SCIENCE AT THE SHINE DOME **2013**

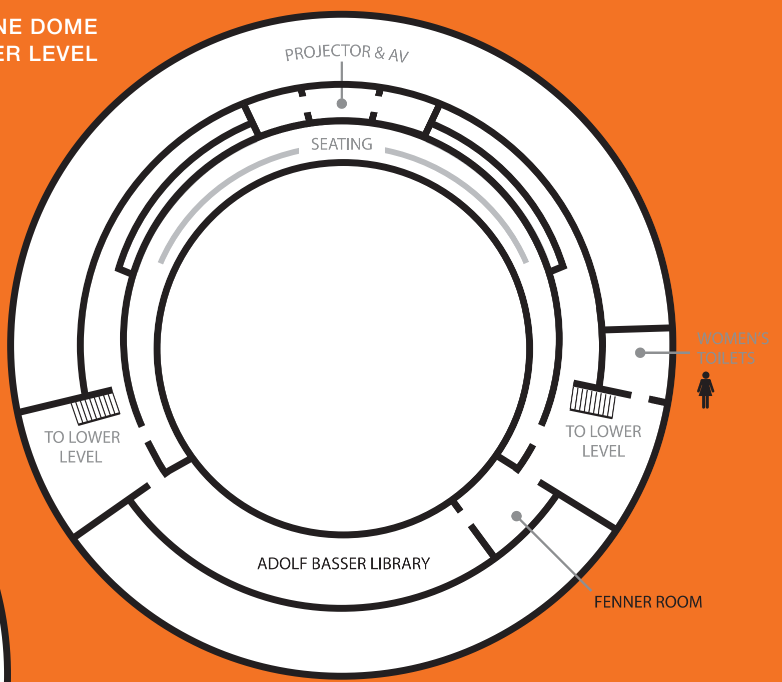
POWER TO THE PEOPLE: THE SCIENCE BEHIND THE DEBATE

Program 29–31 May

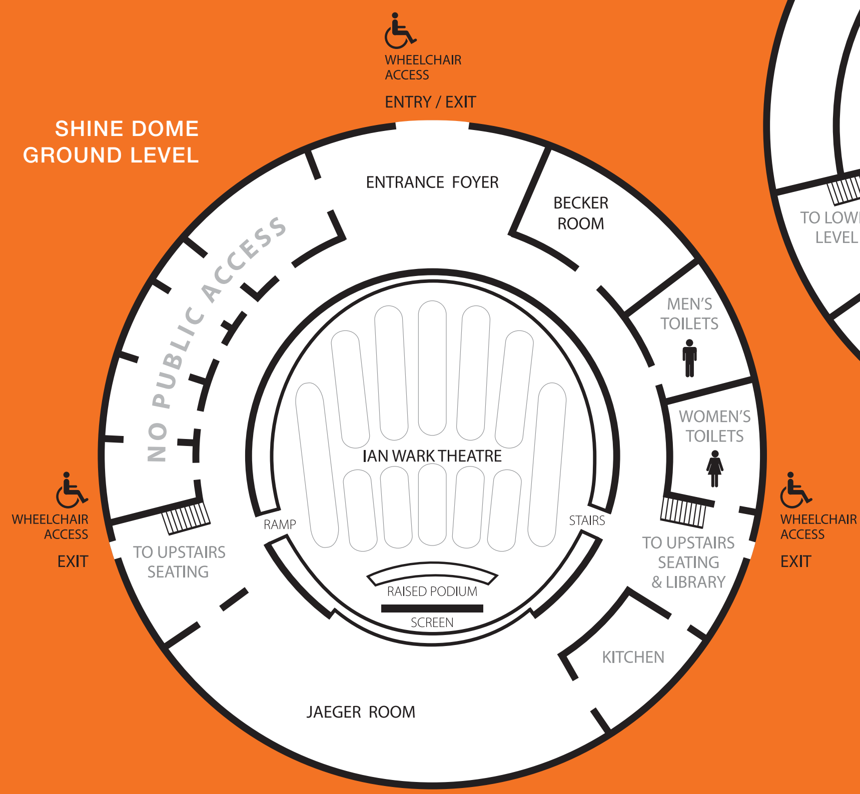
New Fellows Awards AGM Symposium New Fellows Awards AGM Symposium Ne

Australian Academy of Science

SHINE DOME UPPER LEVEL



SHINE DOME GROUND LEVEL



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President's Welcome

It is my great honour and pleasure to welcome Fellows of the Australian Academy of Science, sponsors, special guests, teachers, early career researchers, policy makers and other interested observers to our flagship annual event, *Science at the Shine Dome*.

With the Academy's Annual General Meeting as its foundation stone, this meeting has grown over its 59 years to become a celebration of great science in Australia; a three-day feast of knowledge and inspiration.

Warm congratulations to the 20 new Fellows who were elected this year. I look forward to welcoming you to the Fellowship with a formal admission ceremony, and to hearing you present highlights of your work. Election to the Fellowship is a singular acknowledgement that you have made outstanding contributions to scientific knowledge.

I am excited also to be able to preside over the awards ceremony: each year the Academy recognises a small number of scientists for their extraordinary work over a lifetime, or for highly significant work in their early or mid careers. I am sure the 2013 awardees will present stimulating expositions of their work.

The Academy is committed to nurturing the careers of young scientists. I welcome the participation of young researchers from around Australia, 14 of whom have been supported to attend through the generosity of sponsors. You will find all of our sponsors listed through the pages of this program. We are also delighted to host the eight young scientists who have been selected to travel later this year to Lindau, Germany, to participate in the annual meeting of Nobel Laureates.

Quality science education at all levels is of great importance to the Academy. We are grateful to Professor David Craig FAA, whose continuing generous support has underpinned the Academy's Science Teacher Awards, under which we have brought eight talented and dedicated science teachers from every Australian state and territory to join us at *Science at the Shine Dome*. We also welcome the recipients of other important national awards for science teaching.

As well as attending the science highlights of the week, teacher and young scientist delegates will engage in professional development activities. This event provides a wonderful opportunity to form new friendships and collaborative relationships not only across disciplines but across professions; in particular I encourage you to use the various lunches and dinners during the next few days as an opportunity to proactively seek new acquaintances.

Please also take a moment to visit our primary and secondary education experts, who will be demonstrating the Academy's award-winning hands-on *Science by Doing* and *Primary Connections* curriculum resources in the Jaeger Room throughout the three day event. I particularly encourage you to take advantage of the opportunity to enjoy a preview of the new *Science by Doing* interactive online units, which will be released to Australian secondary schools shortly.

Professor Thomas Maschmeyer FAA has organised a fascinating annual Symposium: a topical and timely exploration of the science driving the future of power generation. High levels of carbon emissions and increasing global temperatures are already affecting our decisions about energy use. Expert speakers will examine thermal power, photovoltaics, next generation fossil fuel technologies, nuclear energy, smart grids and the nexus between power generation, population, economics and sustainability.

Every year I am delighted to see the familiar faces of friends and colleagues, and to welcome new friends. I am so pleased you could join us at the 59th annual general meeting of the Australian Academy of Science.

