is not an exact science. Diagnosis and mapping out a treatment plan and reviewing that plan is paramount.

But, once that diagnosis is made, you can have other people, whether they are nurse practitioners or physician assistants, take on the ongoing care of those patients, referring to the doctor every now and again but having the support of appropriate systems and technologies.

Australia, like the UK, New Zealand and the US, has really started to look at the health workforce. We have put \$1.4 billion into the health workforce over the next four years and we have decided to adopt national accreditation of health professionals – things that will help drive the system. These changes will impact how we assess healthcare professionals, looking at competency-based assessment rather than time-based assessment.

I suspect we can teach physician assistants or other middle-level providers to do a procedure such as knee arthroscopy, via an assessment of technical skills, so that someone who was very good at doing this sort of thing, and wanted to be a knee arthroscopist, could be trained as an arthroscopist – for instance in a two-year course at UQ.

The driver is Medicare benefits, but if the system was changed so that practitioners were registered as arthroscopists only, then things might be different. Imagine this scenario.

### Outcomes of simulator training in laparoscopy

IN THE OPERATING THEATRE, SIMULATOR TRAINED RESIDENTS:

- performed the procedure 30 per cent faster; and
- made six times fewer errors.

STANDARD TRAINED SUBJECTS WERE:

- nine times more likely to fail to make progress;
- five times more likely to injure the gallbladder; and
- five times more likely to burn non-target tissue.

Source: Seymour & Gallaher, *Ann. of Surgery*, 2002

The 'dedicated' arthroscopist gets \$100 for doing an arthroscopy in about 20 minutes. After three or four years the arthroscopist wants to do knee replacements. We now have at UQ or the University of Melbourne this great 18-month course for doing knee replacements, which allows the arthroscopist to extend his/her skills into a new area. These 'dedicated' people, doing technical procedures all the time, become extremely good.

Is this something we could be looking at in 2025? Still having highly skilled professionals doing the procedures, improving access and doing it in a collaborative team based system – are we brave enough to take on the status quo?

One of the problems with health funding at the moment is that it is being predicated and driven very much by procedures. One of the most common procedures is the endoscopy.

Reimbursement is about \$500 for 20 minutes work. By contrast, for an hour-and-a half with a patient working through a very complex history, reaching a considered opinion and working out a management plan, a physician gets about \$130.

I think you actually reverse the funding – so that for doing the history in an hour and a half you get \$500 and you get \$100 for the endoscopy. I think you would change behaviours and you might suddenly find a whole bunch of medical students wanting to be physicians or general practitioners, rather than wanting to be proceduralists.

## Training issues

We also have to change the focus on teaching hospitals as the only place where you can train medical students. We have to train medical students and nurses in teaching hospitals but we also need to train them in the community.

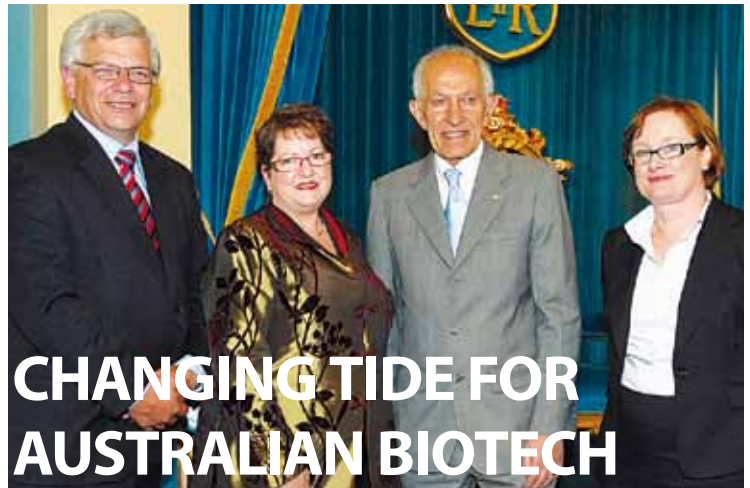
There are absolutely wonderful opportunities for clinical training in general practice primary care, which we don't use because it is too difficult.

Much easier to ring up the Royal Prince Alfred Hospital or Royal North Shore as the Dean and say, "Look, I have got 300 medical students that I want to train next term, can we send them over?" – rather than ringing up 150 different general practices.

We also have to invest in simulated learning environments. Surgeons who train in laparoscopy on a simulator actually have much better outcomes than those who train on patients. In terms of injuring the gall bladder and getting out of hospital more rapidly the results are really important.

Every time we step on a Qantas 747, we know that that pilot has had four crash landings in the last 12 months because that is what Qantas pilots have to do on a simulator. It has relevance for medical training. ◀

**PROFESSOR PETER BROOKS** is one of the doyens of healthcare in Australia and has worked over the years in a number of states and made major contributions both to its delivery and to the training of medical and paramedical personnel. He recently retired from the role of Executive Dean of Health Sciences at the University of Queensland to take on the new position of Director of the Australian Health Workforce Institute, which is a combined enterprise of the Universities of Queensland and Melbourne.



## CHANGING TIDE FOR AUSTRALIAN BIOTECH

AusBiotech reception at Government House, Melbourne. (Left to right) Victorian Agriculture and Small Business Minister Joe Helper, AusBiotech CEO Dr Anna Lavelle, Victorian Governor Professor David de Kretser AC FAA FTSE and AusBiotech Chair, Dr Deborah Rathjen FTSE.

By Deborah Rathjen

[drathjen@bionomics.com.au](mailto:drathjen@bionomics.com.au)

There were strong signs of life at the 2009 AusBiotech conference in Melbourne following a difficult year, marked by a significant decline in investment. Thrust into a 'perfect storm', local biotech companies endured a trying year as investors fled to the safety of low-risk investment options.

In order to survive the global financial downturn, many publicly listed biotech companies reacted by cutting staff, mothballing projects and reducing cash burn. A number of privately held non-listed companies went dormant, waiting to see when the private market would begin re-investing in programs while others delayed the start of clinical trials or cut back the scale of their R&D, in order to preserve their cash in the hope that the tide would turn and capital would become available again.

Despite this difficult operating environment, the Australian biotechnology industry has continued to mature. In the midst of some of the most difficult financial operating environments globally, there has been unprecedented advancement of innovative Australian biotech products towards market. At the close of the 2008–09 financial year, Australia had more than 130 ASX-listed companies with a market capitalisation of \$35 billion.

Australia's biotech sector is widely regarded as punching well above its weight, rating sixth in the world in biotechnology. Our medical discoveries have improved the quality of health for Australians and millions of people around the world with discoveries such as the Cochlear hearing implant, the cervical cancer vaccine (Gardasil) and sleep apnea devices (ResMed) just some of the sector's success stories.

The industry's emergence from the economic downturn was a focus at the conference. There has been a visible improvement in the state of the sector with a rise in both local and international funding of companies over the last three months, and a return of investor interest in the sector opening up a number of new opportunities for Australian biotech companies. Evidence of this can be seen in the Bioshares index, which tracks 111 ASX-listed biotech companies. In the September quarter the index rose 33.1 per cent, outperforming the ASX 300 Index, which rose by 20.1 per cent.

Continued on page 42 ▶





Australian Government

# THE PRIME MINISTER'S PRIZES FOR SCIENCE

## 2010 CALL FOR NOMINATIONS

Nominations are invited for the Prime Minister's Prizes for Science, which are offered to Australian citizens or those who hold permanent residence status in Australia.

The \$300,000 Prime Minister's Prize for Science is awarded for an outstanding specific achievement or series of related achievements in the physical, chemical, biological and technological sciences, mathematics and engineering. The Prize may be awarded to an individual or jointly to up to four individuals.

The \$50,000 Science Minister's Prize for Life Scientist of the Year and the \$50,000 Malcolm McIntosh Prize for Physical Scientist of the Year are awarded to two scientists at an early stage of their research careers, whose outstanding achievements are advancing, or have the potential to advance human welfare or society. To be eligible in 2010, nominees must have completed their PhD within the past 10 years i.e. the date of their testamur must be on or after 20 May 2000.

The \$50,000 Prime Minister's Prizes for Excellence in Science Teaching in Primary and in Secondary Schools recognise two teachers who have made outstanding contributions to science education in Australia. Nominees for these Prizes should be on the staff of a school and active in science education at the time of their nomination.

Nominations for the 2010 Prime Minister's Prizes for Science should be made by nominators who are personally knowledgeable of the nominated achievement and who can offer expert opinions on its worth. Self nominations will not be considered.

Closing Date: Friday, 21 May 2010, 5.00 p.m. AEST

Further information on Eligibility Criteria and Selection Information is available from:

Science Prizes Secretariat  
Department of Innovation, Industry, Science and Research  
GPO Box 5322  
KINGSTON ACT 2604

Phone: (02) 6270 2878 Fax: (02) 6270 2808

Email: [pmprize@innovation.gov.au](mailto:pmprize@innovation.gov.au)

Online Nominations: <http://www.innovation.gov.au/scienceprizes>



**JOHN O'SULLIVAN**

John O'Sullivan received the 2009 Prime Minister's Prize for Science for his achievements in astronomy and wireless technologies. Nearly a billion people use this WiFi invention every day, patented technology developed by John and his CSIRO colleagues, which

has made wireless LAN fast and robust. Today John is working on technology to enable us to look back almost to the beginning of time itself.



**AMANDA BARNARD**

Every new technology brings opportunities and threats and Nanotechnology is no exception. Using supercomputers, Amanda Barnard is predicting the shape, structure and stability of nanoparticles – materials a few millionths of a millimetre in size

– and testing how these materials interact in various environments. For her early career achievements in modelling nanoparticles she received the 2009 Malcolm McIntosh Prize for Physical Scientist of the Year.



**MICHAEL COWLEY**

For his contribution to our understanding of metabolism and obesity, Michael Cowley received the 2009 Science Minister's Prize for Life Scientist of the Year. Michael has shown unequivocally that losing weight is not just a matter of will power.

Together with colleagues at Monash University, he is discovering why obesity increases the risks of heart disease and diabetes while developing therapies to break the connection between these conditions.



OUTSTANDING ACHIEVEMENT IN SCIENCE – EXCELLENCE IN SCIENCE TEACHING



# Informatics – the future of medicine

Medical informatics has been defined as a new science of how clinical knowledge is created, shared and applied – a definition so broad that in 20 years every clinician might be an informatician



By Vitali Sintchenko

vitali.sintchenko@swahs.health.nsw.gov.au

Clinical knowledge is a key factor in the science of informatics and there are two key aspects – how this knowledge can be translated into clinical practice and how medical informatics is changing the way discoveries are made in medicine.

In the clinical arena, serious health problems are usually managed by very complex networks that cross boundaries between many bureaucracies.

Reference to a complicated infectious disease case in which I was involved highlights several issues in the decision space that is created when you manage complex patients. First of all, there is timely access to data and the amount of data that one could generate in such circumstances. In one case many specialists with expertise in different domains were involved – public health, laboratory medicine, infectious diseases, respiratory medicine, abdominal surgery and so on.

The communication load was extremely high because we had to manage a network of practitioners in different localities – on a state level, on a local area health service level, on the Commonwealth level as well as in the commercial sector, for example airlines, lawyers and accountants – to ensure proper case management. The case highlights issues (see Figure 1) in the decision spaces when you manage complex patients.

The amount of data we had was limited and the data quality was just barely sufficient for that amount of data. The turnaround time was not optimal because a lot of the tests were based on conventional techniques that are very time consuming and slow.

We could have managed the patient more rapidly and achieved better decision outcomes, essentially our ultimate goal, with more and better-quality data and communication systems.

The genomic revolution could provide this additional information and could improve the quality and rapidity of decision making.

Just as human beings differ in their genomes, so do bacteria. They behave differently and express different phenotypes – any observable characteristic or trait of an organism, such as its morphology, development, biochemical or physiological properties, or behaviour.

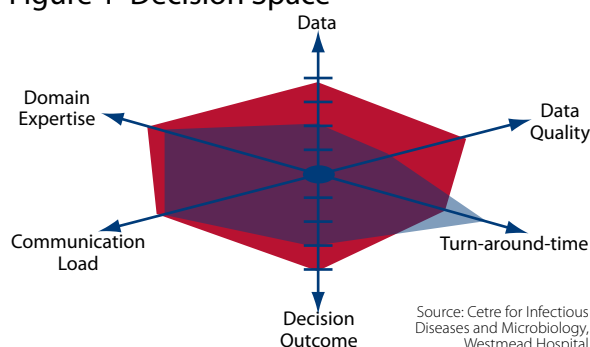
Most importantly, fitness (which is a composite measure of the capacity of the bug to cause the illness and to be transmissible from one person to another) depends on these changes in the genome as well.

This means that this genomic information produces pieces of knowledge which are not only important in patient management but also make an important contribution to preventive measures in a population space in preventive medicine.

Microbial sequencing would significantly improve our management of infectious diseases but it still remains a relatively new technology. Molecular imaging, tele-care and genetic testing are more advanced. Doctors are already starting to use these technologies and their impact on healthcare outcomes is likely to be quite high. Point-of-care testing, rapid tests that can be done at the bedside at the time of decision making, is another very promising technology. Virtual screening – such as a virtual colonoscopy – is obviously much better than real screening, from a patient point of view, at least.

All these disruptive technologies can link together

Figure 1 Decision Space



– healthcare delivery in one space. You can have smart homes with tele-care, smart hospitals with fully integrated electronic health records, smart GP's offices with point-of-care testing and electronic records.

In pathology we have certainly come a long way from very simple analysers that generated in order of 10,000 bytes per day to very high-throughput, massive analysers that generate terabytes of data that we have to process and analyse.

This represents a major bottleneck and a major challenge for healthcare because it means that clinicians have to consider a lot of facts for every decision in clinical practice to achieve the optimal decision quality. Previously we had a few findings. Now with genomics, proteomics, functional genetics and other 'omics' technologies, clinicians have to consider more information than is cognitively possible.

The data complexity model which we are facing now and, particularly, will be facing in the future is much more sophisticated and exceeds the capacity of the IT health resources available. This is certainly true in the Sydney West

where I'm based. It also exceeds the cognitive capacity of clinicians.

Figure 2 shows the information overload which indicates the need to change our learning styles from 'just-in-case' learning currently applicable in clinical schools and universities to 'just-in-time' learning. Consider the amount of information that is becoming available in the public domain. In the National Library of Medicine, PubMed for example, results of 55 clinical trials are published per day, more than 1400 papers are published per day in MedLine and more than 5000 in the rest of the biomedical literature. It's just impossible to cope. If one reads two papers a day one will be years behind very quickly.

Facing this dilemma, the University of NSW's Centre for Health Informatics has been working on these issues of data management, knowledge management and access to knowledge. Quick Clinical is one application which helps clinicians to find answers fairly quickly – within three minutes – by filtering queries using sophisticated and intelligent filters.

At Westmead we are providing clinicians with online guidelines and risk calculators. It doesn't include any genomic information at this stage but does include patient-specific information. Everything can be done on the intranet and it is potentially downloadable to a personal digital device so the range of tools that clinicians have started to use is increasing.

Data integration (Figure 3) is a major problem and what we need to achieve within the next decade, preferably quicker, is to integrate the genomic level of information which is essentially sequences (a very static view) with molecular information, with the tissue-level information, with organism-level information and population-level information to provide clinicians with decision support tools.