Suzanne Cory AC PresAA FRS

Program Wednesday 29 May

New Fellows Seminar

9.00 am

Welcome
Professor Suzanne Cory AC PresAA FRS
President, Australian Academy of Science

9.05 am

Formal admission of new Fellows
Chairs: Professor Chennupati Jagadish FAA FTSE,
Professor Marilyn Renfree AO FAA

Session One — New Fellows Presentations

9.30 am

Professor Matthew Brown FAA
Genetics and the future of medicine

9.45 am

Professor David Craik FAA
Discovery and applications of circular proteins

10.00 am

Professor David Day FAA
An alternative path against oxidative stress in plants

10.15 am

Professor Yuri Estrin FAA
Bulk nanomaterials: properties and promises

10.30 am **MORNING TEA**

11.00 am

Professor John Evans FAA
Relating photosynthesis to leaf nitrogen

11.15 am

Professor Bryan Gaensler FAA
Cosmic magnetism

11.30 am

Professor Andrew Hassell FAA
Quantum billiards

11.45 am

Professor Ove Hoegh-Guldberg FAA
The Ocean in a changing world: from cellular to planetary dysfunction

12.00 pm

Professor Ian Jackson FAA
Laboratory seismology and the Earth's internal structure

12.15 pm

Professor Sharad Kumar FAA
Investigations into cell death and ubiquitination

12.30 pm **LUNCH**

Session Two — New Fellows Presentations

1.30 pm

Professor Max (Gao Qing) Lu FAA FTSE
Engineering nanocrystalline photocatalysts

1.45 pm

Professor Stephen William MacMahon FAA
'Frugal' healthcare innovation — a global research priority

2.00 pm

Professor Boris Martinac FAA
Mechanosensitive ion channels in bacteria

2.15 pm

Professor James Paton FAA
Preventing pneumococcal disease in the 21st century

2.30 pm

Professor Stephen Bruce Powles FAA FTSE
Evolution in action: herbicide resistance in plants

2.45 pm

Dr Richard Richards FAA
Meeting future food requirements: designing better crops

3.00 pm

Dr Louise Marie Ryan FAA
Statistics — the science of uncertainty

3.15 pm

Professor Michael Sandiford FAA
Shaping the continents

3.30 pm

Professor Geoffrey Taylor FAA
Search for the Higgs boson

3.45 pm **AFTERNOON TEA**

4.15 pm

Professor Andrew White FAA
Quantum biology, chemistry, maths and physics

4.30 pm

Professor Bryan Williams FAA
Molecules and mechanisms in the innate immune system

4.45 pm

Close
Professor Suzanne Cory AC PresAA FRS
President, Australian Academy of Science

6.30 pm – 9.00 pm

EMCRs and teachers dinner

(See page 5 for details)

Program Thursday 30 May

Career and early career honorific awards presentations

9.00 am

President's address
Professor Suzanne Cory AC PresAA FRS
President, Australian Academy of Science

Matthew Flinders Medal and Lecture

9.30 am

Matthew Flinders Medal lecture
Professor Kenneth Freeman FAA FRS
The Australian National University
Dark matter in galaxies

Honorific Awards Presentations

10.00 am

David Craig Medal
Professor Peter Lay FAA
The University of Sydney
Biospectroscopic studies and microscopic imaging of cells and tissues: understanding the biomolecular basis of human diseases and their treatments

Hannan Medal
Professor Matthew Wand FAA
University of Technology Sydney
Regression analysis of streaming data

Thomas Ranken Lyle Medal
Professor Cheryl Praeger AM FAA
University of Western Australia
Symmetry: more of the same!

11.00 am **MORNING TEA**

Early Career Honorific Awards Presentations

11.30 am

Fenner Medal
Dr Ulrike Mathesius
The Australian National University
Plants control microbes — microbes control plants

Gottschalk Medal
Dr Benjamin Kile
Walter and Eliza Hall Institute of Medical Research
Platelets, bleeding, and cancer therapy

Anton Hales Medal
Dr Wouter Schellart
Monash University
Control of subduction zone size on plate tectonics and mantle flow

Dorothy Hill Award
Dr Lisa Alexander
The University of New South Wales
A land of droughts and flooding rains? How future greenhouse gas emissions will affect Australia's climatic extremes

Moran Medal
Dr Aurore Delaigle
University of Melbourne
Introduction to functional data analysis in statistics

Pawsey Medal
Associate Professor Christopher Blake
Swinburne University of Technology
Dark energy and the accelerating Universe

1.00 pm **LUNCH**

2.30 – 5.00 pm

Annual General Meeting
(closed session for Fellows of the Academy)

1.45 – 5.00 pm

Social program
(See page 5 for details)

2.00 – 5.00 pm

Early career researcher workshops
- Grant writing — getting your research funded
- Media and communicating science
- Successful scientific collaborations

1.00 – 5.00 pm

Teacher workshops
(See page 32 for details)

7.00 pm

Annual dinner
(Pre-dinner drinks at 7.00 pm, dinner at 7.30 pm)
Gandel Hall, National Gallery of Australia
Presentation of Career Award Medals
Dress code: Black tie/cocktail
Guest Speaker: Sir David King

Program Friday 31 May

Annual symposium
Power to the people: the science behind the debate

Morning session

Chair session 1:
Professor Suzanne Cory AC PresAA FRS

8.35 am

Welcome
Professor Suzanne Cory AC PresAA FRS

8.45 am

Welcome
Dr Dean Morris (Platinum sponsor)
Head of Operations, Australian Synchrotron
Representing the Melbourne Convention Bureau

9.00 am

Improving human well-being on a resource-limited planet — can we do it?
Professor Sir David King FRS FAAS

9.45 am

Solar photovoltaics — recent developments and Australia's key role
Professor Martin Green AM FAA FRS FTSE

10.15 am **MORNING TEA**

Chair session 2:
Professor Ken Baldwin

10.45 am

Solar thermal power — how long till impact?
Mr Wes Stein

11.15 am

Geothermal power — regulatory nirvana for unconventional energy
Mr Barry Goldstein

11.45 am

Unconventional gas — opportunities and limitations
Professor Sue Golding

12.15 pm

Direct injection coal engines (DICE) — a coal paradigm revisited
Dr Louis Wibberly

12.45 pm **LUNCH**

Afternoon session

Chair session 1:
Professor Thomas Maschmeyer FAA FTSE

1.30 pm

Looking out: Australia's potential energy future
Dr Tom Hatton PSM

2.00 pm

Nuclear energy for Australia — policy and politics behind the debate
Dr Ziggy Switkowski FTSE

2.30 pm

Advanced fission and fusion technologies for sustainable nuclear energy
Professor Barry Brook

3:00 pm **AFTERNOON TEA**

Chair session 2:
Professor Chennupati Jagadish FAA FTSE

3.30 pm

Smarter grids — why control, decision, communication, computing and network sciences are also needed
Professor David Hill FAA FTSE

4.00 pm

Energy storage — a disruptive technology for future grids?
Professor Tony Vassallo

4.30 pm

Can energy demand be limited while still improving quality of life?
Professor Ian Lowe AO FTSE

5.00 pm

Conclusion and close of meeting
Professor Robin Batterham AO FAA FTSE

Social events

EMCRs and teachers dinner

(EMCRS, TEACHERS AND GUESTS ONLY)

Wednesday 29 May 2013
6.30 pm
Jaeger Room, The Shine Dome

Participating early and mid career researchers and science and mathematics teachers are invited to a special dinner at the Shine Dome. This is an informal opportunity to get to know one another, make connections and perhaps even meet a mentor: some Fellows of the Academy will attend.

Social program

Thursday 30 May 2013
1.45 pm
National Film and Sound Archive
www.nfsa.gov.au

The National Film and Sound Archive of Australia (NFSA) is the nation's living archive, collecting, preserving and sharing our rich audiovisual heritage.

The collection includes films, television and radio programs, videos, audio tapes, records, compact discs, phonograph cylinders and wire recordings. It also encompasses documents and artefacts such as photographs, posters, lobby cards, publicity items, scripts, costumes, props, memorabilia, oral histories, and vintage equipment.

The NFSA aims to develop a collection that has enduring cultural significance. The curatorial staff guide the acquisition of new material, and the way it is documented and presented.

'Exploring Australia's energy past'

1.45 pm

Depart the Shine Dome for NFSA — short walk

2–5 pm

- Tour of NFSA
- Coffee and cake at Teatro Fellini Café
- Visit to NFSA gift shop
- Screening in Arc Cinema (Customised program — Theme: Energy)

5 pm

Depart for the Shine Dome / hotel — short walk

Annual dinner

Thursday 30 May 2013
7 pm – 11 pm
Gandel Hall, National Gallery of Australia

Dine in style at the National Gallery of Australia's beautiful Gandel Hall. A Who's Who of Australian science attends the Academy's Annual Dinner, at which the lifetime achievements of three outstanding scientists will be celebrated with presentation of Career Awards.

The keynote speaker is Sir David King, Chancellor, University of Liverpool, former Director of the Smith School of Enterprise and Environment at the University of Oxford, and former UK Chief Scientist. His speech is titled: 'Science and policy: is there a role for scientists?'.