The challenge here, however, is that the methods of getting this information on different levels are very different. These are whole domains of study of different specialities in medical science, biomedical science and informatics. There are major problems to be overcome before this beautiful vision of fully integrated records and the linking of clinical patient specific data to changes in a human genome or the genomes of particular microorganisms is realised.

Our group at the Centre for Health Informatics at UNSW has produced an example of how to solve the problem. It was based on text mining of a huge body of literature which already exists in PubMed in a text format. We downloaded millions of extracts from that library and searched all these extracts for key words for entities, like names of genomes, names of microorganisms and syndromes or diseases. Then by recognising these entities in

Figure 2 The case for "Just-in-time" learning

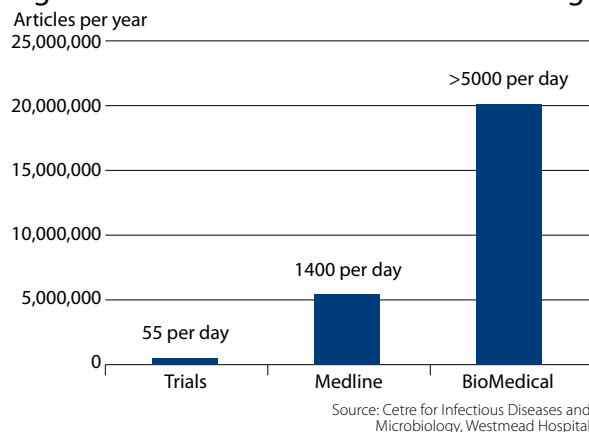
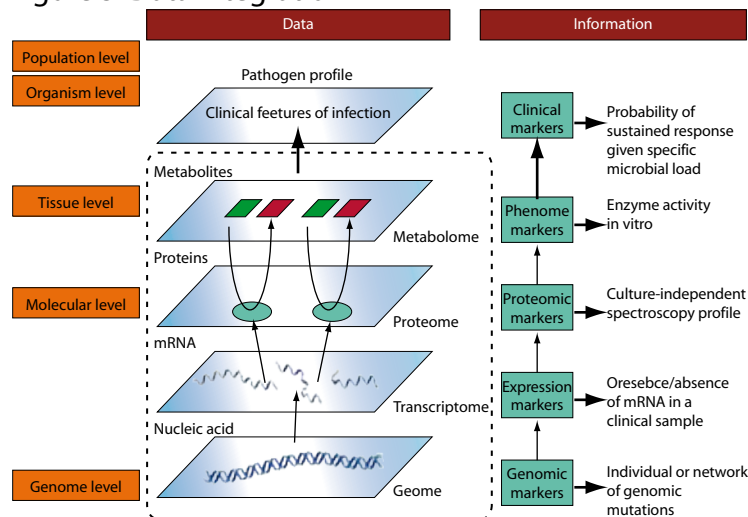


Figure 3 Data integration



a text we built networks, synthesised knowledge and represented this knowledge as a network linking the bug with different gene changes and conditions – essentially building a huge knowledge space – basically, the universe of infectious diseases.

With the genomic revolution and with other disruptive technologies there is a greater opportunity to provide clinicians with more and higher quality data. You can improve the turnaround time of clinical decision-making and you can improve decision outcomes. You have to manage expectations carefully, however. It is very unlikely that you can reduce the level of bureaucracy or reduce the size of the

cially. The public sector promotes free access to sequencing data while the commercial sector obtains patents on gene sequences.

The public sector argues that we have to have free access to all genome information but there are opponents to this view. This is a very important issue because, in the end, the shape that medicine or the healthcare practice will develop depends very much on outcomes of this competition between these two different approaches to knowledge development.

Accuracy of diagnosis has improved dramatically over the years and the art of diagnosis and clinical decision-making has become much more complicated. We see a

Medical knowledge in the 21st century is becoming more costly. We know that healthcare is under cost pressures but knowledge itself is becoming more costly.

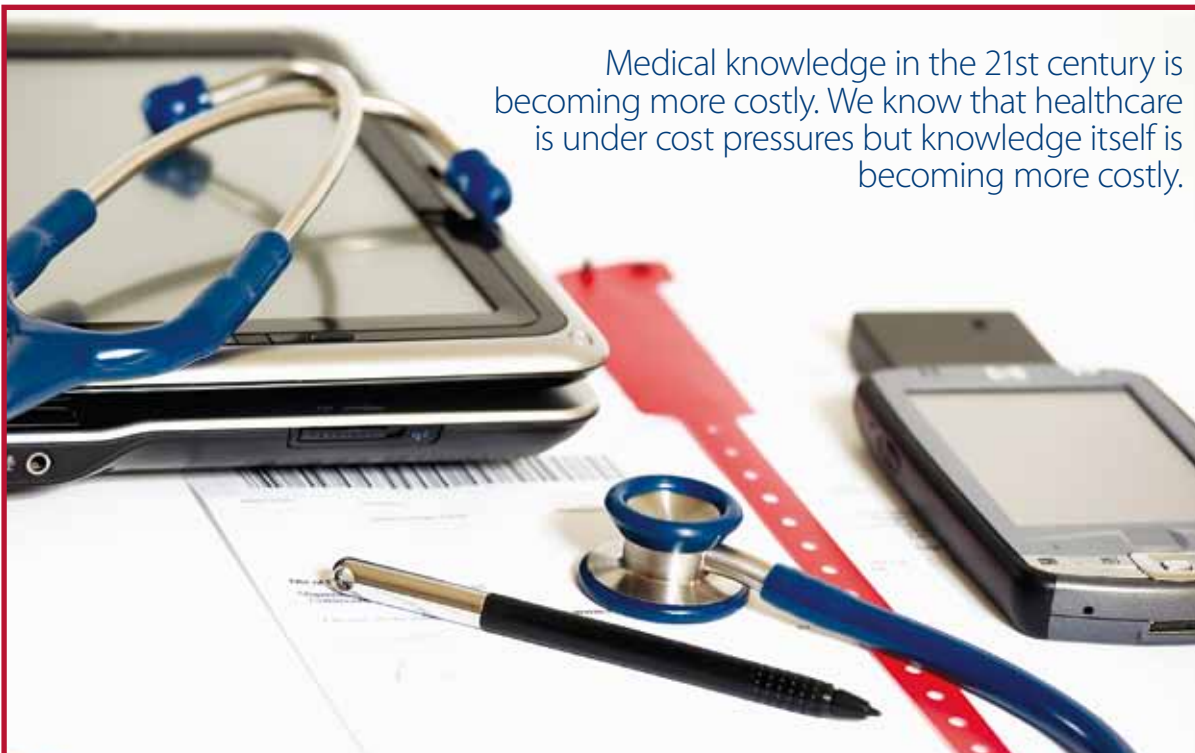


PHOTO: ISTOCKPHOTO

network but you can certainly improve decision-making and this is where genomics comes in.

Medical knowledge in the 21st century is becoming more costly. We know that healthcare is under cost pressures but knowledge itself is becoming more costly. Knowledge accumulates immense commercial value and there are concerns about the way this knowledge can be utilised in the 'knowledge market'.

Both the public sector and commercial sector views of the knowledge market promise better quality, higher reliability and a lower cost service but the drivers are different. Scientific credibility and benefits for human kind are the drivers of the public sector. The commercial sector has the different drivers of share price and market penetration. Free, open access to information is a major characteristic of public access data release but there is restricted access to communication and proprietary software used commer-

patient usually for a very short period of time. We need very quick access to a lot of information to make decisions rapidly and move on.

Informatics can change the way discoveries are made because these techniques can generate hypotheses very efficiently as an alternative to the scientists generating their own hypotheses. They enable a more dynamic view of disease and they certainly enable new knowledge communities, e-research or e-science communities, which could bring a major change in the way we develop healthcare technologies. ◀

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# Tackling obesity

## A weighty issue

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MONASH University



# Disruptive technologies and healthcare

It is critical to increase the efficiency and effectiveness of the available health workforce, and to improve its distribution.



By Margaret Hartley

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**A**t the beginning of the 20th century acute illness (infectious diseases, diseases of early childhood and maternal morbidity) were the major cause of death and challenge to our healthcare system.

Improvements in medical knowledge, technology, diagnostics, and pharmaceuticals meant that from the mid to late-20th century the major cause of mortality and morbidity shifted from acute illness to chronic illness (for example, cardiovascular disease).

The cost of managing chronic disease is estimated to make up some 75 to 80 per cent of the total health budget in Australia with a very significant proportion in the last 12 months of life. In response, the adoption of preventative health care policies and practices, self-management by patients and medical interventions are all integral to today's management of chronic illness.

As we enter the 21st century the focus in Australia is, in addition to chronic disease management, on wellness management within an ageing population.

We spend 9.7 per cent of GDP (currently \$85 billion) on healthcare in Australia and this is variously projected to increase to between 14 per cent and 22 per cent by 2030. The drivers for these projected increases include greater community expectations with an increased standard of living and the 'baby boomer' population bubble entering the ageing population, forcing a major increase in overall cost by volume alone.

As identified in the Productivity Commission's Research report *Australia's Health Workforce* (January 2006) "... the demand for health workforce services will increase while the labour market will tighten. New models of care will also be required. It is critical to increase the efficiency and effectiveness of the available health workforce, and to improve its distribution."

While this demand on the healthcare system has shifted, and continues to shift, with time, the underlying culture of the system has remained relatively static. It is based on medical interventions, acute care and assistive tech-

nologies such as devices and diagnostics and treatments, supported by allied industries (insurance, pharmaceutical supply, biotechnology) and government regulation.

The delivery infrastructure, patient flow and pricing of the healthcare system are thus integrally linked with the stakeholders who work within, and with, the system. It is strongly 'silo'-based with limited exchange of information and little resource sharing. This has limited the capacity for wider inputs (including on realising the full potential of disruptive technology) when governments have sought advice on how best to reform the healthcare system.

Reviews therefore involve recommendations for "evolutionary" change where what will be needed is revolutionary change to achieve the desired outcome of an "agile and responsive and self improving" health system. There must be alternatives to 'business-as-usual' if we are to handle the problems effectively and efficiently.

Disruptive technologies have been proposed as key triggers for reforms aimed at making healthcare and, particularly, chronic disease management more effective, cheaper and better able to assist consumers to determine/participate in their health outcomes.

## Why disruptive technology?

Australia's healthcare system has been quick to adopt supportive/assistive technologies but slow to adopt disruptive technology platforms. To date, technology innovations in medicine and healthcare have tended towards high cost and/or high complexity technology and, in general, neither costs nor complexity tend to reduce over time.

PCs are a good example of a powerful innovation that disrupted other industries by enabling a larger population of less skilled people to do, at a cheaper cost and in the convenience of their own home/work site, things that historically could only be performed by high-cost specialists in centralised dedicated locations (usually inconvenient to the majority or large subsets of the population).

It will be this type of innovation that similarly disrupts

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New technologies offer capacity to support an accessible medical record, improve diagnosis and enhance effective treatments.

the 'business' and/or organisation of healthcare services and that can drive improvements in healthcare delivery, use and outcomes.

If we are to deliberately disrupt the healthcare system however, we must also have some idea of what needs changing/fixing. Further, we need to consider how disruptive technologies will impact on providers, clients, community, regulators, industry and governments so we can plan, and manage these impacts.

### What's possible?

Technological revolutions in health information management, in genomics and personalised medicine are a reality. The 'biotechnology revolution' sees the merging of biology with information technology and is developing at an accelerating pace. This provides us with a window of opportunity to transform our health care system. Thus, biotechnology as a core sector is set to have an even greater impact on the future of healthcare in the 21st century than ICT did in the 20th century.

Genomics offers personalised medicine which, in effect, is a customer-driven approach to healthcare. Developments in DNA sequencing techniques, so that a person's genome can be reliably characterised at low cost, will offer real opportunities in health prevention, early identification of diseases and tailored treatments that would reduce costs while maximising patient outcomes.

The medical information revolution (medical informatics) delivers us a new 'science' of how clinical knowledge is created, shared and applied – its potential to disrupt lies in its capacity to facilitate translation of knowledge into clinical practice. Given that serious health problems are effectively managed by knowledge networks, medical informatics enhances the data/knowledge capacity of the network and extends who can interact with the network regardless of their location. This allows such access and interaction to be remote from traditional network locations (typically hospitals) while maintaining and enhancing

available knowledge. Informatics increasingly allows the collection of only relevant data for presentation and thus mitigates the growing problem of 'information overload'.

Further, developments in bio-engineering, knowledge systems, information technology, and remote tele-medicine have the potential to be disruptive technologies if adopted broadly. Tele-health and home monitoring technologies are assistive technologies that support long-distance clinical healthcare, patient compliance, patient and professional education, public health outcomes and health administration. They allow for a prolonged 'ageing in home', maintaining independence and quality of life for the elderly and should be vigorously pursued.

These technologies offer capacity to support an accessible medical record, improve diagnosis and enhance effective treatments, shift the locus of care towards more convenient and less costly places, and improve both patient satisfaction and health outcomes at reduced cost. Further, personalised medicine linked to integrated diagnosis has the potential to expose sub-optimal health care and the unnecessary costs associated with it.

In addition to improved diagnosis and treatment, these technologies will support our capacity to age well and in the home, by providing security and safety and a range of assistive technologies. Telemedicine will also give some respite to overburdened hospitals.

Application of disruptive innovations will mean we need to change the current assumption behind forecasting health demands in the future – not simply extrapolate the problems of today. Should the future see preventative technologies and medicine make gains in terms of improvement in the health of our aged population, then, rather than the predicted health burden crisis posed by the ageing population, it may be that we will see a stable sustained healthcare demand.

### The challenges

No one disruptive technology alone is going to deliver the reform needed to create an agile, responsive and self improving health system for future generations. It will be the convergence of technologies (bio-engineering, personalised medicine via genomics, knowledge systems, information technology, remote tele-medicine) that will deliver the changes on the scale and in the time frames we seek.

Patients will also need to be better equipped to understand and access the enhanced data pool they will have available as a tool to seek better services. Future clinicians will need to become more proficient in interacting with well-informed consumers. These consumers will have access to large amounts of information and seek to use their purchasing power as a consumer to dictate their healthcare

delivery and positive outcomes at a lower cost – despite the fact that community expectations based on increased knowledge are one of the drivers of increased costs today.

Training and workforce planning will need disruption as well! The healthcare sector is the second-largest employer in Australia and health is framed within a medical model. The healthcare system is fragmented in terms of roles and responsibilities and disruptive technologies will shift some healthcare areas away from complex, high-cost institutions and specialised professionals operating in ‘silos’.

The new focus will be on having a continuum of care providers where the specialist/physician/GP/nurse practitioner/nurse/technician/assistant’s skill level is matched to the complexity of the medical problem. This allows for less expensive professional groups/technicians to be introduced, undertaking progressively more sophisticated tasks in less expensive settings. Governance and clinical practice frameworks would be essential to ensure the standards of health care and outcomes are maintained.