The Gandel Hall is a majestic new multipurpose venue that is spacious, light-filled and exquisitely detailed with gold-leaf doors and red ironbark floors. It opens on to the new Australian Garden in which James Turrell's monumental Skyspace *Within without* offers guests an extraordinary experience of Canberra's skies.

Please note the dress code for this event is 'black tie'. Pre-dinner drinks will be served from 7 pm in the first floor foyer area, followed by dinner at 7.30 pm.

Symposium keynote speaker

Sir David King FRS FAAS

Sir David King is former Director of the Smith School of Enterprise and Environment at the University of Oxford. He is currently Chancellor of the University of Liverpool, Senior Scientific Advisor to UBS bank and Science Adviser to President Kagame of Rwanda.

Sir David was the UK Government's Chief Scientific Adviser and Head of the Government Office of Science from October 2000 to December 2007. He promoted the need for governments to act on climate change and was instrumental in creating the new £1 billion Energy Technologies Institute. As Director of the Government's Foresight Programme, he created an in-depth horizon scanning process, which advised government on a wide range of long term issues, from flooding to obesity. He also chaired the government's Global Science and Innovation Forum from inception; advised on issues including the foot-and-mouth disease epidemic of 2001, post 9/11 risks, GM foods and energy provision; and was heavily involved in the Government's Science and Innovation Strategy 2004–2014.

Sir David was born in South Africa in 1939, attended the University of Witwatersrand, Imperial College and the University of East Anglia, and became Brunner Professor of Physical Chemistry at the University of Liverpool in 1974. In 1988 he was appointed 1920 Professor of Physical Chemistry at the University of Cambridge and later Master of Downing College (1995–2000), Head of the University Chemistry Department (1993–2000), and Director of Research in the Department of Chemistry (until September 2010). He has published more than 500 papers in chemical physics and on science and policy, and received numerous prizes, fellowships, and honorary degrees.

Sir David is also Honorary Fellow of the Indian Academy of Sciences and Honorary Foreign Fellow of the American Academy of Arts and Sciences. He was knighted in 2003 for his work in science, and received the Legion of Honour award from the French President in 2009.

Symposium speakers

Professor Robin J Batterham AO FAA FTSE, University of Melbourne

Robin Batterham is Kernot Professor of Engineering at the University of Melbourne and President of the Australian Academy of Technological Sciences and Engineering. Until recently he was Group Chief Scientist, Rio Tinto Limited and Chairman of the International Energy Agency Expert Group on Science for Energy. He has had a distinguished career in research and technology, in the public and private sectors in areas such as mining, mineral processing, mineral agglomeration processes, and iron making. He is inventor on more than 20 patent families. Professor Batterham was Chief Scientist for the Australian Government from 1999 to 2005. Professor Batterham's current research interests centre on energy systems, including geothermal energy, energy reduction in comminution and in dewatering of low grade materials.

Professor Batterham is the symposium's closing speaker.

Professor Barry W Brook, University of Adelaide

Barry Brook is a Professor and ARC Future Fellow at the University of Adelaide's Environment Institute, where he holds the Sir Hubert Wilkins Chair of Climate Change. He has published three books, more than 200 refereed scientific papers, and regularly writes popular articles for the media. His awards include the 2006 Australian Academy of Science Fenner Medal and the 2010 Community Science Educator of the Year. His research focuses on the causes and consequences of extinction, analysis of energy systems for carbon mitigation, and simulation models of the synergies of human impacts on the biosphere.

Advanced fission and fusion technologies for sustainable nuclear energy

Next-generation nuclear energy — including advanced fission reactors, fusion-fission hybrids and pure hydrogen-fusion designs — offers a means to produce vast quantities of zero-carbon and reliable electricity and process heat. For fission, new designs that are now ready for commercial demonstration can take advantage of the superior physical properties of plutonium in a fast neutron spectrum to convert essentially all of the mined uranium into useful fissile material and abundant electricity. The Integral Fast Reactor (IFR) and similar 'Generation IV designs' can change in a fundamental way the outlook for global energy on the necessary massive scale. These resource extension properties multiply the amount of usable fuel by a factor of more than 100, allowing demand to be met for many centuries with fuel already at hand, by a technology that is known today, and whose properties are largely established. Demonstrating a credible and acceptable way to safely recycle used nuclear fuel will also clear a socially acceptable pathway for nuclear fission to be a major low-carbon and sustainable energy source for this century. For fusion, there are exciting medium- to long-term prospects, based on work now being done on the International Thermonuclear Reactor Experiment (ITER) and on hybrid fusion-fission designs that use molten-salt coolants and use thorium and hydrogen isotopes as fuel. Replacement of fossil fuels is urgently needed to sustain global society whilst mitigating environmental impacts, and sustainable forms of nuclear energy offer a realistic and effective way of achieving this goal.

Professor Sue Golding, University of Queensland

Sue Golding holds BSc (Hons I) and PhD degrees from the University of Queensland and has more than 30 years experience in the application of geochemistry to the origin of resources in sedimentary basins. She has published more than 100 journal articles and book chapters and edited a pioneering text on coal seam gas entitled *Coalbed Methane: Scientific, Environmental and Economic Evaluation*. Professor Golding is an international expert on coal seam gas and carbon sequestration in sedimentary basins. A significant focus of her research group at the University of Queensland is on technology related to environmentally sustainable energy provision. The research spans multiple scales from natural analogue studies of coal basins to determine the origins of coal seam methane and mechanisms that keep carbon dioxide naturally sequestered to experimental studies of the impact of carbon dioxide interaction with sandstones and coals.

Unconventional gas — opportunities and limitations

Unconventional gas refers to natural gas trapped in low permeability rocks such as coal, shale and tight sandstone and limestone, which is not recoverable using conventional oil industry approaches. The IEA has forecast a potential 'Golden age of gas' and estimates recoverable unconventional gas resources worldwide are of a similar size to recoverable conventional gas resources at around 400 trillion cubic metres. Current production comes mainly from North America, with lesser production from Australia, China, India and Indonesia. The wide geographic distribution of unconventional gas resources contrasts with conventional gas resources and is already reshaping the global energy landscape. Developing unconventional gas resources is an intensive process that uses technologies such as hydraulic fracture stimulation and horizontal drilling and typically requires a larger number of wells than conventional gas production. Many countries that currently import natural gas have considerable unconventional gas potential but are concerned about the perceived social and environmental impact of unconventional gas production. The full potential of unconventional gas will only be realised if governments and industry commit to high environmental standards, robust and well resourced regulatory regimes and full public access to information.

Mr Barry A Goldstein, South Australian Government

Barry Goldstein has more than 30 years of international experience in energy businesses. He is South Australia's Executive Director for Energy Resources, Chair of COAG's Coal Seam Gas Steering Group, Chairman of the Australian Geothermal Energy Group, Australia's representative to the International Energy Association for geothermal energy, an AAPG Asia-Pacific Councillor, and serves on the boards of the Geothermal Resource Council (USA) and the Australian School of Petroleum (University of Adelaide). Before joining the South Australian Government, Mr Goldstein was Exploration Manager and Chief Geologist for Santos, Chief Geologist — Bridge Oil, and Chief Geologist — Kuwait Foreign Petroleum Exploration Corporation, after starting with Phillips Petroleum. He has explored for and discovered energy resources in the North Sea, Indonesia, Australia, PNG, and South America. He graduated from the University of New York (Bachelors — Geology, 1975) and the University of Missouri (Masters — Geology, 1977). Last, he has a sense of humour.

Regulatory nirvana for unconventional energy

Unconventional gas development is proving to be positively transformational for economies. Some unconventional Australian and international gas projects have, or have been perceived to have, significant environmental, health or social impacts. This presentation will characterise unconventional gas plays; and lay out the factors taken into account in considering whether or not to approve unconventional gas projects so as to ensure compatibility with co-existing natural, social and economic environments. It will also describe world's best practice to sustain optimised land access for unconventional gas development by credibly informing people and enterprises potentially affected by unconventional gas operations, with time to draw considered views, so potentially affected stakeholders' rights to object to land access are fully supported, and community expectations for net outcomes are attained. Trustworthy regulation will enable efficient, profitable and welcomed deployment of capital, technologies and infrastructure for the commercialisation of unconventional gas in Australia.