For disruptive technologies to deliver the promise they offer they must be clearly understood, socially accepted and deemed to be safe. Regulatory and funding mechanism re-

forms will be needed across the healthcare system to adapt and drive change while maintaining clinical standards, patient protection and safety and quality outcomes. ◀

*ATSE has established a Health and Biotechnology Working Group as a platform for further study and sound information and advice. The Working group will be the basis for ATSE’s engagement with relevant stakeholders and decision makers to encourage the realisation of the potential of Disruptive Technologies in delivering healthcare reform.*

**DR MARGARET HARTLEY is the Chief Executive Officer of ATSE. She leads the Academy’s National Office in delivering its strategic goals and driving technological solutions to key problems facing Australia today. Dr Hartley has a strong background in health, safety and environmental regulation leading and managing Australia’s chemical regulation policy framework, and developing and implementing related health policy. She was the Principal Scientific Advisor to the Australian Government Department of Health and Ageing and the Director of the Office of Chemical Safety and served on Australia’s National Drugs and Poisons Scheduling Committee. Prior to her 23 years in Government, Margaret held research positions in pharmacology and epidemiology.**

## SMART TECHNOLOGY FOR HEALTHY LONGEVITY

The Academy’s Project *Smart Technology for Healthy Longevity* will deliver a key input into aged healthcare planning in Australia, focusing on some key issues:

- increasing impacts on the aged population of the consequences of climate change such as increased temperatures, natural disasters and vector-borne diseases, as well as infectious diseases;
- the wish of most aged people to live independently and need suitable housing and support;
- the fact that currently most houses are clearly not user-friendly for the aged;
- the anticipated shortages of carers, with a predicted shortage of 153,000 formal and informal carers for dementia patients by 2029; and
- the care of people in rural areas and in the indigenous sector.

Australia is in a good position generally in regard to the state of technology for ageing, but the application of technology is trailing far behind its potential – so there is limited application of technologies in the assistive areas for the elderly.

Some of the contributing factors that have caused this dichotomy are:

- poor definition of needs;
- lack of acceptance of the technologies;
- poor design; and
- cost issues.

A key aspect of the Academy project is converging technologies. There are clear opportunities in the combination of nanotechnology, biotechnology, information and communications technologies and cognitive sciences. It is the convergence of those technologies that offers real prospects to assist independent and assistive living for the ageing.

Preliminary findings show there are some major funding issues between Federal and state governments and that there is a lack of a clear policy on ageing.

The project will classify possible opportunities in the application of technologies for the aged under three headings – Security and Safety; Diagnosis and Treatment; and Assistive Technologies – which will be mapped into short, medium and longer-term time frames.

The Project report will map out future

issues associated with applying available technologies – identifying significant areas for R&D in Australia and the opportunities that exist for industry to develop and apply existing and new technologies.

The Academy will identify opportunities for international collaboration and for more coordination of the enormous amount of work going on in Australia but most of it is in isolated pockets.

A likely recommendation is the establishment of an interdisciplinary centre or institute to coordinate the various nodes of activity and to develop a level of critical mass and momentum in the area.

The Academy also expects to make some observations on the need for a national policy on ageing at home, design concepts for new smart homes and retrofitting existing homes, the development of an appropriate public policy framework and the funding of that policy.

The Academy report will be completed towards the end of the first quarter of 2010. ◀

**By Dr Vaughan Beck, Executive Director – Technical, ATSE**



# The challenge of ageing in Australia

There is a great deal of excellent research on technology and ageing in Australia, but it is uncoordinated and needs a focus around gerontechnology as a discipline



By Greg Tegart

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All industrialised and many developing countries are experiencing a demographic transition from predominantly younger populations to a much larger proportion of old people. This has resulted from a decrease in fertility rate due to societal changes coupled with an increase in life expectancy due to better diet and healthcare.

The rate at which this transition is occurring varies from country to country depending on fertility rate and rate of immigration. The change is more rapid in countries with little or no immigration (like Korea and Japan) than in countries like Australia, with a vigorous immigration program.

In the latter case, demographic behaviour is strongly influenced by the contemporary economic and social situation. When the economy is unfavourable, births are delayed and migration falls. When the economy is strong, birth rates rise and new migrants are attracted.

Thus estimates of future demography need be linked to future economic and social trends. In broad terms, the outlook is that the Australian economy will be strong across coming decades with the sustained economic growth of China and India underwriting continued growth of the Australian economy and therefore of the population.

On this basis, the latest projection from the forthcoming *Intergenerational Report* indicates a population of 35 million by 2049 with the percentage of people over 65 rising from about 11.5 to 22 million and the percentage of those over 85 from about 1.5 to 5.0 – which translates to 7.7 million aged over 65 and 1.8 million over 85.

An inevitable consequence of increased age is the progressive decline in the functional capacity of organs and muscles. However there is a wide variation in the rate of decline at various ages. Although the percentage of people aged 65 and over is increasing, it is the 'oldest' old, the 85 plus, that is the growing cohort. These are the frailest, and experience the highest incidence of diseases and of disability.

Thus in 2003 while about 21 per cent of the population aged 65 and over had a profound or severe disability,

the proportion increased to 65 per cent for persons aged 85 or above. As an example of future demands for care, while dementia is rare in people under the age of 65 years, rates increase markedly with age. With almost 40 per cent of those with dementia aged 85 years and over, the projected increase in the 'oldest' old segment will lead to a dramatic rise in dementia cases.

In itself, ageing has been historically a relatively minor driver of rising health costs. Non-demographic factors, particularly increasing utilisation of services and the use of new and expensive technologies, have been the major source of rising health expenditure over the past 20 years.

Real per capita spending has been increasing for all major components of government health expenditure. This has arisen because rising incomes, while providing the capacity for increased government funding of healthcare, has created greater expectations of better treatments and investment in new health technologies to improve and prolong people's lives.

Since older people use more health services, the impact of costs arising from demand and new technology is amplified by a greater proportion of aged in the population.

There are a variety of living environments to which people may progressively move as they age. The so-called 'continuum of care' is – home, independent apartment living, assisted living facility, skilled nursing facility and 24-hour care unit. Each move along the continuum escalates the cost of care and may alter quality of life.

Although some people downsize or move into an aged-care facility, more than 80 per cent of people aged 65 and over live independently. Of these, some 40 to 50 per cent are estimated to live in lone-person households. The desire to maintain independence in one's own home (ageing-in-place) is routinely identified as a passionate priority by people as they age. Apart from maintaining their quality of life, such a situation provides economic benefit to society as a whole by reducing the public resources devoted to aged care.

## Role for technology

There is clearly a need for change in the approach to elderly care at home to a culture of ageing-in-place. This involves considerations of security and safety, diagnosis and treatment, and assistance with mobility and social communication. All of these can be dealt with by using technology.

A wide range of products already exists such as safety and security technologies: fall detection; mobility aids; smoke monitors; door locks; treatment-monitoring; telemedicine; health medication compliance; social connectedness – mobile phones, video and email; mobility-warning systems for older drivers; and safer transport vehicles.

However, despite the availability and general affordability of these products, the market penetration, apart from mobile phones and computers, is small in the existing cohort of elderly people. There appear to be a number of factors which contribute to this situation in the general categories of how user needs and markets have been defined, how products have been designed and how the services are currently delivered to the home.

New approaches that link technologies such as information technology, biotechnology and nanotechnology more closely with aged-user needs can create new and more acceptable products. Europe moved strongly in this direction a decade ago with the concept of 'gerontechnology' to describe the linking of technologies with medical studies of ageing (gerontology) and there is now a strong International Society of Gerontechnology.

The growing importance of this situation in developed economies has stimulated engineering academies and professional engineering bodies in various countries such as the UK, France, Germany and the US to produce reports recently detailing approaches and priority areas of research applicable to their situations.

In Australia, Engineers Australia has a group working in this area on assistive technologies but there is no recognition of gerontechnology as a discipline. All the reports call for greater government recognition of the impact of the ageing population on their societies and for increased support of development and application of technologies to provide solutions.

## Role for ATSE

The award of a grant from the Australian Research Council under the Linkage Learned Academies Scheme has provided the opportunity for ATSE to look at the state of technology for aged people overseas and to compare it with the situation in Australia to identify opportunities for Australian researchers and industry.

The current Academy's *Smart Technology for Healthy*

*Longevity* Project – now nearing completion – uses the expertise of Fellows and invited experts to provide an informed view of the future situation of technology for ageing-in-place in Australia.

The Project is being led by me, together with Professors Terry Turney FTSE and Peter Hudson FTSE, and a steering committee chaired by ATSE Vice President Mr Peter Laver AM FTSE. A questionnaire has been sent to Fellows and workshops have been held in Brisbane, Sydney and Melbourne. Discussions have been held with researchers, practitioners, associations and government officials.

A valuable input was the recent EU/Australia Workshop on the topic in Paris which enabled a delegation of 12 Australians to meet with their counterparts in France, Germany, the UK, the Netherlands and the Czech Republic. This was funded by a grant from the Department of Innovation, Industry, Science and Research as an activity under the EC-Australia S&T Cooperation Roadmap and was organised by ATSE, the French Academy of Technologies and EuroCASE (the European Council of Applied Sciences, Technologies and Engineering).

The Project report is still being completed but some preliminary findings have emerged:

- there is a great deal of excellent research on technology and ageing in Australia, but it is uncoordinated and needs a focus around gerontechnology as a discipline;
- in telemedicine, Australia is a leader in applications for rural communities but commercialisation of local research is difficult;
- Australian research on management of chronic diseases at home and on prevention of falls is excellent but needs wider application;
- in the area of aids for vision and hearing, Australia is first-class;
- Australia is lagging in application of elderly-friendly housing and smart homes for the frail aged, but a number of significant projects are well advanced in planning; and
- development of a national broadband system offers great opportunities for application of e-health and for greater inclusion of the frail aged into society. ◀

**PROFESSOR GREG TEGART AM FTSE** retired from the Australian Public Service as Secretary of the Australian Science and Technology Council. Since then he has been a Visiting Professor of Science Policy at the University of Canberra and is currently a Professorial Research Fellow in the Centre for Strategic Economic Studies, Victoria University. He was Founding Director of the APEC Centre for Technology Foresight in Bangkok in 1998 and retired as Chair of its International Advisory Board last year.

# Telehealth technology to manage chronic disease

Telehealth is broader than telemedicine – where telecommunications are used in remote diagnosis – utilising a broad range of ICT technologies to manage disease and wellness



By Nigel Lovell

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In developed countries, chronic disease now accounts for more than 75 per cent of healthcare expenditure and nearly an equivalent percentage of disease-related deaths. The burden of chronic disease (often, but not exclusively, associated with ageing) includes congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), asthma, hypertension and diabetes.

Over the past 50 years there has been an epidemiological shift in disease burden from acute to chronic diseases that has rendered acute care models of health service delivery inadequate to address population health needs.

In response to these changes in disease demographics and the economic imperatives caused by an ageing population, service delivery models are shifting their focus from episodic care to continuity of care, from institutional care to community and home-based care, from disease treatment to disease prevention, and from an individual approach to a multidisciplinary team approach.

To support this change of focus, information and com-

munications technology (ICT) infrastructure is required to facilitate shared services such as virtual health networks and electronic health records, knowledge management (care rules and protocols, scheduling, information directories), as well as consumer-based health education, demographic data, clinical signs monitoring and evidence-based clinical protocols.

The application of a broad range of ICT as it applies to managing disease and wellness is termed 'telehealth'. It is broader than the concept of 'telemedicine', which is typically defined as a system of healthcare delivery in which physicians examine patients through the use of telecommunications technologies – remote diagnosis. Telehealth incorporates a wider range of health-related activities including patient and provider education, point-of-care diagnostics, clinical decision support services and, most importantly, provides tools for self-management of disease and wellness.

The work of our research group in the telehealth area dates back about 15 years. We began by designing appropriate technologies for use in primary healthcare. There are many examples of ICT applications in chronic disease management. However, many are ill-conceived in that they are driven by the underlying technology and not by a clinical problem that needs to be addressed.

In 2001 we began to trial home telecare technology for the management of chronic disease. At that time much rhetoric existed about the perceived patient benefits and potential cost savings of the 'tele' word when applied to healthcare:

- how important is the clinical need in terms of improving health care and reducing current costs?
- does the proposed technology impact significantly on the clinical problem?
- is there adequate input from all stakeholders including patient groups and end-user representatives?

Surprisingly in many forums the questions being asked then are still being asked today.

Over the past eight years these technologies have been commercialised in Australia by a start-up company

Professor  
Branko Celler,  
one of the  
inventors of  
TeleMedCare's  
telehealth  
system, using  
the device  
to record  
an electro-  
cardiogram.





(TeleMedCare Pty Ltd, [www.telemedcare.com.au](http://www.telemedcare.com.au)) and extensive product and clinical trials have been under way both in Australia and the UK.

The key goal of TeleMedCare was to turn rhetoric into reality. While it was and is an evolving process, appropriate home telehealth technologies were engineered into health-care solutions that were then integrated with existing health service delivery models.

These systems were researched, constructed, trialled and evaluated with support from both the Federal and State Governments and from the Australian National Health and Medical Research Council.

A range of health management solutions are now being sold and deployed throughout Australasia to hospitals, local health authorities, residential aged care facilities, community care centres, medical insurers, health and lifestyle centres and individuals.

Just as the clinical interventions when managing chronic and complex disease require a holistic approach, so too does the home telehealth approach. Why has this approach gained success in Australia while others have not?

There exists no single silver bullet for design of an effective telehealth system. The chronic disease conditions by their nature are complex and multi-factorial – and so too are the requirements for a telehealth management system.

The critical issue in deploying a usable system is to firstly have a deep understanding of the healthcare sector and to use this understanding to appropriately hide the layers of complexity from the end-users. A patient interacts with the system by way of scheduled measurements and medication reminders. By default, a clinician views management reports only on his or her patients with adverse or deteriorating clinical measurement trends.

From a systems viewpoint, to make such complex tasks appear simple and be time and cost-effective requires a convergence of many factors – integration of innovative, low-cost sensors to perform clinical measurements; scheduling for medications and measurements; a longitudinal history of past measurements and appropriate tools including targeted patient education to facilitate patient self-management; remotely maintainable client-side software; and web services for case management by healthcare workers and administrators.

Research and trials in Australia and the UK have clearly demonstrated that the TeleMedCare system is a viable and important way of providing monitoring and follow-up care to patients suffering the burden of chronic disease.

Studies have shown that nearly 90 per cent of the care a person needs to manage a chronic disease must come directly from the patient. Self-management interventions, such as self-monitoring, patient education and feedback,

and decision making, lead not only to improvements in health outcomes, but also to increased patient satisfaction and reductions in hospital bed days and carer visits.

As an example, a study of 13 COPD patients being monitored for a year in the UK (Norfolk Primary Care Trust) showed, with the use of telehealth, that both hospital admissions and hospital bed days could be reduced by 70 per cent and that the need for GP visits could be halved, without comprising patient wellbeing.

Another essential, on-going task is the development of a decision-support framework to enhance the health carer's review of the remotely acquired monitoring data and to support the clinical decision-making experience.

The amount of clinical information that can be generated from a telehealth monitoring system is substantial and comes in several modalities (physiological, questionnaire, medication data and so on). Analysis of these data and correlation with clinical history by the decision-support system will be used to highlight important sections of patient results, provide summary analyses and recommendations and will assist in the efficient review and risk stratification of multiple patient results.

The health carer will be automatically alerted if any of the monitored data indicates deterioration in the health status of a patient. Furthermore, outputs from the decision-support system can be used to influence changes in workflow.

The path to creating a comprehensive and holistic home telehealth system is hugely integrative and complex. It is only now after a decade of intense development and trialling that we are beginning, in a controlled and automated way, effectively and efficiently to close the clinical care management loop.

Such modifications to the clinical care workflow will flag the way for the next generation of home telehealth. ◀

*Professor Lovell spoke on 'Telehealth technologies in the management of chronic disease and healthy ageing' at the Europe–Australia workshop on Smart Technology for Healthy Longevity in Paris in October 2009.*

**PROFESSOR NIGEL LOVELL** is currently Professor of Biomedical Engineering at the Graduate School of Biomedical Engineering, University of New South Wales. He has authored more than 300 refereed journals, conference proceedings, book chapters and patents and been awarded more than \$65 million in R&D and infrastructure funding. His research work has covered areas of expertise ranging from biological signal processing, biophysical modelling, and design and commercialisation of medical device technologies. This includes successful commercialisation of a range of telehealth technologies and leading an R&D team working on a visual prosthesis (bionic eye).

# Medical bionic technologies – the next generation

Minister Carr's recent announcement of \$50 million in funding to develop a bionic eye injects critical funding into an Australian flagship technology



By Robert Shepherd

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**M**ost informed Australians are aware of this nation's successful development of the bionic ear that restores hearing for deaf recipients, but few would realise that the Australian company Cochlear Ltd has held at least 70 per cent of the market share against fierce US and European competition since its inception 25 years ago.

This success is a reflection of Australia's high quality translational research and Cochlear Ltd's excellence in biomedical engineering, commercialisation and marketing.

The medical bionics industry, primarily centred around the development of implantable neurostimulation devices, is undergoing massive growth in the US, Europe and Asia.

Cochlear's bionic ear remains the most sophisticated medical bionics device commercially available, although other commercial devices include spinal cord stimulators for the treatment of chronic neurological pain, vagus nerve stimulators for the suppression of epileptic seizures and deep brain stimulators (DBS) for the treatment of movement disorders associated with Parkinson's disease.

Collectively, these products form the nucleus of a significant and rapidly growing market. For example, in 2005, the total US market for neurostimulation products (including bionic ears) was estimated at \$830 million. This market is expected to grow at a compound annual rate of 17 per cent, reaching more than \$1.8 billion in 2010, with the potential to double or triple over the following decade (Medtech Insight Report A577).

In addition to this existing market, other devices are currently undergoing development. These include retinal prostheses for the blind ('bionic eye'); functional electrical stimulation for restoration of limb movement as well as bladder and bowel control; DBS for severe depression and morbid obesity; cortical prostheses for the detection and suppression of epileptic seizures; vestibular prostheses for the correction of balance disorders, and brain computer interfaces that sense and use neural signals to partially restore control, communication and give independence to paralysis victims.

## Cooperative, outcome-oriented culture

Medical bionics is a rapidly emerging field of translational research with direct clinical and commercial application. Through the development of the cochlear implant Australia has played a leadership role in this technology. The Government's injection of \$50 million to develop a bionic eye is an important contribution in maintaining Australia's lead in a flagship technology.

Bionic Vision Australia (BVA) ([www.bionicvision.org.au](http://www.bionicvision.org.au)) will receive \$42 million over four years to develop a neurostimulator designed to target neurons in the rear of the eye (the retina) to enable vision to blind patients suffering from degenerative retinal conditions. BVA consists of the University of Melbourne, the University of New South Wales, National ICT Australia, the Centre for Eye Research Australia and the Bionic Ear Institute, as well as collaborators from the Australian National University and the University of Western Sydney. A second team, made up of researchers from Monash University and the Alfred Hospital, will receive \$8 million over a similar time frame to develop a neurostimulator designed to directly excite neurons in the region of the brain that processes visual signals (the visual cortex). Collectively, these projects will stimulate the development of clinically significant devices and contribute important new technologies and knowledge to this field.

Medical bionics operates at the intersection of neuroscience, computer science, engineering, medicine and clinical research. Success in such a multidisciplinary environment demands continual communication, a high level of collaboration and an outcome-oriented culture.

For the field to stay vibrant we must attract and inspire secondary students to study science and engineering. This is particularly significant given the great public interest in new developments in medical bionics. Moreover, it is equally important that young scientists, medical doctors and engineers within our organisations receive the key inter-generational support, encouragement and transfer of

skills from those that have gone before them.

Our mentoring experience at the Bionic Ear Institute has been very positive. Our postdoctorate and PhD students are working alongside experienced researchers who played significant roles in the development and commercialisation of a number of medical devices, including the bionic ear. For example, our six Research Professors collectively have more than 180 years' experience in the field that includes 35 years of direct commercial experience, more than 80 patents and nearly 700 peer-reviewed papers. That is a significant amount of knowledge to transfer!

## The research platform

The Bionic Ear Institute has invested consistently in the development of the bionic ear for more than two decades and the team has developed expertise in a broad range of disciplines. The Institute has become a leader in the practical application of new technologies to the field of medical bionics. Our research and collaborative interests have expanded to include exciting new work such as the development of a bionic eye, drug delivery and infection control, intelligent implants for neurological applications such as epilepsy control, as well as our ongoing commitment to bionic ear research.

Our approach focuses on the development of medical bionics as a platform technology whereby the Institute collaborates with key clinical and engineering partners within each project and rapidly moves new technological advances across the research platform for multiple applications. Although medical bionics research is highly competitive internationally, we believe the development of a platform technology in this field is unique and will play an important role in sustaining and growing the Institute and the field of medical bionics in Australia.

A recent independent economic analysis, funded in part by the Victorian Government, supported our approach by forecasting an internal rate of return of between 11.5 to 18 per cent a year over a 20-year period if a significant investment is made now (Allen Consulting Group report to the Bionic Ear Institute, 2008).

Medical bionics is a technology with many immediate clinical applications and demonstrable commercial returns.

Although Australia has demonstrated commercial leadership in the field over 25 years, research funding has often been problematic (for example in 2008–09, 75 per cent of our Institute's funding was derived from sources other than Australian and Victorian Government grants). Senator Carr's recent funding announcement for the development of a bionic eye injects critical funding into this flagship technology.

Our exciting challenge is to develop clinically and commercially successful devices while inspiring the next generation towards careers in engineering and science. ◀

*Professor Shepherd spoke on 'Biomedical Implants' at the Europe–Australia workshop on Smart Technology for Healthy Longevity in Paris in October 2009.*

**PROFESSOR ROBERT SHEPHERD** is the Director of the Bionic Ear Institute and a Chief Investigator on Bionic Vision Australia's successful \$42 million grant from the Australian Research Council's Research in Bionic Vision Science and Technology initiative. He has worked for more than 30 years in the field of cochlear implants and medical bionics including leading the original pre-clinical safety and efficacy studies used by Cochlear Ltd as part of their successful submissions to the FDA. He receives research funding from the US National Institutes of Health, the NHMRC and the ARC. In November 2008 he ran 'Medical Bionics: A new paradigm for human health', an international conference as part of the Sir Mark Oliphant Conferences supported by ATSE.



**Professor Chris Williams** inspects a prototype flexible electrode array with Research Engineer Dr Mohit Shivdasani and PhD student Rosemary Cicione.



# SMART STATE: ARE WE THERE YET?

The 2009 Oration from the ATSE Annual General Meeting Dinner and Oration held at Customs House, Brisbane, on 15 November 2009 delivered by Professor Peter Andrews AO FTSE, Queensland Chief Scientist. The full oration is at [www.atse.org.au/index.php?sectionid=1366](http://www.atse.org.au/index.php?sectionid=1366)

The idea of the Smart State was born 10 years ago and since then about \$3.5 billion has been invested in R&D and innovation in Queensland. The impact of that has been 39 new research institutes and about 60,000 new jobs, of which 10,000 are scientists.

We've done some great things in research but we won't really merit the Smart State accolade until we take the next step and convert that research base into outcomes – social, environmental or economic.

The next step is happening now. Premier Anna Bligh introduced in 2008 a vision called 'Toward Q2: Tomorrow's Queensland'. Basically it is a vision for 2020 that says: "Let's take 'smart' and expand it to include 'strong' (in an economic sense), 'fair', 'healthy' and 'green'. Let's share those ambitions with our families, our communities, our businesses, and let's set some stringent targets that will give us clear goals to work towards."

Similar targets are being developed around Australia. Similar ambitions are held around Australia. They represent a set of problems that we all collectively have to face. In addressing these broad ambitions of 'green', 'fair', 'healthy', 'smart', 'strong' – as a community, as scientists and engineers, and as the Academy – we need to look at some key facts.

## Smart

Forty-six per cent of Australians do not possess sufficient prose literacy to function in a knowledge-intensive economy; 53 per cent of us didn't possess sufficient numeracy to do so; and 70 per cent of us



Peter Andrews delivers the 2009 Oration.

don't possess sufficient problem-solving skills.

In the last published Trends in International Mathematics and Science Study (TIMSS) survey, eight per cent of Australian students achieved the advanced benchmark in science compared to 32 per cent of Singaporeans; and in mathematics, six per cent of Australians achieved the benchmark compared to 40 per cent of Singaporeans.

Regard these as a paradigm for the western and eastern worlds. The Australian numbers were very similar to those in the US, while those for Singapore also applied to China. Why are we doing so badly?

We spend the least time teaching primary school and middle school mathematics in the OECD and we spend the third least time teaching middle school science in the OECD. In many cases that time is taught by teachers who have not studied maths and science at tertiary level and who don't feel themselves well equipped to teach those subjects.

So we have to inspire students with good teaching and inspire teachers by revealing to them the relevance of science, engineering and related subjects to the future of the world. We need to ensure that children are inspired by science.

We have absolutely no choice – if we are going to be competitive in the 21<sup>st</sup> century, we must have the smartest scientists, and that means we must have the smartest teachers.

## Strong

We need to develop more knowledge-based industries. All will be built on R&D and innovation, areas where business expenditure in Australia is notoriously low. In the non-business sector we're as good as most nations in the world but the investment is spread over dozens of universities and research organisations and there is no focus on the goals that we as a nation might want to achieve.

Let's keep a sizable chunk of our research funding for that pure, excellent, untargeted research that we've always done so well, and which has led to so many of our most important and impactful discoveries. But let's take the rest and focus it on things we really want to achieve. Let's put it into industries where Australia has a real competitive chance of succeeding.

We should start picking winners. We should pick the sectors that bring together strengths in Australian research with strengths in world markets, where we can put the two together for a win-win. And, having decided to pick those winners, we should back the winners with serious R&D investment governed by serious boards of the sort I described before, bringing together researchers and industrialists who know the patch.

## Healthy

Over the course of the 20th century the life span of Australians has increased by 20 years,

but 80 per cent of aged Australians – those in the process of living that extra 20 years – suffer from chronic disease, and 70 per cent of Australia's total health costs are due to largely preventable chronic disease. The risk factors for chronic disease are rising astronomically but our investment in its prevention is not.

First, we need more studies on health economics, understanding where we can intervene in the process, where we change the process, where we can make the biggest economic impact by screening for this disease or that disease or putting in place that preventive measure. Second, we need to put in place the screening programs. And third, we need to take this country's medical research science base, which is superb, and use it to build our capacity in preventive medicine.

We should demand that the preventive health budget is increased from 2.2 per cent to at least 5 per cent of our national health budget and that 50 per cent of the NHRMC budget is specifically directed towards and focused on how we can prevent, detect and provide early and effective treatment for chronic disease.

## Fair

From teenage maternity to chronic disease, the cycle of disadvantage continues.

People in the social service departments in Brisbane or in Canberra say we need to develop a common database that lets us know what's going on at an individual and community level. No such database exists.

The other thing we need to do is address the problems. Perhaps this Academy and its sister academies should work together to address the health, the social, the technological issues around building functioning economies in those socially disadvantaged areas. We should put a slice of our research investment in this country into the interface between the social, technological and health sciences and really drive a targeted program looking for solutions to the challenges of social disadvantage.

## Green

To feed nine billion people on this planet by 2050 we'll have to produce twice as much as we're doing now from every hectare of arable

land in this country. It's a massive challenge and one which, we're not yet really focusing on – more than half of the agricultural businesses in this country already report problems with soil erosion, soil compaction, soil acidity or soil salinity.

We are the driest inhabited continent and we use more water, in one form or another, than almost anyone else. But it's obvious that, just as in the case with the land, we need to have a much better understanding of all the parameters that come into play in the supply and demand equations for water.

We are proceeding at accelerating speed to burn all the fossil fuels on this planet, and we're churning out truckloads of noxious gas – not just carbon dioxide – in the process. The Precautionary Principle says to me "if you're doing that you'd probably better get moving on developing cleaner, renewable fuels."

The big issues facing our environment are all about land, air and water – issues that are not well understood. We spend a lot of money on them in Australia, spread over a lot of different organisations. We should coordinate that research process, figuring out which problems we still need to understand, which solutions we need to create.

Those are my thoughts on what we scientists and engineers need to do if we are going to be smart, strong, healthy, green and fair.

There are two key themes. One is, we're not going to survive and prosper in the 21st century unless we produce better scientists, and that means better teachers, better teacher training and better teaching resources. The other one is, we're not going to survive and

prosper in the 21st century unless we take our very strong research base and focus it on some of the things that matter.

## Queensland initiatives

I think there are some clear lessons for Australia in many of the things that Queensland is doing in this space.

Premier Bligh has established a body called R&D Queensland, which is charged with pulling together all the research in all of the various Queensland Government departments and focusing it around those various ambitions that I've described.

She has reorganised the machinery of government, reducing 23 government departments to 13 departments – focused around the five key ambitions – and introduced performance pay for Directors-General, linked to those ambitions and targets. She wrote charter letters to all her ministers, describing their obligations with respect to those targets and ambitions. And she required all government departments to develop target delivery plans that will guide their activities until 2020.

With respect to teacher quality, she has initiated a major review of education in Queensland, including consideration of the 10-year science, technology, mathematics and engineering education plan that ATSE Fellow Else Shepherd and others helped develop earlier this year.

I think, as it comes together, this focus may be helpful in building better bridges with the rest of the science team around Australia and internationally and generating solutions for some of the challenges we face.

## Alan Trounson to address Clunies Ross Awards dinner

World-renowned IVF pioneer and stem cell biologist Professor Alan Trounson will be the keynote speaker at the 2010 ATSE Clunies Ross Award Dinner at the Melbourne Town Hall on 19 May 2010.

He was the inaugural CEO of the Australian Stem Cell Centre in 2002 and was appointed Director of the Monash Immunology and Stem Cell Laboratories, established in 2003.

In 2007, Professor Trounson confirmed his role as one of the world's leading minds in stem cell sciences when he was appointed permanent President of the California Institute of Regenerative Medicine – a \$3 billion agency founded to support and advance stem cell research and regenerative medicine.

The 2010 awards dinner will be followed by the Extreme Science Experience on Thursday 20 May, where awardees will interact with more than 400 Victorian Year 10 students in what has become a highlight event for science students.

# Research the key to world food security

Agriculture policy is defence policy ... and refugee, immigration, environmental, health, food and economic policy.



By Kaye Basford

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**“W**orld food security ... is at its lowest in half a century”, wrote Julian Cribb, a well-known consultant in science communication and founding editor of [www.sciencealert.com.au](http://www.sciencealert.com.au) in the lead article in the ATSE Focus magazine issue titled “Food for the world: the nation’s challenge”.

This issue is elaborated on by Joachim von Braun, Director General of the International Food Policy Research Institute, in an article published in *Nature*.