Professor Martin A Green AM FAA FRS FTSE, University of NSW

Martin Green is a Scientia Professor at the University of New South Wales, and Executive Research Director of the University's Photovoltaic Centre of Excellence. His group's contributions to photovoltaics include development of the world's highest efficiency silicon solar cells and commercialisation of several different cell technologies. He is the author of several well-known books on solar cells and numerous papers. His work has resulted in many major international awards including the 2002 Right Livelihood Award, commonly known as the Alternative Nobel Prize, the 2007 SolarWorld Einstein Award and the 2010 Eureka Prize for Leadership. In 2012, Professor Green was appointed a Member of the Order of Australia in recognition of his contributions to photovoltaics and to photovoltaic education.

Solar photovoltaics — recent developments and Australia's key role

There has been a photovoltaics revolution over the past four years, with prices dropping by 80%, bringing forward significantly the period of cost-effective contribution to large-scale energy supply. The revolution arises from a manufacturing shift from high-cost, high-technology European, Japanese and USA locations to Asia, particularly China. Australia and Australians have played key roles in this transition. Initial production lines of market leaders Suntech-Power and JA Solar were established by Australians and, of the top 10 manufacturers in China, eight have UNSW-trained staff as VP Technology or Chief Technical Officer, or had them when it counted. These companies look to Australia for future technology, giving Australia the opportunity to become the technology-hub of a massive industry. By 2020, photovoltaic cost-competitiveness will extend from present retail levels to wholesale levels ultimately becoming, in accordance with conclusions of the Australian Government Bureau of Resources and Energy Economics, the cheapest long-term Australian electricity option.

Dr Thomas Hatton PSM, CSIRO

Tom Hatton is CSIRO's Group Executive, Energy, overseeing the Division of Earth Science and Resource Engineering, the Energy Technology Division, the 'Energy Transformed and Wealth from Oceans' Flagship, and the 'Advanced Coal Technologies' and 'Petroleum and Geothermal Research' portfolios. He previously directed the CSIRO *Water for a Healthy Country* Flagship and in three years as Director developed it into the largest portfolio in the organisation and the largest water research effort in Australia. The Flagship achieved wide recognition for high-impact science consciously aimed at meeting Australia's most serious water challenges. Bringing together diverse disciplines ranging from the traditional areas of climatology, hydrology and engineering to the social and behavioural sciences, he built large teams from within CSIRO and partner research institutions to deliver significant outcomes for industry and government. Born in Hollister, California, Dr Hatton completed a BSc (summa cum laude) and MSc in Natural Resources at Humboldt State University, and a doctorate at Utah State University. In 1999 he was awarded the inaugural WE Wood Award for scientific excellence in the field of salinity research. In 2008, he received the CSIRO Chairman's Medal and the Australian Public Service Medal for his contributions to the management of Australia's water resources.

Looking out: Australia's potential energy future

As Australia's largest source of greenhouse gas emissions, our energy choice will shape Australia's sustainability profile. The future of energy therefore matters. However this future also faces many uncertainties, which fall into four major categories: economic, technological, social and regulatory. For example, the unlocking of vast shale gas resources in the US has launched nothing short of an energy revolution. The economic flow-on consequences on global oil and gas markets have yet to play out fully. Many new technologies stand ready to similarly unlock previously uneconomic fossil or renewable resources. How the development and demonstration of these technologies will progress is difficult to predict. Furthermore, technological feasibility and cost alone will not be sufficient to determine the fate of new technologies. As historic experience shows, societal acceptance is the ultimate determinant of what regulation will and will not allow in the energy sector. In this uncertain environment three approaches would maximise wealth and energy security and prepare us for a cleaner energy future. Firstly, we should maintain a broad set of energy options to have the ability and agility to respond to changes if and when they occur. Secondly, we need to focus on using the existing energy assets and system as efficiently as possible. Technologies already exist or are on the drawing board that can achieve this. Thirdly, we should continue the work on greenhouse gas mitigation options, at a minimum as an insurance for our substantial exports of fossil fuels.

Professor David Hill FAA FTSE, University of Sydney

David J Hill received a BE (Electrical Engineering, 1972) and BSc (Mathematics, 1974) from the University of Queensland, and a PhD in Electrical Engineering from the University of Newcastle in 1977. He is Professor of Electrical Engineering (appointed 1994) and an Australian Research Council Professorial Fellow (2011–15) in the School of Electrical and

Information Engineering at the University of Sydney. He is also a Senior Principal Researcher with National ICT Australia. Since 2012 he has held a visiting Chair Professorship under the Distinguished Scholars Scheme at The Hong Kong Polytechnic University. His general research interests are in network systems, stability analysis, distributed control and the control and planning of power systems. His work is now mainly on advanced energy networks. Professor Hill is a Fellow of the Institute of Electrical and Electronics Engineers, USA, the Society for Industrial and Applied Mathematics, USA, the Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering. He is also a Foreign Member of the Royal Swedish Academy of Engineering Sciences.

Smarter grids — why control, decision, communication, computing and network sciences are also needed

The modernisation of electricity networks to accommodate increasing renewable energy targets and new technologies, such as electric vehicles and demand management, all over just a few decades, leads to system control and planning challenges. The term 'smart grids' has arisen around the anticipated greater use of information technology in the operation of electricity networks, particularly at distribution levels. It is clear that all these advances when seen over the long-term present a series of analytical challenges. To name two, we will have to deal with much greater uncertainty and scale in computations. For example, the latter arises from the increasing granularity of control devices across transmission and distribution. Related to uncertainty, we can no longer see future planning in terms of steady load growth and incremental additions to the network. This presentation is based on a Future Grid project in Australia funded by the CSIRO and four universities. Closely related projects, which are running in the USA and Germany, will also be discussed. These take a long-term view out to 2030 at least and in some cases 2050. The focus in Future Grid is on delivering the first analytical framework of its kind to systematically investigate the most efficient energy network (electricity and natural gas) configurations for Australia. With this framework, Australia will be able to identify the lowest cost pathway to integrate significant amounts of large and small scale renewables into the grid with existing technologies while maintaining operational stability. Thus it will pave the way for significant emissions reductions in Australia's most carbon intensive economic sector.

Professor Ian Lowe AO FTSE, Griffith University

Ian Lowe is emeritus professor of science, technology and society at Griffith University in Brisbane and holds adjunct appointments at two other universities. He is President of the Australian Conservation Foundation and a Fellow of the Australian Academy of Technological Sciences and Engineering. He was made an Officer of the Order of Australia in 2001 for services to science and technology, especially environmental science. He received in 2000 the Prime Minister's Environmental Award for Outstanding Individual Achievement and the Queensland Premier's Millennium Award for Excellence in Science. He also received the 2002 Eureka Prize for Promotion of Science. He chaired the advisory council that produced the first national report on the state of the environment in 1996, helped develop the framework for the UNEP reports on the Global Environmental Outlook reports and has refereed major international reports on natural systems. In 2009 the International Academy of Sciences, Health and Ecology awarded him the Konrad Lorenz Gold Medal.

Can energy demand be limited while still improving quality of life?

We have dramatically improved our material living standards by harnessing fuel energy on a prodigious scale. Every aspect of modern life demands huge quantities of fuel energy, both direct uses such as heating, lighting and transport, as well as to provide food, water, housing and economic output. Much of this energy use is extremely inefficient. Several international studies show that all those services could be provided using much less energy. The UN report *Resource Efficiency and Economic Outlook for the Asia-Pacific* notes that current energy use threatens the life-support systems on which we depend, while the basic needs of many remain unmet. It calls for 'a new Industrial Revolution' to reduce resource use per capita by 75%. Achieving this scale of improvement is technically possible, but impeded by outdated economic assumptions and models.

Mr Wes Stein, CSIRO

Wes Stein is Research Program Leader, Solar Power, and Manager of the National Solar Energy Centre at CSIRO. His responsibilities include developing and delivering the next generation of solar thermal power

technologies through leadership, strategic R&D, demonstration projects and innovative energy strategies that foster the development of a national and global sustainable energy industry. He has been responsible for initiating and building CSIRO's program and the National Solar Energy Centre to $40M of R&D projects and a strong team of 30 scientists and engineers. It is the leading group in Australia and a leading group in the world.