“Between 2005 and summer 2008, the international prices of wheat and maize (corn) tripled, and that of rice grew five-fold,” he said.

“Poor people typically spend 50-70 per cent of their income on food, and their wages did not adjust quickly enough to compensate for their shrinking purchasing power. From 2003–05 to 2007, the number of undernourished people increased from some 848 million to 923 million, largely because of the food price crisis.”

Some of the attention-grabbing aspects of this issue are now in the popular press, for example in Joel Bourne Junior’s article entitled “Feeding the World” in *National Geographic*.

“Last year, the skyrocketing cost of food was a wake-up call for the planet ... spurring food riots in nearly two

dozen countries and pushing 75 million more people into poverty.

“But unlike previous shocks driven by short-term food shortages, this price spike came in a year when the world’s farmers reaped a record grain crop. This time, the high prices were a symptom of a larger problem tugging at the strands of our worldwide food web, one that is not going away any time soon. Simply put: for most of the past decade, the world has been consuming more food than it has been producing.”

The last point is shown in the graph of grain stock statistics from 1960 to 2009. Yet cereal production has been steadily increasing during the same period.

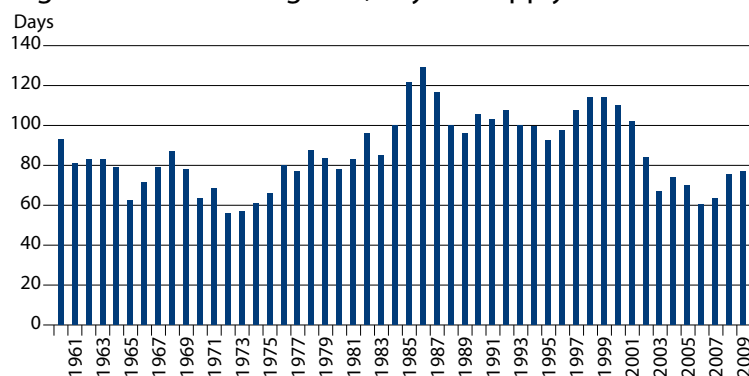
The real issue is that the world’s population has gone from three billion in 1959 to six billion in 1999 and is predicted to top nine billion by 2050 (an expected increase of 50 per cent in 50 years). Total food demand is forecast to rise by 110 per cent, with developing countries like China and India wanting an increasing amount of protein food.

The Green Revolution after World War II involved a high-input farming systems approach of irrigation, fertilisers and pesticides with high-yielding varieties. Yields more than doubled in Asia during the 1960s and ‘70s, lowering prices of the staple crops that feed most of the world.

Can we double food production by the middle of this century? Maybe, but it won’t be easy. Here are some constraints:

- We have less water for food production. Surface water available to agriculture is declining everywhere, particularly given the increasing demand by cities. Groundwater levels are also falling.
- The arable land area is shrinking. This is mainly because we are building on it as cities expand.
- Soil and nutrient losses through erosion and leaching are a big problem – 10 per cent of arable land is affected by serious degradation (so badly that you can’t grow a crop anymore) and more than 70 per cent is degraded to some extent. Coastal seas and lakes are affected by

Figure 1 World total grains, days of supply 1960 to 2009



Source: [www.fas.usda.gov/psdonline](http://www.fas.usda.gov/psdonline)



sediment, nutrient and pesticide contamination. We lose six to seven times more nutrients than we produce and apply through chemical fertilisers.

- Biofuels have expanded into food production areas and distorted the food chain and pricing structure. If there is a new use for plant material, then someone has to do without, and this situation has been referred to as “the rich burning the food of the poor”. While we are moving away from using starch (plants that are used as food for humans) and considering cellulose (crop residue or woody tissue) as a source for biofuels, all plants compete for soil, water and nutrient resources.
- People are now more concerned with caring for the environment. Hence pollution, contamination and high use of resources are frowned upon. This is going to affect the amount and cost of food that we can produce.
- Financial support for agricultural research and development, especially on-farm production, has gone down all over the world, particularly from the public domain. This means that less new farm technology will flow from developed to developing countries.

Given these facts, the only issue that seems to be still debatable in some places is the impact of climate change. The scientific evidence indicates higher temperatures, drier conditions (in some places, like Australia), and more variable (and extreme) conditions. Thus we are likely to have more droughts, and less frequent, but higher intensity rain.

As Julian Cribb said “The present challenge is to double world food output using less land, far less water, far fewer nutrients and with the prospects of less technology to do so, in the teeth of increasing drought.” He didn’t mention that we also want to look after our environment more carefully than we have done in the past.

We need to use less water in our cities and improve water use efficiency in crop production – increase yield with less available water. Examples include minimum tillage with retained stubble to limit evaporation and run-off and breeding drought tolerant varieties.

Nitrogen was a fundamental limit to traditional agriculture. The only natural source of this essential nutrient was nitrogen fixation (a symbiotic process between the host plant and bacteria). We have more than doubled its availability through nitrogen fertilisers, but it is at the expense of an energy-rich process (very high temperatures and very high pressure) resulting in the release of carbon dioxide. Using nitrogen fertiliser also results in nitrous oxide (another greenhouse gas).

Pests, diseases and weeds can reduce yield by 30 per cent. We must improve control by biological intervention or by breeding more disease resistant varieties. Australia had the first comprehensive and really successful biologi-

cal pest control (cactoblastis – a grub that ate the prickly pear), but also the first really disastrous one (introduction of cane toads to control stem borer in sugarcane). As climate changes, new pests will arise in areas where they have never been before, posing one of the biggest threats to biosecurity (and therefore food security).

Quantitative and molecular geneticists target traits for crop improvement. This can be achieved via conventional breeding or through genetic modification. The classic example of the latter is the introduction of Bt cotton – genetically engineered to produce a natural insecticide that comes from the Bt (*Bacillus Thuringiensis*) bacterium, so the plants can kill their own insect pests. Already about 80 per cent of the corn crop in the US is GM-based.

It would be unwise to put faith in genetic modification being the ‘silver bullet’ to double crop production. Most traits, such as drought resistance, are influenced by many genes interacting with each other and problems are not overcome with the identification and introduction of a single gene.

Food security is a multi-disciplinary challenge. Our farming systems must become more sustainable and we need detailed, research-intensive effort – realising that incremental improvement generally results and there are few quantum leaps.

Spending on agricultural R&D is crucial, but it has been reducing in real terms. At the same time, we must increase the rate at which such knowledge is disseminated.

I agree with Julian Cribb’s summary: “Australia has not yet understood that agriculture policy is defence policy. It is refugee policy, immigration policy and environmental policy, as well as health, food and economic policy. We persist in seeing it as an isolated and unimportant issue. We have not grasped its significance as the central issue of human destiny in the 21st century”.

*This is an edited version of a presentation to the Thirty Club, a group of University of Queensland and senior business executives in Brisbane.*

**KAYE BASFORD FTSE** is Head of the University of Queensland’s School of Land, Crop and Food Sciences – a multi-disciplinary cross-campus school focussed on agricultural, environmental and food sciences. She is President of the International Biometric Society and a Past President of the Statistical Society of Australia Inc. As Professor of Biometry, her teaching and research is at the interface of statistics and quantitative genetics through the development and dissemination of appropriate methodology for the analysis and interpretation of genotypic adaptation in large-scale plant breeding trials. Her awards include the 1998 Medal of Agriculture from the Australian Institute of Agricultural Science and Technology and a 1986 Fulbright Postdoctoral Fellowship to Cornell University.

# Mathematics and Australia

by Cheryl Praeger

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Cheryl Praeger

**T**he massive drift from senior mathematics in high schools must be addressed if the universities are to be able to produce anything approaching the required number of graduates in quantitative disciplines. As the vital role of technology in modern society increases, the mathematical sciences are becoming indispensable.

Many disciplines such as physics and economics have always relied on a foundation of mathematics, but now virtually every area of our lives depends on the mathematical sciences – from healthcare to telecommunications, from understanding climate change, to making secure financial transactions.

Mathematics is more than just important. It is a critical skill that all Australians should have in order to improve their lives and the lives of those around them.

To face future challenges, Australia – and in particular my state of Western Australia, with its resources boom – needs people who not only have a broad mathematical understanding, but who are highly skilled in science and mathematics.

It has been found that mathematics is the only science subject whose study in high school consistently enhances performance across all science disciplines. An important reason is that a mathematical training promotes clear logical thinking.

We need to ensure a strong mathematical education for our young people to underpin their other skills, whether in science, medicine, engineering or technology. This requires a new educational focus on nurturing mathematically talented young people to ensure they realise their potential.

To achieve this we must address a current serious shortfall of well-qualified mathematics teachers in schools. The most recent study of staffing in schools revealed that the highest rates of unfilled vacancies are in mathematics, with

10 per cent of secondary principals reporting at least one unfilled teacher vacancy. Perhaps more seriously many mathematics teachers have studied a less than ideal level of mathematics at university.

In addition to the shortage of mathematics teachers, demand by Australian employers for mathematics and statistics graduates continues to outstrip the supply. Both the CSIRO and the Australian Bureau of Statistics have grave concern about their ability to recruit graduates simply to cover retirement replacement let alone growth.

This demand for high mathematical skills comes at a time of desperate shortage of well-trained mathematicians and statisticians in Australia. The percentage of Australian students graduating with a mathematics or statistics major is 0.4 per cent, less than half the OECD average of 1 per cent.

Australia needs to at least double the number of mathematics and statistics graduates it produces to properly equip itself for the future.

Support at all levels is required. I was especially delighted that, in awarding me 2009 Western Australian Scientist of the Year, the Western Australian Science Awards recognised the central role of the mathematical sciences.

The mathematical sciences have been described as a “hidden achiever”, perhaps due to the universal nature of mathematics. Mathematical research rarely focuses on solutions to a single applied area but rather tries to develop generic, but still complete, solutions to wide classes of problems. Even when a single critical application is addressed, the mathematician is keenly aware of the generality and fundamental nature of her or his contributions.

For example, the mathematician founder of the modern computer, Alan Turing, stated in his 1945 proposal to build an electronic computer: “There will be positively no internal alterations to be made even if we wish suddenly to

switch from calculating the energy levels of the neon atom to the enumeration of groups of order 720.”

Turing was illustrating that the same fundamentals of mathematics can apply to vastly different problems, giving applications from physics (the neon atom) and my own mathematical discipline of group theory. This illustration resonates strongly with me personally since many of the computer algorithms I design and analyse are implemented in the two major international computer algebra systems MAGMA (based in Sydney) and GAP (originating in Germany and now based in Scotland) so that they are available for all users of these computer systems.

Among the 3,000 or so research publications citing use of MAGMA in the research are dozens of papers on cryptography, computer science, communications theory, biology, chemistry, economics and physics, alongside hundreds of papers in 19 distinct mathematical disciplines.

The generality and power of mathematics may unwittingly contribute to the invisibility of the mathematical sciences to the community at large. Even though the application of mathematics and statistics provides tangible benefits to all areas of life, those areas – and those sectors of the economy – each have their own names: modelling climate change, secure communications, imaging, defence research, the Human Genome project. The list is endless, and most do not clearly identify themselves as involving a high level of mathematics.

The community at large does not see mathematics and

statistics as critical to the vast majority of technologies in use every day. Neither do our high school students who are migrating to easier options from senior mathematics courses. The massive drift from senior mathematics in high schools must be addressed if the universities are to be able to produce anything approaching the required number of graduates in quantitative disciplines.

The UK recently turned its performance in mathematical sciences and education around in a remarkable way by combining aggressive teacher recruitment with substantial inducements, regulation of teacher education numbers to match demand from schools, an impressive careers program supported by the government and professional societies – and the designation of mathematics as part of the strategically important subjects program. If the UK can do this, so can Australia.

I invite and welcome our political leaders – the Prime Minister and his parliamentary colleagues – to join in reinforcing the importance of mathematics to the future well-being of Australia and Australians.

This will inspire students and their parents to appreciate both the importance of the mathematical sciences and the many exciting career options that depend upon developing good mathematical skills.

**Winthrop PROFESSOR CHERYL PRAEGER AM FAA is Director of the Centre for Mathematics of Symmetry and Computation at the University of Western Australia. She is an Australian Research Council Federation Fellow and was recently named the Western Australian Scientist of the Year.**

## LETTER

# REALITY DELUSION

In his *Tractatus Logico-Philosophicus*, Ludwig Wittgenstein (1889 – 1951) wrote: “The limits of my language mean the limits of my world. Logic pervades the world: the limits of the world are also its limits. So we cannot say in logic: the world has this in it, and this, but not that ... We cannot think what we cannot think; so what we cannot think we cannot say either”.

There are some fundamental concepts that we regularly use in our daily life, which nonetheless defy any rational definition.

Time is one of them. St. Augustine of Hippo (354 – 430) wrote: “What then is time? If no one asks me, I know. If I wish to explain it to one that asketh, I know not. My soul is on fire to know this most intricate enigma”.

Straight line is another such concept. If you tell me that straight line is the shortest distance between two points on the surface – this is not a definition – this is a property of a straight line, but only in the Euclidean

geometry. In Non-Euclidean geometries the shortest distance is called geodesic line.

John von Neumann (1903–1957) told one of his students: “Young man, in mathematics you don’t understand things, you just get used to them”. When Michael Faraday (1791–1867) was asked by the Chancellor of the Exchequer about the usefulness of electricity, Faraday replied: “One day, Sir, you may tax it”.

I also recall a very old anecdote from my undergraduate days. Professor asked one of his students: “What is electricity?” “Ah, Goddamn” replied the student “only this morning I knew, and now I forgot!”

“Young man” sternly replied the professor, “it is absolutely essential that you must try and call to mind this definition. You were the only human being who had this knowledge, and now you tell me that you forgot”.

**Aleksander Samarin, FTSE**

## Letters to the Editor

ATSE *Focus* welcomes letters from readers in response to articles. Please keep letters brief to enhance publication prospects. Longer letters may be run as contributed articles. Please address to [editor@atse.org.au](mailto:editor@atse.org.au)



# STELR PROFESSIONAL LEARNING PROGRAM

As part of its national campaign to improve the standard and impact of science and technology education, the STELR Project will run its 2010 Professional Learning Program for more than 350 teachers across the country in March. The program will be held in Melbourne on 1–2 March for about 140 teachers from Victoria, South Australia and Tasmania. More than 60 teachers from Queensland and the NT will gather in Brisbane on 8–9 March and some 120 educators from NSW and the ACT will gather in Sydney on 15–16 March. The final event will be held in Perth, on 22–23 March for about 36 WA teachers. Two teachers from each of the 185 participating schools will attend the seminars, along with mentors that have been employed to work closely with and support the schools when they are undertaking the STELR Stage One Project. The participants will gain valuable knowledge of the content and philosophy of the STELR Stage One teaching program and work through the hands-on activities with the equipment that the schools receive to implement the Project.

■ STELR is an ATSE initiative, driving an exciting new curriculum program that aims to reverse the low level of interest among students in science courses and careers. It targets students in years 9/10 – and their science teachers – and will be provided to more than 150 schools across Australia in 2010, with the support of the Australian Government. [Details at www.stelr.org.au](http://www.stelr.org.au)

## Victorian Government applauds STELR

The Victorian Government has lauded the STELR concept with an endorsement in its latest Blueprint Implementation Paper

Energising Science and Mathematics Education in Victoria. The paper reviews the context – why science and mathematics are important – and sets out a number of strategies and actions for the future. Included in these – under the heading Resources to support a contemporary curriculum – the paper says Victoria will “Expand the number of schools participating in the Science and Technology Education Leveraging Relevance (STELR) program, an initiative of the Australian Academy of Technological Sciences and Engineering designed to engage Years 9–10 students in hands-on learning about renewable energy, which has received \$2 million of Commonwealth funding for 2010.”

The paper is at [www.eduweb.vic.gov.au/edulibrary/public/govrel/Policy/energising-sci-maths-ed.pdf](http://www.eduweb.vic.gov.au/edulibrary/public/govrel/Policy/energising-sci-maths-ed.pdf)

## UNMET DEMAND FOR SURVEYORS AND SPATIAL SCIENCE GRADUATES

Government infrastructure projects are creating an unmet demand for surveyors and spatial science graduates in areas such as road projects, port and mining developments and transport tunnels, says Queensland University of Technology Spatial Science Program coordinator Robert Webb.

“I estimate a 25 per cent increase in spatial science and surveying graduates is needed to meet demand for current Queensland infrastructure projects and to meet skills shortages domestically and internationally,” Mr Webb said.

“Graduate work is almost guaranteed. They can take their skills anywhere, from measuring polar icecaps to constructing skyscrapers and land titling housing developments.”

Mr Webb said Google Earth™, global positioning systems (GPS) and other technology were also driving demand for spatial science and surveying skills.

## GREEN GROWTH A KEY ISSUE ON 2010 AGENDA

Green Growth is a key topic for ATSE work in 2010, following a January visit to the Republic of Korea by ATSE President Professor Robin Batterham AO FREng FAA FTSE and ATSE Executive Director Technical, Dr Vaughan Beck FTSE.

The three-day visit enabled:

- Professor Batterham to make a presentation at the Science and Technology Leaders Forum: Innovation Strategy for Green Growth in Asia, organised by the Korean Federation of Science and Technology Societies (KOFST) and the Science and Technology Policy Institute (STEPI);
- discussion on Green Growth issues with various organisations in Korea; and
- planning with the National Academy of Engineering of Korea to hold joint Australia-Korea Workshops on Green Growth.

The Science and Technology Leaders Forum in Seoul was a high-level meeting of leaders of key organisations in Asia – STEPI (Korea),

Chinese Academy of Science, National Institute of Science, Technology and Development Studies (India), National Institute of Science and Technology Policy (Japan) and ATSE.

The Forum reflected the strong advocacy of Green Growth strategy, policy and funding by the South Korean Government and set the scene for strong Green Growth interaction between Australia and Korea during 2010 and 2011.

The first step will be a joint Australia-Korea green growth international workshop 27 to 29 April 2010 in Seoul. Substantial progress in planning for this event made in the Seoul meetings. A return workshop is planned for 2011 in Australia.

- *Green Growth recognises the challenges of a carbon-constrained world and an increasing population for Australia – which require a coordinated approach and the development of internationally competitive technologies that can achieve synergistic relationships between environmental sustainability and economic growth.*

# Warren Centre launches PPIR

The Warren Centre for Advanced Engineering has launched a landmark report, which comprehensively reviews professional engineering performance, innovation and risk.

The central finding of the report is that in order to maximise the effectiveness of engineering, we need a way of defining and formally recognising how all those involved in an engineering endeavour interact with and respond to one another.

The report, *Professional Performance Innovation and Risk™ in Australian Engineering Practice*, was launched by Mr John Grill FTSE, the CEO and Managing Director of WorleyParsons.

In launching the report, Mr Grill said: "The role of the professional engineer in our society is of great importance to me ... Unfortunately I feel that the term engineer has been misused in Australia ... diminishing its status and blurring its value."

"For example, when we listed WorleyParsons on the ASX we were strongly advised not to use the term 'engineer' to describe our business, which seeing that's principally what were at the time, was very sad. Our prospectus did not have the term engineer in it at all."

The report explores the role of the engineer; the expectations of community and clients; the contemporary and professional realities for engineers; the effects of complex laws on everyday engineering; engineering risk and responsible risk-taking; and the relationships between professional performance, innovation and risk.

The Warren Centre for Advanced Engineering is an independent institute committed to fostering excellence and innovation. It is a self-funding, not-for-profit industry-linked body, driven by volunteers and operating within the Faculty of Engineering at the University of Sydney.



John Grill launches the report.

PHOTO: JOHN SARKISSIAN, CSIRO



CSIRO test-bed antenna.

## CSIRO ASTRONOMY AND SPACE SCIENCE FORMED

CSIRO has formed a new Division, CSIRO Astronomy and Space Science (CASS), bringing together CSIRO's radio astronomy capabilities (the Australia Telescope National Facility), NASA Operations (including the Canberra Deep Space Communication Complex), CSIRO Space Sciences and Technology and the CSIRO Boeing Advisor.

The enlarged unit will encompass radio astronomy, deep space tracking and communication activities on behalf of NASA, space science coordination, advanced aerospace business development, and national/international facilities management.

The Chief of CASS will be responsible for both radio astronomy activities and space science and will report to the CSIRO Group Executive for Information Sciences, Dr Alex Zelinsky FTSE.

CSIRO Chief Executive Dr Megan Clark FTSE said the creation of this Division reinforces CSIRO's role in managing global-scale facilities and the importance of its space science.

"CASS also supports the increasing alignment of astronomy and space science in Australia and will strengthen CSIRO and Australia's positioning to host and operate the Square Kilometre Array (SKA) the \$3 billion next-generation international radio astronomy facility," Dr Clark said.

Dr Zelinsky said CASS would add to CSIRO's existing capabilities and expertise in operating national and international facilities.

"CASS will be primarily responsible for outcomes through the management of the Australia Telescope National Facility, and through the newly approved direct management of the CD-SCC Facility, as well as CSIRO Space Sciences and Technology (CSST)," Dr Zelinsky said.

# Fascinating take on the Great North Walk

The Great North Walk, a 250-kilometre bushwalking track linking Sydney and Newcastle, via the Hunter Valley, is a national icon for scenery and history.

It passes through a diverse range of natural habitats and bushland as well as rural and urban settings, including Sydney Harbour, Berowra Valley, the Hawkesbury River, Watagan Mountains, Lake Macquarie and the Newcastle coastline.

The Great North Walk is a must-see for bushwalkers and nature lovers alike. With camping grounds, water stations and other facilities scattered throughout, the walk boasts lookouts, rainforest, a plethora of diverse native flora and fauna, sandstone ridges, coastal terrain and well-maintained boardwalks.

It was initially constructed as a celebration of Australia's Bicentenary in 1988 and is a responsibility of the NSW Department of Lands, hosting an estimated 40,000 local, interstate and international visitors who use the walk annually, either taking the challenge of the full 12 to 16 day hike, or enjoying shorter sections of the walk.

And now there's a fascinating book for walkers and students of the history of

the area – *The Great North Walk Companion* (376 pages, paperback, available from [www.digitalprintaustralia.com/bookstore/non-fiction/travel/the-great-north-walk-companion.html](http://www.digitalprintaustralia.com/bookstore/non-fiction/travel/the-great-north-walk-companion.html) for \$27.50).

The authors – A Henderson-Sellers, K McGuffie and B Henderson-Sellers – don't give away too much about themselves, but we know one to be Professor Ann Henderson-Sellers FTSE, former head (2006–07) of the World Climate Research Program, based in Geneva; Director of the Environment Division at ANSTO from 1998 to 2005; Deputy Vice-Chancellor RMIT from 1996–98; and founding Director of the Climatic Impacts Centre at Macquarie University, where she continues to hold a Professorship in Physical Geography.

Describing itself as "fiction not fact", the book traces the history and elements of the walk through the amalgam of curiosity, observations, commentary and "discussions with passersby" forged by the authors during their traverse of the track over the 12 months to September 2009. It also raises some mystery about the identity of the "fourth" member of the team, to whom the book is dedicated.

The book is a treasure hunt or 'geo-quest' against a majestic scenic background, with three components – rock art and engravings, obelisks and memorials, and the unfolding of the life tale of the "mystery" companion.

It contains notes of interest about flora and fauna, architecture, sites of interest (Aboriginal and post white settlement) and an excellent index.

For those interested in the Great North Walk or the history in which it rests, *The Great North Walk Companion* is a well-written and almost essential 'companion'.

Editor

## Australian biotech

◀ Continued from page 19.

Delegate sentiment pointed to a general belief that the worst of the global recession may be behind us and emphasis was placed on exploring emerging opportunities for increased engagement with Asia, which over the past few years has committed billions of dollars to building and strengthening its biotech and life sciences industry. As a regional neighbour, with an already strong biotech sector, the synergies are ripe for close partnership and increased investment between Australia and Asia.

The maturation of the local sector and its strong international reputation was confirmed at the inaugural AusBiotech Australasian Life Science Investment Summit, which immediately preceded AusBiotech 2009. The Summit showcased local R&D from 40 early and late-stage companies, attracting more than 100 investors, 32 of whom were representing international investment organisations.

The overwhelming consensus amongst investors at the Summit was that Australian science and research is held in high esteem overseas and perceived as first class, offering strong opportunities for international investment.

Among more than 1400 delegates at AusBiotech 2009, there was significant international representation from 30 countries, with some of the largest international delegations ever attending, including those from Britain, South Korea, Singapore, Canada and New Zealand. A delegation from South Africa attended the conference for the first time.

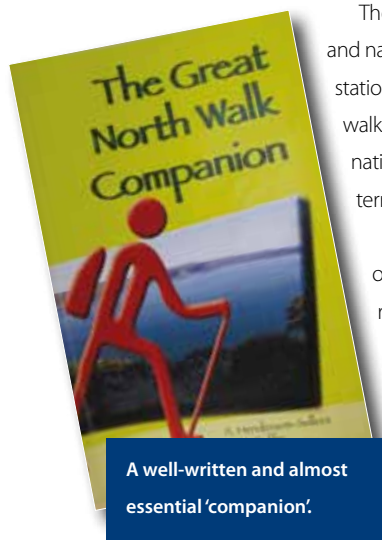
The Conference covered a comprehensive program with sessions in four biotechnology streams: human health and medical technology; agriculture, industrial and food; and investment and business.

This year's Nancy Millis Oration was given by Dr Megan Clark FTSE, the CEO of CSIRO. The oration was named in honour of Emeritus Professor Nancy Millis AC MBE FAA FTSE, whose contribution to biotechnology was vast.

The AusBiotech-Roche 2009 Excellence Awards honoured Dr Greg Collier, CEO of ChemGenex, for individual contribution, with ChemGenex the first Australian company to submit a New Drug Application (NDA) to the US Food and Drug Administration for a cancer medicine.

The AusBiotech 2009 Excellence Award for a company contribution went to Acrux, which recently announced of successful Phase III human clinical trials results for Axiron – a product in development for the treatment of testosterone deficiency in men.

**DR DEBORAH RATHJEN FTSE is Chair of AusBiotech and CEO and Managing Director of Bionomics, which she joined in 2000 from Peptech Limited, where she was General Manager of Business Development and Licensing. Dr Rathjen was a co-inventor of Peptech's TNF technology and leader of the company's successful defence of its key TNF patents. Dr Rathjen has significant experience in research, business development and licensing. She is an expert in the field of cell biology with specific expertise in inflammation and cancer. Dr Rathjen is a member of the Australian Biotechnology Advisory Council and served on the Prime Minister's Science Engineering and Innovation Council and the IR&D Board.**



A well-written and almost essential 'companion'.



## UNSW Tyree Building will host landmark energy research

Deputy Prime Minister Julia Gillard recently oversaw the start of work on a landmark new energy research centre at the University of New South Wales which will honour a long-standing Fellow and philanthropist.

The \$125 million Tyree Energy Technologies Building (TETB) will be a flagship research facility at UNSW, bringing together in one centre the University's internationally recognised research and teaching in key energy areas including photovoltaics, carbon capture and storage, oil and gas reserves, nanomaterials, energy policy and market analysis.

The TETB is supported by \$75m in funding under the Federal Government's Education Investment Fund and is one of the first EIF projects to get under way.

Deputy Prime Minister Gillard officiated at an official sod-turning ceremony on the site of the new building, which was also attended by UNSW Vice-Chancellor Professor Fred Hilmer, Dean of Engineering Professor Graham Davies and Sir William Tyree OBE FTSE.

Sir William, a UNSW alumnus and a major philanthropic supporter of Australian engineering and educational research, has generously donated \$1 million towards the new centre and pledged a further bequest of \$10 million.

The TETB will be the focal point for the University's Centre for Energy Research and Policy Analysis (CERPA) and will also house the School of Photovoltaics and Renewable Energy Engineering, the Centre for Energy and Environmental Markets, the School of Petroleum Engineering and the laboratories of the ARC Photovoltaics Centre of Excellence and the ARC Centre for Functional Nanomaterials.

Due for completion in 2012, the TETB will support research, teaching and industry collaboration in areas of critical importance to Australia's energy security and international climate treaty obligations. It will also provide a formal learning space for 300 engineering students.

The TETB will be a leading example of sustainable construction, with a 6-star Green Star building rating, a gas-fired tri-generation plant for power, heating and cooling and a roof-mounted solar panel array utilising UNSW solar cell technology.

### Else Shepherd gets UQ honour

Powerlink Chair and the first woman to graduate from electrical engineering at UQ, Ms Else Shepherd AM FTSE, is the University's Alumnus of the Year for 2009.

UQ Vice-Chancellor Professor Paul Greenfield AO FTSE said UQ was honoured by a wealth of exceptional graduates, who reflected their strength on to the University and the students who followed them.

Ms Shepherd was inspired to pursue a career in engineering by the 1957 launch of the Russian satellite Sputnik. After attending Brisbane Girls Grammar School, she began studying electrical engineering at UQ from 1962, graduating in 1965.

In 1994, Ms Shepherd was appointed to her current position as Chair of Powerlink – a new company set up by the Queensland Government to oversee the state's electricity transmission system following the break-up of



Else Shepherd



Sir William Tyree and Julia Gillard.

the Queensland Electricity Commission (QEC). Powerlink owns, develops, operates and maintains Queensland's \$3 billion, 1700km high-voltage electricity transmission network.

As a member of Engineers Australia's Accreditation and National Industry Liaison Board, Ms Shepherd is keen to see increasing public awareness of the role engineers play in society. She sees interdisciplinary collaboration, for example the early take-up by engineering professionals of recent developments in quantum physics and materials science, as an opportunity to enhance the standing and contribution of the profession.

She also sits on the National Electricity Market Management Company (NEMMCO) Board, the Brisbane City Works Advisory Board and the International Electrotechnical Commission Council Board.

### Joanne Daly

Dr Joanne Daly FTSE, Group Executive of CSIRO's Agribusiness portfolio, has been appointed to the newly created Biosecurity Advisory Council, which will provide independent advice on Australia's biosecurity systems. Dr Daly is the former Chief of CSIRO Entomology (2003–07) and is currently CSIRO's representative on the Primary Industry Standing Committee. Dr Daly was a member of the Quarantine and Exports Advisory Council.

# New Year's Honours

The Academy congratulates the six Fellows who were named in the Australia Day Honours for their contributions to Australian society.

## Dr Ian Grey AM FTSE

Dr Grey was honoured for service to science, particularly in the field of mineralogy as a crystallographer, and to the mineral sands export industry.