He is a member of the Australian Solar Institute's Research Advisory Committee, Australia's representative on the International Energy Agency's SolarPACES Executive Committee, lead author for the IPCC Special Report into Renewable Energy, co-author of a study for the World Bank on the global Status and Opportunities for Concentrating Solar Power, and recently co-edited a book on Concentrating Solar Power. He is a member of the UNIDO International Solar Energy Centre for Technology Promotion and Transfer and is a member of the Australian Institution of Engineers. Before joining CSIRO he worked for 19 years in the power industry with Pacific Power.

Solar thermal power — how long till impact?

Solar thermal power was first built and operated commercially in the late 1980s. However it has since been outpaced by other energy technologies. Its time to make a real dent in global emissions is still to come, but when? This talk outlines the state of play for the technology, and the emerging technologies. The main thrust is lower cost power by reducing component cost and, importantly, improving efficiency, predominantly through higher operating temperatures. Higher temperatures pose optical, thermodynamic and material challenges, all of which we are better positioned to address than two decades ago. Solar thermal technology also provides the option of thermal storage which can ensure dispatchable solar electricity, and can be used to generate 'drop-in' solar fuels as part of our present fuel mix. The future appears sunny.

Dr Ziggy Switkowski FTSE, Suncorp Group, RMIT University

Ziggy Switkowski is Chairman of the Suncorp Group, Chancellor of RMIT University and Chair of Opera Australia. He is a former chief executive of Telstra, Optus and Kodak (Australasia) and currently a non-executive director of Tabcorp, Oil Search and Lynas. Dr Switkowski is a graduate of the University of Melbourne with a PhD in nuclear physics. He is a Fellow of the Academy of Technological Sciences and Engineering and of the Australian Institute of Company Directors.

Nuclear energy for Australia — policy and politics behind the debate

Interest in adding nuclear energy to the range of non-fossil fuel options available in Australia has been jolted by the events of Fukushima. Yet the arguments in support of nuclear energy remain compelling — reliable, affordable, efficient base load electricity generation with low greenhouse gas emissions in a uranium-rich country with stable geology and climate and a technically sophisticated society. But there is little informed debate about this option and politicians see only downside in terms of votes. Are we really different to other economies, and are the challenges to nuclear in Australia financial, technical, political or all of these?

SYMPOSIUM SPEAKERS

Professor Tony Vassallo, University of Sydney

Tony Vassallo holds the Delta Electricity Chair in Sustainable Energy Development at the University of Sydney. He took up this position in October 2008. Prior to this, he held the position of Senior Principal Research Scientist with CSIRO and has worked as a consultant to industry and government. Professor Vassallo has more than 80 fully refereed papers in international journals and eight patents in the field of energy storage devices, six of which are US or other international patents. He is the immediate past President of the Australian Institute of Energy, and leader of the Clean Energy Research Cluster in the Faculty of Engineering at the University of Sydney. His area of research is energy storage and its use in future electricity networks.

Energy storage — a disruptive technology for future grids?

Today, most electricity grids have very little capacity to store electricity — and this is almost exclusively provided by hydro-electric energy storage. As a consequence, the design of the physical infrastructure and electricity markets have evolved to ensure adequate generating capacity is always available to meet all possible demand profiles. This is evident in the ubiquitous baseload-intermediate-peaking generation structure of most grids. The widespread adoption of mobile computers and phones, and the need for providing viable, high specific energy storage for electric vehicles, has accelerated battery research towards the triple targets of low cost, long life and high specific energy devices. This development could easily overlap into grid connected energy storage and form the basis of a new network asset-distributed energy storage. If economic energy storage becomes available, it could seriously affect how future electricity grids operate, and have a profound influence on the value of existing network and generation assets.

Dr Louis Wibberley, CSIRO

Louis Wibberley is Leader of the Advanced Carbon Power Program in CSIRO Energy Technology. Dr Wibberley has more than 30 years industrial research experience in combustion, environmental control, metallurgical processing, and power generation. He is currently responsible for development of an R&D program for the direct carbon fuel cell, with recent projects involving industry and the Victorian Government. Earlier, he established post-combustion capture as a major research program for CSIRO. Prior to this, he spent 18 years in industrial research with BHP Billiton, including development of new energy and environmental technologies, which led to introduction of a sustainable development levy on coal extraction to fund additional research. In 2004 this led to the COAL21 Action Plan — the principal technology development and implementation response of the Australian coal industry to the CO_2 challenge. His leadership of projects in the CRC for Coal in Sustainable Development provided the technical basis for a range of prospective low emissions coal technologies. Outcomes from this work have led to several pilot and demonstration projects currently underway in Australia. He holds a B. Metallurgy and PhD.

Direct injection coal engines (DICE) — a coal paradigm revisited

The direct injection coal engine (DICE) is an alternative power generation technology with potential to exploit Australia's world-class coal reserves to generate low cost, low CO_2 electricity. The technology involves producing coal water slurry (a micronised refined coal or MRC), which is injected into specially adapted large diesel engines. A range of well-established processes can be used for preparing the fuel — with the appropriate science and technology. As diesel engines have very high thermal efficiency (even at small scale) and excellent flexibility, DICE has the potential to provide low CO_2 base load, ancillary services and backup capacity — attributes essential to underpinning a high penetration of renewables and rapidly changing electricity markets. DICE also provides the option of co-firing MRC produced from biochars to further reduce the carbon intensity of electricity production. The presentation will cover recent developments and R&D in Australia, establishment of an engine development program by major engine manufacturers, and the scientific hurdles necessary to de-risk and commercialise the technology.

Symposium chairs

Professor Thomas Maschmeyer FAA FTSE, University of Sydney

Thomas Maschmeyer was born in Hamburg in 1966. He completed his PhD at the University of Sydney in 1994 and then moved to the UK for research appointments in London and Cambridge. After his positions as Professor and Head of Department (1998) and Vice-Chairman (2000) at the Delft Institute of Chemical Technology, he returned to Australia as ARC Federation Fellow in late 2003 and was recently awarded a Professorial ARC Future Fellowship. He is also co-founder and was one of the initial directors of Ignite Energy Resources Ltd, a low carbon footprint energy and fuels company. He serves on the editorial boards of six international journals, is President of the Catalysis Society of Australia, and an adviser and consultant to many governmental bodies and companies. He received the 2007 Le Févre Prize of the Australian Academy of Science for outstanding basic research in chemistry by scientists under 40.

Professor Chennupati Jagadish FAA FTSE, Australian National University

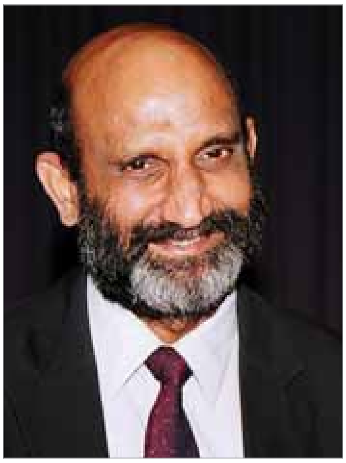


PHOTO: SANDY SPIERS

Chennupati Jagadish is an Australian Laureate Fellow, Distinguished Professor and Head of Semiconductor Optoelectronics and Nanotechnology Group in the Department of Electronic Materials Engineering, Research School of Physical Sciences and Engineering, the Australian National University. Professor Jagadish established a major research program in the field of optoelectronics and nanotechnology upon moving to Australia in 1990. His research interests include compound semiconductor optoelectronics, nanotechnology and photovoltaics. He advises high tech industries in Australia and overseas in the field of photonics and nanotechnology and collaborated with researchers from 20 different countries. He has been elected as a Fellow of 14 professional societies and scientific academies. He has received many awards and recognitions including the IEEE Third Millennium Medal in 2000, Quantum Device Award in 2010, Electronics and Photonics Division Award of the Electrochemical Society in 2012 and Peter Baume Award in 2006 (ANU's prestigious and highest award) for excellence in research and research leadership.

Professor Ken Baldwin, Australian National University

Ken Baldwin is the Director of the Energy Change Institute at the Australian National University, where he is also Deputy Director of the Research School of Physics and Engineering. Since 2011 he has been a member of the Project Steering Committee for the *Australian Energy Technology Assessment* produced by the Bureau of Resources and Energy Economics in the Department of Resources, Energy and Tourism. Professor Baldwin is an inaugural ANU Public Policy Fellow and winner of the 2004 Australian Government Eureka Prize for Promoting Understanding of Science, for his role in initiating and championing 'Science meets Parliament'. In 2007, Professor Baldwin was awarded the W.H. Beattie Steele Medal, the highest honour of the Australian Optical Society, and in 2010 he was awarded the Barry Inglis Medal by the National Measurement Institute for excellence in precision measurement. Professor Baldwin is a Fellow of the American Physical Society, the Institute of Physics (UK), the Optical Society of America and the Australian Institute of Physics.

New Fellows seminar

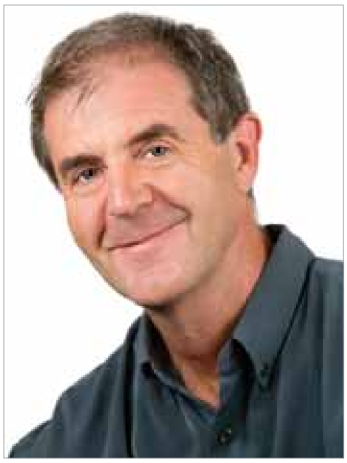
Professor Matthew Brown, University of Queensland

Matthew Brown is a clinician-scientist who trained initially in medicine and rheumatology in Sydney, Australia before moving in 1994 to Oxford to pursue research in genetics of bone and joint diseases, particularly ankylosing spondylitis. He was appointed Professor of Musculoskeletal Sciences at the University of Oxford in 2004 and was Deputy Director of the University of Oxford's Institute of Musculoskeletal Sciences from 2003–05. In 2005 Professor Brown returned to Australia, taking a chair of Immunogenetics at the University of Queensland Diamantina Institute in Brisbane. There he continues to work in genetics of common diseases, as well as running a specialist service for spondyloarthritis patients at Princess Alexandra Hospital. Professor Brown was appointed Director of the University of Queensland Diamantina Institute in 2011.

Genetics and the future of medicine

Most common human diseases are influenced by our genetic makeup, and in recent years rapid progress has been made in identifying the genes involved, with thousands of genetic variants being robustly demonstrated to influence the risk of developing a broad range of diseases and traits. These discoveries and the advent of genome sequencing technology are going to revolutionise the practice of medicine. Genetics offers the potential to change the practice of medicine from therapy of those with already established disease, to disease prevention. There is much to be done to prepare us for the introduction of genetics into routine medical practice though, and to protect us from it, and these preparations lag well behind the pace of change in the technology. The genetic discoveries made in the past six years since the breakthrough development of genomewide association study approaches are providing fascinating insights as to how human diseases arise. The rate of discovery though has overwhelmed the functional biology community. Although there are already numerous exciting examples of new treatments arising from these discoveries, there is a clear need to redirect a lot of biomedical research resources into translating those discoveries into new biological understanding and therapies.

Professor David Craik, University of Queensland



David Craik is a NHMRC Senior Principal Research Fellow at the Institute for Molecular Bioscience, the University of Queensland. He obtained his PhD in organic chemistry from La Trobe University in Melbourne (1981) and undertook postdoctoral studies at Florida State and Syracuse universities before taking up a lectureship at the Victorian College of Pharmacy in 1983. He was appointed Professor of Medicinal Chemistry and head of School in 1988. He moved to the University of Queensland in 1995 to set up a new biomolecular NMR laboratory. His research focuses on the application of NMR in drug design, and on toxins, including conotoxins. His group has a particular focus on structural studies of disulfide-rich proteins, and on the discovery and applications of circular proteins and novel protein topologies. He has trained more than 50 PhD students and is the author of 480 scientific publications.

Discovery and applications of circular proteins

Conventional proteins are linear chains of amino acids that fold into complex three-dimensional shapes. Our work focuses on the study of new classes of proteins whose ends are joined together to form a circular backbone. Circular proteins have now been found in all kingdoms of life and are exceptionally stable relative to conventional proteins. Our work focuses on a family of proteins we discovered called cyclotides. These plant-derived proteins have the additional feature of a knotted arrangement of cross-linking disulfide bonds between their six conserved cysteine residues. The combination of their circular backbone and knotted disulfide bond network makes cyclotides exceptionally stable. We are applying them as protein engineering scaffolds to stabilise peptide-based drugs. Furthermore, using the lessons learned from cyclotides we have re-engineered conventional linear proteins by chemically joining their ends together to make them more stable and 'drug like'. One example concerns the use of a peptide from the venom of a marine cone snail, which has potential for the treatment of chronic pain. By chemically joining the ends together we stabilised the protein to make it orally active. This presentation will describe the discovery and characterisation of circular proteins in nature and their applications in drug design.

Professor David A Day, Flinders University of South Australia

David Day is Deputy Vice Chancellor (Research) at Flinders University. David was awarded his PhD from Adelaide University and undertook postdoctoral studies in the United States before joining CSIRO as a Queen Elizabeth II Fellow. He subsequently moved to ANU where he became Professor of Biochemistry and Molecular Biology. In 1999, he took up the Chair of Biochemistry at UWA and later moved to the University of Sydney where he was Executive Dean of the Faculties of Science. David's research has focused on carbon and nitrogen metabolism in plants with an emphasis on mitochondrial respiration and its interaction with photosynthesis and other cellular metabolism, and symbiotic nitrogen fixation in legumes, where he pioneered the study of nutrient transport across symbiotic membranes.

An alternative path against oxidative stress in plants

Plants often encounter hostile environments that place them under stress. Reactive oxygen molecules produced under these conditions act as signals to activate defence mechanisms, but also cause cell damage. Mitochondria, the subcellular compartments involved in energy production, are a site of reactive oxygen species (ROS) generation and are involved in the response of cells to oxidative stress. In plants, mitochondria contain special electron transport proteins, referred to as the 'alternative pathway', that bypass sites of ROS generation and act as 'safety valves' during energy transduction. Alternative pathway genes are activated upon exposure of plants to environmental stresses, such as salinity and high temperature, as part of the cell's attempt to minimise damage. Genetically manipulating the model plant *Arabidopsis thaliana* to express these proteins constitutively alters plant growth and may enhance plant survival under duress.

Professor Yuri Estrin, Monash University

Yuri Estrin received his PhD degree in solid state physics in 1975. After about 10 years as a researcher at the Institute of Crystallography of the Academy of Sciences in Moscow, he held several professorial positions in Germany and Australia and currently is Professor in the Department of Materials Engineering of Monash University, where he directs the Centre for Advanced Hybrid Materials. His research interests are focusing on the mechanical properties of metallic materials, particularly bulk ultrafine grained materials for structural and functional applications. A further area central to his research interests is geometry-inspired design of novel materials and structures. Professor Estrin has authored more than 430 peer-reviewed papers. His work has received international recognition through numerous awards, including an Alexander von Humboldt Award, an honorary doctorate of the Russian Academy of Sciences, and adjunct professorships at four universities.

Bulk nanomaterials: properties and promises

Nanostructuring of metallic materials by severe plastic deformation (SPD) is a potent way to enhance their mechanical strength. To that end, a range of SPD techniques has been developed over the past two decades. A wealth of accumulated experimental data and recent successes in theoretical modelling of the evolution of a metal billet to a nanocrystalline material give promise of nearing breakthroughs that will see the utilisation of SPD at industry scale. In this talk, a brief overview of SPD methods, the properties of materials obtained by using them, and the potential for industry-scale applications will be given. The main focus will be on mechanical properties, but examples of improved functional properties will also be given. In particular, the potential of nanostructuring for producing improved permanent and bioresorbable medical implants will be considered. A further example will concern the enhancement of hydrogen storage capability of magnesium alloys by SPD processing.