Dr Grey, Chief Research Scientist, CSIRO Minerals, was elected a Fellow in 2002, recognising his scientific and technological innovations that resulted in significant growth in the Australian synthetic rutile industry over 30 years.

He is a former President of the Society of Crystallographers in Australia, a Fellow of the Mineralogical Society of America and a foreign member of the Russian Academy of Sciences.

## Dr Stephen Gumley AM FTSE

Dr Gumley was honoured for service to public sector management, particularly through leadership of the Defence Materiel Organisation (DMO), and the development and implementation of significant reforms in procurement and sustainment of military equipment.

Dr Gumley, a 1979 Rhodes Scholar, was named by Engineers Australia in 2006 as one of the 100 most influential engineers. He joined the Academy in 2007.

In February 2004, Dr Gumley was appointed the inaugural Chief Executive Officer of the DMO, part of the Australian Department of Defence and responsible for acquiring and sustaining all military equipment. His contract was renewed in 2008.

Prior to that role he was CEO of the Australian Submarine Corporation (ASC).

## Dr Peter Jones AM FTSE

Dr Jones, a Fellow since 1991, was honoured for service to the information technology industry, to the promotion of internet-based communications networks, and to science education.

Dr Jones has been involved in computer design and computer-based communication for 50 years, after graduating with science and engineering degrees and a PhD in aeronautical Engineering from Sydney University.

He worked as a systems designer and systems engineer in universities and commercial organisations in UK, Australia and the US before working as a founder and Vice President for R&D for Network Systems Corporation in the US. He was Managing Director/Chair of Techway Limited, a computer service company that was listed on the Sydney Stock Exchange in 1993, from 1979 to 1995.

He is a former Member, Prime Minister's Advisory Committee on Science and Technology and Member, Australia Telescope Steering Committee.

## Professor Ronald Quinn AM FTSE

Professor Quinn was honoured for service to scientific research, particularly in the field of chemistry as a leader in the development of therapeutic compounds from marine organisms and plant materials.

Professor Quinn is one of the world leaders in the systematic study and application of natural product chemistry.

He is Director of the Eskitis Institute for Cell and Molecular Therapies at Queensland's Griffith University and was formerly a research scientist with Roche Research Institute of Marine Pharmacology, following academic appointments at ANU, University of Hawaii and Arizona State University.

He joined the Academy in 2003.



Peter Jones

Robert Breakspere



Ian Grey

Ronald Quinn

## Emeritus Professor Bruce Thom AM FTSE

Professor Thom was honoured for service to the environment as an advisor and advocate for the ecological management of the coastal zone, as a contributor to the public debate on natural resource policy, and to the academic and professional discipline of geography.

Professor Thom was elected to the Academy in 2002 to recognise his translation of outstanding science into effective coastal environmental policy and practice, linking government, planners, scientists and the community into sustainable patterns of planning and management.

He is former Chair of the Coastal Council of NSW and is a Member of the Wentworth Group of Concerned Scientists. He was Vice Chancellor of the University of New England and before that Professor of Geography and later Pro Vice Chancellor (Research) at the University of Sydney.

## Emeritus Professor Robert Breakspere AOM FTSE

Professor Breakspere was honoured for services to science and technology as an academic and researcher.

Educated in the UK, he was appointed Head, School of Physical Sciences, and foundation Professor of Chemical Technology at UTS, following academic and research appointments at UK Atomic Energy Authority, ICI, University of Wales and the Max-Planck Institute of Biophysical Chemistry.

He became Dean of the UTS Faculty of Science before joining CQU as Pro Vice Chancellor (1993-98). He has been Director of Breakspere Consulting since.

Professor Breakspere, who joined the Academy in 1997, served as Chair of the Education Committee (2000-2005) and on Council (2002-2005).

# Clunies Ross winner also wins CSL Florey Medal



John Hopwood

Professor John Hopwood AM FAA, South Australian Scientist of the Year 2008 and a 2009 ATSE Clunies Ross Medal winner, has followed in the footsteps of some of Australia's greatest medical researchers, including immediate past winner Professor Ian Frazer FAA FTSE and Nobel Laureates Professors Barry Marshall and Robin Warren, by being awarded the 2009 CSL Florey Medal.

Professor Frazer also won a Clunies Ross Medal in 2008 following his 2007 Florey Medal.

This award, by the Australian Institute of Policy and Science, and sponsored by CSL, takes its name from Australia's first Nobel Laureate in Medicine, Sir Howard Florey, who made an indelible impact on world health by developing penicillin.

Professor Hopwood heads the Lysosomal Diseases Research Unit in Adelaide, which he formed in 1976. This is the only group researching lysosomal storage disorders nationally and is the largest multidisciplinary group working on them world-wide. The Unit is world-renowned for its research capabilities and the translation of research findings into state-of-the art diagnostic services.

Lysosomal diseases are genetically inherited. Symptoms are progressive and impact on many body organs including the skeleton, heart, lungs and brain with devastating effects.

## Construction disputes must reduce

Mr Tony Barry FTSE, Chief Executive, Asia Pacific, of Aurecon, and Chair of the national Dispute Avoidance and Resolution Taskforce, has attacked the cost of disputes in Australia.

He said the waste of resources on non-productive tasks could not continue.

"Wasting resources on non-productive tasks represents a massive loss to the Australian community in terms of the lost opportunity to deliver real value through improved transport, health, education and industry infrastructure and facilities," Mr Barry said.

He was speaking at the recent launch of a new guide aimed at reducing the number of disputes in the construction industry.

The Guide to Leading Practice for Dispute Avoidance and Resolution, was developed by the Co-operative Research Centre (CRC) for Construction Innovation, based at the Queensland University of Technology.

The guide had been developed following significant industry input and collaboration, and original research that identified proactive issue resolution methods, Mr Barry said.

"It incorporates suggested change strategies and implementation tools to help people in the construction industry avoid the root causes of disputes."

The Australian construction industry employs about one million people and undertakes some \$120 billion of non-residential work annually.

Construction Innovation chair, QUT Adjunct Professor John McCarthy, AO, said research indicated \$7 billion in direct and avoidable dispute resolution costs were incurred annually.

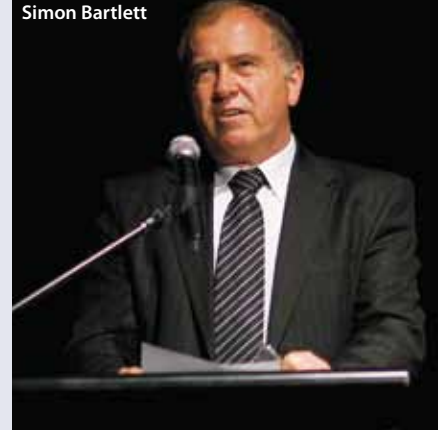
The guide can be found at [www.construction-innovation.info](http://www.construction-innovation.info)

## Simon Bartlett the 2009 Professional Engineer

Simon Bartlett FTSE, Chief Operating Officer of Powerlink, Queensland, has been named by Engineers Australia as the 2009 Professional Engineer of the Year.

He is a leading engineer in Australia's electric power industry and, for more than 37 years, has been the initiator and driving force behind a range of new technologies and innovative designs, maintenance and work

Simon Bartlett



practices in the Queensland generation and transmission sectors.

Powerlink has more than 240 professional engineers undertaking hundreds of engineering projects.

The award, announced at a dinner at the Great Hall of Parliament House, Canberra, is made annually to a practicing professional engineer, judged against criteria that considers competence and significant achievement in community affairs, proficiency in the use of communication skills in engineering projects and a demonstrated understanding of the role and purpose of the engineering profession within society.

Mr Bartlett was awarded a Certificate of Special Commendation from the Prime Minister and the Queensland Premier for outstanding leadership in Cyclone Larry Relief Effort in 2006.

He also initiated and led Powerlink's community goodwill programs, including Powerlink Greenworks and Townsville's Community Environment Fund.

## Roger Lough

Former Chief Defence Scientist Dr Roger Lough has been appointed to the Government's new Space Industry Innovation Council. The council will meet in February and its focus will be on earth observation, satellite communications and navigation. It will also consider the implications arising from the Defence White Paper and the National Security Science and Innovation Strategy.



# A new chapter in a long science career



John Wright

PHOTO: CSIRO

It was the year that Pink Floyd released *Dark Side of the Moon* and *Are You Being Served?* made its television debut. It was long before the words 'climate change' became headline news – 1973 was also the year that CSIRO's Sustainable Energy Advisor, Dr John Wright FTSE – who retired at the end of 2009 – joined the organisation as a research scientist in the Sydney laboratories of the then Division of Mineral Chemistry.

Now regarded as one of Australia's leading climate and energy experts, Dr Wright moved through the ranks of the national science agency working in a range of areas including mineral processing, coal technologies and renewable energy.

He conceived and led the establishment of Australia's \$36 million National Energy Centre in Newcastle and designed the CSIRO Energy Transformed Flagship research program.

"John has been the architect of CSIRO's low-emission energy technology research and his achievements are the foundations for our ongoing efforts to mitigate climate change," said CSIRO Energy Group Executive, Dr Beverley Ronalds FTSE.

"His leadership of our solar-thermal, biofuel, energy efficiency, low-emission fossil fuel and clean transport research means that, as a country, we are developing the tools to help reduce greenhouse gas emissions," Dr Ronalds said.

Until 2008 Dr Wright was the Director of the CSIRO Energy Transformed Flagship before taking on his pre-retirement role as CSIRO's Sustainable Energy Advisor.

Dr Wright said his career with CSIRO had been full of opportunities. "The organisation has given me so many opportunities to make

a difference, particularly in energy science and engineering. And with my colleagues, I think we have grasped those opportunities right across the fossil fuel and renewables areas," Dr Wright said.

Although he is retiring from CSIRO, Dr Wright is not retiring from his energy interests and will continue to work on various committees and boards, as well as doing some consulting work.

## Margaret Sheil

Professor Margaret Sheil, Chief Executive Officer of the Australian Research Council (ARC), has been appointed to the Board of the Australia-India Council. Prior to her appointment to the ARC in 2007, she had a long and distinguished academic career in chemistry, most recently as Deputy Vice-Chancellor (Research) at the University of Wollongong.

## Bruce Hobbs features in Royal Society anniversary

Dr Bruce Hobbs AO FAA FTSE, former Chief Scientist of WA, is prominent in the Royal Society's celebration of its 350th anniversary.

All Royal Society content (more than 65,000 articles dating back to 1665) is on free access until end of February to mark the Society's 350th anniversary – further details on the anniversary are at <http://royalsocietypublishing.org/seefurther>.

Royal Society Publishing has also published an issue of *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* entitled *Patterns in our planet: applications of multi-scale non-equilibrium thermodynamics to Earth-system science* compiled and edited by Alison Ord, Giles W Hunt and Dr Hobbs.

Details of the issue: <http://rsta.royalsocietypublishing.org/site/issues/patterns.xhtml>

The issue contents are



Bruce Hobbs

available online until the end of February at <http://rsta.royalsocietypublishing.org/content/368/1910.toc>.

## Dongke Zhang heads new UWA energy centre

The University of Western Australia, inspired by the challenges associated with providing energy now and for future generations, has established the UWA Centre for Energy within the Faculty of Engineering, Computing and Mathematics.

The Centre will conduct world-class scientific research and technological development and provide consulting services in natural gas, petroleum, coal and biomass, geothermal energy and energy efficiency, marine and subsea and future energy.

Winthrop Professor Dongke Zhang FTSE, the foundation Director of the Centre, said the naming of the Centre reflected the current importance of petroleum, natural gas and coal as the dominant primary energy sources through the rapidly growing oil and gas industry in WA and the strong coal industry in Australia, and the potential change in energy balance.

"The Centre is a great example of collaboration between UWA and industry which will significantly contribute to the sustainable future of Western Australia," said Professor Zhang who, in the past 10 years, has attracted more than \$16 million in research funding from industry sources as well as Australian Research Council (ARC) funding.

## Harry Poulos

Professor Harry Poulos AM FAA FTSE, Senior Principal with Coffey Geotechnics in Sydney, won the 2009 Crampton Prize of the Institution of Civil Engineers (UK) for his paper 'A Practical Design Approach to Pile with Negative Friction'. Professor Poulos, Emeritus Professor of Civil engineering, University of Sydney, also delivered the Terzaghi Oration at the 17th International Conference on Soil Mechanics and Geotechnical Engineering in Alexandria, Egypt, in October, the of which title was 'Tall Buildings and Deep Foundations – Middle East Challenges'.

## Leading the charge in innovation

Two ATSE Fellows are among leading Australian innovators who feature in Innovation Profiles, an interactive suite of web, video and print media which encompasses real-life stories and experiences of 25 leaders from five Industry Innovation Councils.

Developed and launched recently by the Department of Innovation, Industry, Science and Research (DIISR), Innovation Profiles are real stories of innovation in industry in Australia.

Mr Tristram Carfrae FTSE (Built Environment), an Arup engineer, believes that looking to the future is much more important than most people appreciate.

"Human nature tends to be the reverse," he says. "It tends to be 'what have we done before'. I think the best strategy is a combination of what is the best solution to date and how can we now do it better."

He recognises that being innovative in the world of engineering is no easy thing because, as he puts it, "the natural tendency of engineers is to be risk-averse and there's an assumption that doing something innovative increases the risk."

The need to be innovative is pressing, he says. By 2050 "we're going to have six billion people living in urban environments and almost all that increase will come in the developing world where that environment has to be built between now and 2050.

"The resource and energy consumption of doing so will kill the planet if we don't do it in an innovative, better, more efficient, more economical fashion."

Mr Gary Zamel FTSE (Future Manufacturing), Managing Director, Mine Site Technologies Pty Ltd, decided 25 years ago to start up a company to address a key issue in the industry in which he had grown up:



Tristram Carfrae

providing communications in mines to make them safer. That start-up now exports into the United States, Canada, China, Africa and South America.

The mining industry, he says, teaches the importance of risk assessment. "One of the things that we pride ourselves on is that we don't take steps without understanding the risks."

He says a key issue is passion. "If you can see that someone comes forward with an idea and they are passionate about it then you're much more likely to back that idea."

To see these Fellows talking about their aspirations and experiences go to [www.innovation.gov.au/Section/Industry/innovation/index.html](http://www.innovation.gov.au/Section/Industry/innovation/index.html)

### Frank Lawson awarded Doctor of Engineering

With nearly 50 years association with Monash University's Faculty of Engineering, Professor Frank Lawson FTSE, an Honorary Professorial Fellow at Monash, was awarded the Doctor of Engineering in October 2009.

This was the first Doctor of Engineering award in Chemical Engineering – the university's highest award. The degree gives formal recognition to scholars who have made a substantial, original and distinguished contribution to knowledge. Eligibility for the award of the degree is assessed on the basis of scholarly published work that is judged by national and international peers to indicate the candidate's authoritative standing



Frank Lawson

in the field and his or her achievements in the advancement of knowledge.

Professor Lawson began his career with Monash in December 1962 when he was appointed to the position of Lecturer. In 1966 he was promoted to a Senior Lecturer.

Professor Lawson still contributes to the Department of Chemical Engineering through his work as a sessional lecturer and continues his research interests. He joined the Academy in 1995.



Ian Duncan and  
Sue Murphy

### WA Division welcomes new Fellows

Two new Fellows were among 45 Fellows and partners who rounded out 2009 at the WA Division annual meeting and Christmas dinner at the Lake Karrinyup Country Club in December.

Division Chair Dr Ian Duncan presented Ms Susan Murphy, Chief Executive of the Water Corporation with her Fellowship certificate, and took the opportunity to acknowledge sponsors and supporters of Division events and acknowledge the achievements and contributions of WA Fellows during the year.

### Peter Andrews

Queensland Chief Scientist and ATSE 2009 Orator Professor Peter Andrews AO FTSE last year hosted a small, international symposium on the subject of 'Life in the Torrid Zone' with James Cook University Vice-Chancellor Professor Sandra Harding. The symposium considered opportunities and threats facing the tropical world and proposed a number of ways in which they might be addressed to achieve win-win outcomes for tropical Australia and its neighbours in the tropical world. A report that draws together key points from the think tank's deliberations is now available at [www.jcu.edu.au/torridzone](http://www.jcu.edu.au/torridzone).

## Craig Venter will deliver 2010 Graeme Clark Oration

The 2010 Graeme Clark Oration, which will provide an opportunity to be inspired by one of the world's most influential scientists, will be held on Wednesday, 17 March at the new Melbourne Convention Centre, South Wharf.

Presented by the ICT for Life Sciences Forum, the Graeme Clark Oration is a public event honouring the pioneering work of Professor Graeme Clark AC FRS FAA FTSE, whose research and leadership in bringing together a multi-disciplinary team in the 1970s led to the development of the world's first multi-channel cochlear implant, or bionic ear. Today, over 120,000 people around the world have received a bionic ear and the gift of hearing.

The Oration is delivered by an internationally renowned individual whose integration of the Physical and Life Sciences is having a profound impact on human health and society. The 2010 Oration will be delivered by Dr Craig Venter, genomics pioneer, and Founder and President of the J Craig Venter Institute.

Dr Venter was the first to map the genome of a living organism and played a critical role in mapping the human genome, the blueprint of human life and in September 2009, the US President presented Dr Venter with the National Medal of Science, the highest honour awarded to scientists by the United States government.

The Oration is a free public event, but registration is necessary. Registration will open in mid-February. Pre-register at <http://ict4lifesciences.org.au/>

## Ray Golding had a wide influence

The Academy regrets to advise Fellows of the death in November of former James Cook University Vice Chancellor Professor Ray Golding AO FTSE, aged 74.

Professor Golding was James Cook VC from 1986 to 1996 and was previously Pro Vic Chancellor (1978-86) and Professor of Theoretical and Physical Chemistry (1968-86) at the University of NSW.

New Zealand-born and educated, Professor Golding took his PhD at Cambridge and became a Fellow of the New Zealand Institute of Chemistry, the Institute of Physics, the Royal Australian Chemical Institute, the Royal Society of Arts and the Royal Astronomical Society. He was also a Fellow of the Pacific Conference on Marine Science and Technology (PACON).

His interests were diverse. He played a key role in the establishment of the Australian Defence Force Academy, helped establish the Australian Festival of Chamber Music (Director/Chair 1990-96), served on the Council of the PNG University of Technology (1986-93) and headed a Townsville trade delegation to Indonesia in 1992.

He took a strong interest in tourism (Director/Chair Australian Tourism Research Institute 1990-97), marine science (Chair Australian Marine Science Consortium 1984-2002) and served on many bodies associated with chiropractic and osteopathy practice.



Ray Golding

## Richard Williams wins chemical industry award in UK

Professor Richard Williams OBE FTSE, an ATSE Foreign Fellow, has received the 2009 Research and Development for Society award from the Society of Chemical Industry in the UK. The award recognises his contribution in the translation of research into commercial entities that have benefitted society.

Professor Williams is Professor of Mineral and Process Engineering and Pro-Vice-Chancellor at The University of Leeds.

In recent years Professor Williams' activities at the University have included creation of innovative companies specifically addressing improvements aimed at environmental and business improvements in the chemical, nuclear and energy efficiency sectors.

The work undertaken by Professor Williams and colleagues at Leeds includes development of 'nanofluids' – which are liquids that transfer heat more efficiently than conventional materials. These have potential applications in enabling new technologies for more energy efficient ways of transferring heat in home, transport, large scale computer installations and solar energy systems.

## Cathy Foley

Dr Cathy Foley, an Australian leader in applied physics, commenced her two-year term as President of FASTS in November – the second women to be elected to this role in FASTS' 24-year history. Dr Foley was recently awarded the National Telstra Women's Business Award for Innovation and has been appointed to the Questacon Advisory Board.



Richard Williams



# Wayne Osborn to chair AIMS

Wayne Osborn



Mr Wayne Osborn FTSE, former Managing Director of Alcoa Australia, has been appointed chair of the Council of the Australian Institute of Marine Science, replacing Dr Ian Gould FTSE, who had completed his five-year term.

Mr Osborn is a former chair of the Australian Aluminium Council, joined the Thiess Board in 2005 and was in 2008 appointed the inaugural chair of GESB Mutual Ltd, the financial services company based in Western Australia. Mr Osborn joined ATSE in 2008.

Dr Gould, Chancellor of the University of South Australia and a former mining executive with Comalco and North Broken Hill, has served on the Council since 2002.

Mr John Grace FTSE, ATSE Vice President, has been reappointed to the Council. He had served as a five-year term as Councillor since 2004.

Dr Ian Poiner FTSE, who joined ATSE in 2008, is the AIMS CEO and former Deputy Chief, CSIRO Marine Research.

## Fellows among top bulk handling engineers

Three Academy Fellows have been named by Australian Bulk Handling Review among Australia's Top 20 bulk handling engineers.

### ■ Emeritus Professor

#### Alan Roberts AM

**FTSE** (pictured), University of Newcastle, is described as one of the international "giants of bulk solids research". He has been a Fellow since 1989.



Alan Roberts

### ■ Emeritus Professor Peter Arnold

**FTSE**, University of Wollongong, is said to "sit atop the hierarchy of bulk solids academics". He joined ATSE in 1993

### ■ Dr Russ Morrison AM FTSE, Brisbane-based Chief Executive of engineering

consultancy BMT WBM, a Fellow since 1995, "has been involved in many innovative and challenging engineering projects".

Professor Roberts has combined a glittering academic career and the publication of seminal technical papers with an almost uncanny ability to solve industry problems.

He is the foundation director of TUNRA Bulk Solids Research Associates of the University of Newcastle which he established in 1975. This group carries out some 160 industrial projects per year in Australia and overseas and has completed more than 2,500 projects in some 40 countries.

Professor Arnold, a prolific researcher, teacher, author and consultant for 45 years, he has made major advances in bulk solids flow properties.

He is a Professorial Fellow in the Centre for Bulk Solids and Particulate Technologies and an expert advisor to Bulk Materials Engineering Australia, both at the University of Wollongong. He is a Fellow of Engineers Australia and a Life Member of the Australian Society for Bulk Solids Handling. In 1991, he was awarded a Doctor of Science Degree by the University of Wollongong in recognition of his extensive work in bulk solids handling.

Dr Russ Morrison's long professional career has involved many innovative and

challenging engineering projects from the design of hypersonic wind tunnels, jet engine test facilities, to robotic machines, to scramjets.

Over the past six or seven years, he has developed and led a specialist analysis group working on complex engineering problems involving fluid flow, heat transfer, structural dynamics, and control systems. At the same time he developed an automated, robotic wagon vibrator to assist in removing sticky coal from bottom-dump coal wagons.

He was awarded the 2004 AGM Michell medal for his contributions to mechanical engineering.

## Kaye Basford heads IBS

Professor Kaye Basford FTSE, Professor of Biometry and Head, School of Land and Food Sciences, University of Queensland, has just commenced a two-year term as President of the International Biometric Society (IBS).

Professor Basford, also ATSE Queensland Division Secretary, will draw on the knowledge and experience gained during her recent term as President of the Statistical Society of Australia.

She intends to promote the IBS as a supportive environment in which interaction, collaboration and learning opportunities are facilitated and enhanced so that members (particularly young people and those from special circumstance countries) can broaden their collegiate network for personal and professional development.

'Biometry' is the active pursuit of biological knowledge by quantitative methods. The IBS, founded in 1947, promotes the development and application of statistical and mathematical theory and methods in the biosciences (which includes agriculture, biomedical science and public health, ecology, environmental sciences, forestry, and allied disciplines). The Society has more than 5,300 members (from 80 countries) in 34 regions and groups.

## Alan Baker

Dr Alan Baker FTSE, Emeritus Research Leader, Air Vehicle Division at the Defence Science and Technology Organisation (DSTO), has been awarded the 2009 Specialist Gold Award of the Royal Aeronautical Society. The citation is "For Exceptional Work Leading to Substantial Advances in Aerospace".

## Richard Larkins

Professor Richard Larkins has been appointed to chair a high-level reference group established to provide guidance for a review of the best way to fund flexible and sustainable regional higher education. The Review of Regional Loading – Issues for Regional Provision is part of the Australian Government's commitment to Transforming Australia's Higher Education System and response to the Bradley Review.

# Howard Worner award winner named

Jared McNeill is the winner of the inaugural 2009 Howard Worner Memorial Scholarship. Jared, from Bowral, is studying mechanical engineering at the University of Wollongong.

Academy Fellows will recall that Professor Howard Worner CBE FAA FTSE was a renowned Australian metallurgist and scientist from rural Victoria who was Professor of Metallurgy at the University of Melbourne and then went on to become Director of Research for BHP and then CRA.

After retiring from CRA, Professor Worner became involved with the University of Wollongong (UOW) where he continued his interest in continuous smelting techniques and led a committed research group investigating the applications of microwave heating to industrial processing. He remained very active until his death in 2006 aged 94.

Chairman of ITC Group of Companies, Dr Brian Hickman FTSE, supported by the Office of Community and Partnerships, established the Memorial Scholarship fund at the University in 2008 to honour Professor Worner.

The scholarship, valued at \$10,000 a year, recognises Professor Worner's rural origins by providing scholarships for students from rural backgrounds to study engineering or science at UOW. With generous donations from individuals and mining companies the fund has now been established but is seeking further gifts from supporters to reach an endowment goal of \$200,000 so that at least one scholarship can be awarded in perpetuity.

Fellows interested in supporting Professor Worner's legacy by contributing to the fund can contact the Office of Community and Partnerships on (02) 4221 3073 or send tax-deductible contributions directly to the Office of Community and Partnerships, University of Wollongong, Northfields Avenue, Wollongong NSW 2550.

Jared McNeill

## Jim Woodcock left his mark on the minerals industry

James (Jim) Thorpe Woodcock AM, a former strong contributor to ATSE whose findings had a significant impact on Australia's mineral processing industry, has died at the age of 83.

He leaves a legacy to the Australian minerals industry from his research and its application in many operations in Australia and overseas, his research papers and books, and his training of young scientists over a period of 60 years.

Born in Brompton, England in 1925, Jim arrived in Melbourne in 1940 with his family as evacuees from Hong Kong. He completed his schooling at Melbourne High School then went on to the University of Melbourne to study metallurgical engineering. He completed his bachelor degree in 1946, was awarded the Dixon Scholarship in Metallurgical Engineering at the University of Melbourne in 1947, and then went on to complete a Master of Engineering Science early in 1948.

Jim started his working career with a gold mine in central NSW before joining the CSIRO in 1951, where he continued to work for more than 58 years, acting in the capacity of Honorary Fellow after his retirement in 1990.

Jim's research had significant impact on the mineral processing industry, developing methods still in use today.

Jim was a long-term member of the Australasian Institute of Mining and Metallurgy (AusIMM) and its Honorary Editor from 1963 to 1993, involved in the production of more 60 books. He was also Honorary Editor for

ATSE from 1977 to 1991 and edited and produced about 20 books for the Academy.

## Linking Australia and Japan

ATSE is hosting a group of eight mid-career researchers from Japan visiting Australia from 14-26 February 2010 to progress S&T

linkages in Energy and Environment; Novel Materials and Resources; and Biotechnology.

This important opportunity is being funded by DIISR and the Japan Society for the Promotion of Science, and administered by ATSE and the Engineering Academy of Japan (EAJ).

The Japanese party is being hosted by scientists at various Australian universities, CRCs, CSIRO elements, research institutions – including various ATSE Fellows – whose support is invaluable. The Exchange will commence with an orientation session in Canberra on 15 February and conclude with a debriefing session on 26 February in Sydney.

## John Simmons

Professor John Simmons FTSE, ATSE Vice-President and Chair of the Membership Committee, has been awarded a University of Queensland Citation for Outstanding Contributions to Student Learning in the School of Mechanical and Mining Engineering. The citation is "For significant and sustained excellence in teaching that has inspired, challenged and encouraged University of Queensland engineering students over four decades".

## Robert Watts

Professor Robert Watts, President, Royal Australian Chemical Institute, has been elected Vice President of FASTS. Professor Watts is a former Chief Scientist and Vice President Technology for BHP Billiton and was earlier head of the School of Chemistry at the University of Melbourne.

## Gustaaf Hallegraef

Professor Gustaaf Hallegraef, from the University of Tasmania (and Tasmanian Division Chair of ATSE), was one of 75 researchers who will team up with international collaborators under Australian Government International Science Linkages – Science Academies Program awards. Professor Hallegraef will work with Professor Phillip Reid, of the Sir Alistair Hardy Foundation for Ocean Science, UK, on 'Climate change and ocean acidification: will coccolithophorids be winners or losers?'

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# 2010 ATSE Clunies Ross Awards Presentation Dinner

**WEDNESDAY 19 MAY 2010**

**MAIN HALL, MELBOURNE TOWN HALL,  
MELBOURNE**

The ATSE Clunies Ross Awards recognise Australia's pre-eminent scientists, innovators and technologists who have bridged the gap between research and the marketplace.

The 2010 Award Dinner will be a unique opportunity to celebrate excellence in science, engineering and technology and network with leaders in industry, government and academia.

To register your interest in attending the Awards Dinner contact Rebecca Bone on 03 9864 0908 or email [events@atse.org.au](mailto:events@atse.org.au)



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## 2011 ATSE CLUNIES ROSS AWARDS **CALL FOR NOMINATIONS**

For more information about the nomination process or to download a nomination form visit [www.cluniesross.org.au](http://www.cluniesross.org.au) Entries close 30 June 2010

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# CANCER INHIBITORS MADE IN PLANTS

**UQ researchers examine ways to manufacture low cost cancer drugs using plants.**

Dr Josh Mylne from the Institute for Molecular Bioscience (IMB) at UQ discovered a gene for sunflower seed trypsin inhibitor. He modified this gene so that plants can produce a molecule that inhibits an enzyme associated with prostate cancer in humans.

Dr Mylne and his team are developing these transgenic plants as a unique way of producing high volume, low cost cancer drugs.

The project exemplifies the innovation and excellence possible in the multidisciplinary research environment at UQ. IMB is one of UQ's seven globally-recognised research institutes.

UQ consistently ranks among the world's top universities\* and attracts over 4000 people annually from around the world to pursue research higher degrees (RHD).

Through Australia's most convenient RHD entry scheme, you may apply for admission and scholarship with just one form, any day of the year. To apply, visit [uq.edu.au/grad-school](http://uq.edu.au/grad-school) and discover Australia's world-class research for yourself.

*\*UQ has been named in the top 50 universities in the world for the fifth year running in the UK's 2009 Times Higher Education-QS World University Rankings.*