Professor John Evans, Australian National University

John Evans gained his PhD in 1984 from the ANU under the supervision of Professor G D Farquhar. He compared the photosynthetic properties of wheat and related species in relation to leaf nitrogen. After postdoctoral fellowships at the Plant Breeding Institute, Cambridge, UK and then CSIRO Division of Plant Industry, Canberra, he returned to the ANU on a Queen Elizabeth II Fellowship. In 1994 he gained a tenured research position at the Research School of Biological Sciences where he has focussed on photosynthesis research. Professor Evans is a plant physiologist who has specialised in quantitatively linking biochemical and anatomical properties to the performance of leaves and plants. His research has made significant impacts in three areas, namely: relating photosynthesis to nitrogen, quantifying the conductance to CO_2 diffusion within leaves, and analysing how plants acclimate to their light environment. Current projects aim to increase crop yield potential to enhance global food security.

Relating photosynthesis to leaf nitrogen

The process of photosynthesis requires the capture of sunlight and conversion of this energy into biochemical intermediates that drive the assimilation of carbon dioxide into sugar. Structural proteins are required to hold pigments in specific arrays and a large number of enzymes are needed to catalyse the biochemical reactions. These proteins are abundant and account for the majority of nitrogen present in leaves. Consequently, the photosynthetic rate of a leaf reflects the amount of nitrogen, its allocation between different proteins and the properties of these proteins. Three key nitrogen pools are those associated with chlorophyll for light capture, cytochrome f for electron transport and Rubisco for CO_2 assimilation. As many of the proteins are highly conserved, some nitrogen costs can be generalised. However, the relative abundance of individual proteins can alter in response to the environment or differ between species. For example, light intensity during growth affects leaf morphology during development and subsequently the allocation of nitrogen between proteins. Future food security requires the development of crops that yield more and attempts are being made to engineer improvements in photosynthesis by increasing capacity and or efficiency with respect to nitrogen, water and light.

Professor Bryan Gaensler, University of Sydney

PHOTO: DANIEL BOUD

Bryan Gaensler is an Australian Laureate Fellow at the University of Sydney, and is Director of the Centre of Excellence for All-sky Astrophysics (CAASTRO). He received his PhD from the University of Sydney in 1998, and subsequently held positions at MIT, the Smithsonian and Harvard before returning home to Australia in 2006. He has authored more than 230 refereed papers on cosmic magnetism, neutron stars, supernovae and the interstellar medium, while his popular astronomy book *Extreme Cosmos* was published worldwide by Penguin in July 2012 and is now being translated into nine other languages. He is the Editor-in-Chief of Australia's national astronomy journal, *PASA*, and was previously the International Project Scientist for the Square Kilometre Array. Gaensler was the 1999 Young Australian of the Year, gave the 2001 Australia Day Address to the nation, and received the Academy's 2011 Pawsey Medal.

Cosmic magnetism

A remarkable discovery made by 20th century astronomers was that the Universe and most of the objects in it are magnetised. Although magnetic fields are completely visible even to our most powerful telescopes, we now have the capability to make detailed measurements of the strength and geometry of magnetic fields in distant objects throughout the cosmos. I will explain how we study cosmic magnets, ranging from strengths of just 0.0000000001 teslas in the depths of interstellar space, through to an incredible 1 000 000 000 000 teslas at the cores of magnetars. These data provide unique physical probes of the processes through which stars and galaxies form, age and evolve. I will conclude by explaining how the window to the magnetic Universe is only now beginning to fully open, and will describe the range of exciting new experiments that are about to commence.

Professor Andrew Hassell, Australian National University

Andrew Hassell took his bachelor's degree in mathematics at ANU and his PhD at MIT. After two years at Stanford University he returned to Australia on an ARC Postdoctoral Fellowship and has been at ANU since 1996. He held an ARC Research Fellowship during 1999–2004 and is currently a Professor of Mathematics and Future Fellow. Honours awarded to Andrew include Australia's first gold medal at the

International Mathematical Olympiad in 1985, a University Medal in 1989, a Fulbright award to study in the USA 1990–94, and the Australian Mathematical Society Medal in 2003. Andrew's area of research is mathematical analysis, particularly the study of solutions of partial differential equations using a technique known as microlocal analysis. He has contributed to mathematical knowledge in the areas of scattering theory, spectral theory, the time-dependent Schrödinger equation, quantum chaos and numerical methods.

Quantum billiards

In classical billiards, a ball travels along a straight line inside a two-dimensional region, bouncing each time it meets an edge. In quantum billiards, a wavefunction is defined at each point inside a two-dimensional region, and evolves in time according to Schrödinger's equation. In the 'high energy limit', the quantum billiard behaves more and more like its classical counterpart. I will illustrate this phenomenon with examples and discuss some mathematical research problems in this research area.

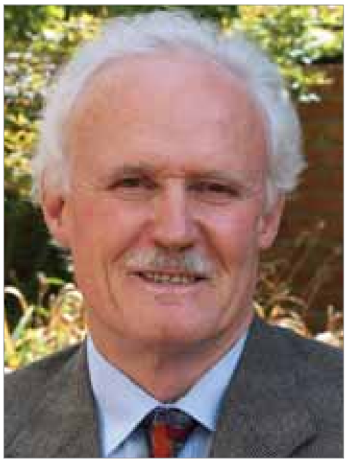
Professor Ove Hoegh-Guldberg, University of Queensland

Ove Hoegh-Guldberg (BSc Hons Sydney; PhD UCLA) is Professor of Marine Science and Director of the Global Change Institute at the University of Queensland. He has also held academic positions at the University of Sydney, UCLA and Stanford, and has spent his research career focused on tropical coastal ecosystems such as coral reefs. His research team has explored the fundamental mechanisms that underpin the physiology and ecology of these highly biodiverse ecosystems, as well as their response to rapid environmental changes such as global warming and ocean acidification. Professor Hoegh-Guldberg has also worked extensively with the media and has been awarded a Eureka Prize (1999), QLD Smart State Premier's Fellowship (2008–13), Thomson Reuters Citation Award (2012), and an ARC Laureate Fellowship (2013–18). His research interests have led to collaborations with organisations such as the Intergovernmental Panel on Climate Change, Royal Society of London, US Academy of Sciences and The World Bank. He is married to biologist Dr Sophie Dove with whom he has two children.

The Ocean in a changing world: from cellular to planetary dysfunction

Most of the heat and much of the CO2 associated with the Enhanced Greenhouse Effect ends up in the Ocean. Despite its enormous volume and thermal inertia, ocean temperature and pH have begun to change at rates not seen for millions of years. Not surprisingly, life in the Ocean has also begun to change. Coral reefs are one of the earliest ecosystems to show clear climate driven changes, with symbiotic corals across thousands of square kilometres losing their characteristic brown colour ('bleach') and in many cases dying. Understanding these changes has defined my research career. After generations of talented postdoctoral fellows and students, we now know that small increases in sea temperature are driving these changes, and that the impacts are profound across almost every aspect of the physiology and ecology of symbiotic corals and coral reefs. Of great concern is the scientific consensus that our current CO2 emission pathway will result in the elimination of coral reefs by mid-century. Given that 25% of marine biodiversity resides in and around coral reefs, and reefs are crucial to the well-being of 1 in 10 people, these changes are extremely serious. As with the many other challenges presented by climate change, science continues to have a central evidentiary role in understanding, communicating and ultimately solving these planetary challenges.

Professor Ian Jackson, Australian National University



Ian Jackson trained in physics and geophysics at the University of Queensland and the Australian National University, with subsequent postdoctoral experience at the California Institute of Technology. His research since 1978 in the ANU's Research School of Earth Sciences has focussed on laboratory measurement of physical properties of geological materials, the development of appropriate models to describe their thermoelastic and mechanical behaviour, and applications to the structure and dynamical processes of the Earth's interior. He was awarded the 1988 Pawsey Medal and the 2011 Jaeger Medal of the Australian Academy of Science, and elected in 2003 to Fellowship of the American Geophysical Union. In 2012 he was appointed Director of the ANU's Research School of Earth Sciences.

Laboratory seismology and the Earth's internal structure

Spatial variations of the speeds of compressional (c.f. sound) and shear waves, derived from the traveltimes of elastic waves radiated by earthquakes, provide critical information concerning the Earth's internal structure. Complementary studies document the variations of seismic-wave attenuation, that is, the systematic decrease of the amplitude of a travelling wave. These seismic properties are characteristic of the medium and the prevailing environmental conditions. The interpretation of seismological models of the Earth's internal structure is therefore dependent upon laboratory measurements of seismic properties under conditions that simulate those of seismic-wave propagation. High-temperature viscoelastic relaxation, arising from the stress-induced migration of crystal defects such as vacancies, dislocations and grain boundaries, and poroelastic effects in fluid-saturated media, both result in strain-energy dissipation and reduced wave speeds at sufficiently low frequencies. We have responded to this challenge by developing forced-oscillation methods with which it is uniquely possible to measure the elastic moduli that control shear and compressional wave speeds and associated strain-energy dissipations, under conditions of appropriately low frequency (mHz-Hz), high temperature and pressure, and fluid saturation. Selected applications of these techniques to materials representative of the Earth's crust and upper mantle will be described.

Professor Sharad Kumar, Centre for Cancer Biology, Adelaide

Sharad Kumar is a NHMRC Senior Principal Research Fellow and the co-Director of the Centre for Cancer Biology in Adelaide. He obtained his PhD from the University of Adelaide and postdoctoral training at the University of Queensland. He then worked at CSIRO as a research scientist before receiving a Japanese Government Fellowship to spend two years as a visiting fellow at the RIKEN research institute in Japan. Following this he took up a faculty position at the Cancer Institute in Tokyo before returning to Adelaide. His laboratory discovered, named and characterised a number of key regulatory genes/proteins, including the Nedds, e.g. Nedd1, a centrosomal protein required for g-tubulin recruitment; Nedd2 (caspase-2) — the first known apoptotic mammalian caspase; Nedd4 — the first WW-HECT type of ubiquitin-protein ligase; Nedd5 (Septin2), the first characterised mammalian septin; and Nedd8, a ubiquitin-like protein involved in a protein modification system, now widely known as neddylation. His group also discovered a large part of the *Drosophila* cell death machinery and a number of proteins that regulate the function of Nedd4 ubiquitin ligases. Professor Kumar now studies caspase biology and functions in cancer and ageing, mechanisms of developmentally programmed cell death, and the physiological functions and regulation of the Nedd4 family members.

Investigations into cell death and ubiquitination

While looking for molecules that regulate development of the central nervous system I cloned a number of genes that I named the 'Nedds'. The proteins encoded by some of the Nedd genes subsequently became prototypic members of the new functional groups. For example, Nedd8 turned out to be a protein that regulates other proteins when it is attached to them; a process now commonly termed 'Neddylation'. In recent years my laboratory has focused on another two of these proteins, Nedd2 and Nedd4. Nedd2, now called caspase-2, is one of the most conserved of the apoptosis effector proteases known as caspases. It has possible apoptotic and non-apoptotic functions. Nedd4 became the prototype for a family of ubiquitin protein ligases (the Nedd4 family) defined by unique domains. These ubiquitin ligases play various essential functions in animal physiology, such as controlling blood pressure, inflammation and iron homeostasis. At the symposium I will discuss some of the recent highlights from our work.

Professor Max Lu, University of Queensland

Max Lu is a world-leading scientist in materials science and chemical engineering. He has made many seminal and sustained contributions to science, including a new method for synthesis of highly reactive single crystal TiO2, new insights into the surface chemistry and modifications of nanoporous materials, molecular engineering techniques of membranes and efficient photocatalyst for clean energy and water. He has published more than 450 journal papers with more than 18,000 citations and an h-index of 67. He has also demonstrated practical applications of nanomaterials in hydrogen energy and environmental processes with more than 20 international patents. His international recognitions include prestigious awards (e.g. Federation Fellowship, ExxonMobil, Le Fevre Prize, Chemeca

Medal, and ISI Highly Cited Researcher), more than 100 plenary and keynote invitations, and 12 journal editorial boards/editorships.

Engineering nanocrystalline photocatalysts

Nanoparticles and nanocrystals of semiconducting oxides constructed from nanoscale building blocks often possess unique and much improved properties. Such materials are promising in enabling innovative technologies for conversion and storage of renewable energies for the future. With current challenges in climate change and sustainable development, nanotechnology is especially exciting because it provides great opportunities for technological advances in areas of solar power, solar hydrogen production and storage. This talk highlights the latest developments in oxide nanomaterials such as titania as photocatalysts. Materials such as layered titania and single anatase crystals are photoactive materials promising for cheap and efficient solar cells, hydrogen production from water splitting and solar detoxification of water and air. Latest advances in bandgap engineering of TiO_2 for visible light photocatalysis will be highlighted and discussed.

Professor Stephen MacMahon, George Institute for Global Health

Stephen MacMahon is Principal Director of The George Institute for Global Health. He also holds professorships in medicine at the University of Sydney and the University of Oxford. He is an authority on the prevention and treatment of cardiovascular diseases, with a special interest in the management of these conditions in resource-poor settings. Professor MacMahon is responsible for more than 400 staff at George Institute research facilities in Australia, the UK, China and India. In addition to his University and Institute appointments, Professor MacMahon holds several external appointments, including that of Chairman of the International Scientific Board of the UK BioBank. He has published several hundred scientific papers and delivered many invited lectures. For his work in the field of cardiovascular disease, he has received numerous awards, fellowships and honours. In 2012 he was appointed to the Fellowship of the British Academy of Medical Sciences.

'Frugal' healthcare innovation — a global research priority

Of the seven billion people alive today, less than two billion have reliable access to the medical care required to manage those conditions most likely to cause premature death and disability. About half of those without such access live in the emerging economies of Asia. In these regions there is increasing awareness that the consequences of poor healthcare include reduced economic productivity and increased social unrest. However, there remains considerable uncertainty as to how to provide essential healthcare affordably to all who require it. Certainly, the models of care developed in countries such as Australia are unaffordable and impractical for most low or middle-income countries (and are, arguably, unsustainable for most high-income countries). As a consequence, there is a pressing need to expand efforts to develop 'frugal' solutions targeting a range of core healthcare components. At The George Institute for Global Health, a major focus of our research is the formulation and evaluation of innovative low-cost strategies to deliver care for the management of serious cardiovascular and metabolic diseases in resource-poor regions of India and China.

Professor Boris Martinac, Victor Chang Cardiac Research Institute, Sydney

Boris Martinac is an experimental biophysicist. He graduated from elementary school and classical gymnasium in Zagreb, Croatia and majored in physics from the RWTH Aachen University, Germany where he also received his PhD degree in biophysics. After three years of postdoctoral study in electrophysiology of ciliates at the Ruhr University, Bochum, Germany he moved to the Laboratory of Molecular Biology, University of Wisconsin-Madison in the United States where he studied microbial ion channels by patch clamp. In 1993 he became Senior Lecturer at the University of Western Australia, Perth, Australia where he rose to the rank of Associate Professor in 1999 and Professor in 2004. From 2005 to 2009 he was Foundation Professor of Biophysics at the University of Queensland, Brisbane, Australia. As an ARC Australian Professorial Fellow he moved in 2009 to Victor Chang Cardiac Research Institute in Sydney where he is Head of the Mechanosensory Biophysics Laboratory and an NHMRC Principal Research Fellow.

Mechanosensitive ion channels in bacteria

Ion channels are molecular gated pores present in excitable membranes of all types of living cells found on Earth. They function in numerous biological processes that range from sensory transduction in touch, hearing, vision, smell, taste and pain sensation, control of the heartbeat, muscle contraction and brain function to control of the volume and fluid content in animal, plant and microbial cells. Microbes, including bacteria, have often been used to advance our knowledge of basic principles underlying diverse aspects of cellular biology. A wealth of available information of microbial biochemistry, genetics and molecular biology provided also a fertile ground for understanding the basic molecular design of ion channels including bacterial mechanosensitive channels MscL and MscS, which function as molecular force transducers measuring small changes in the concentration of solutes and water across bacterial cell membrane. Extensive multidisciplinary studies of MscL and MscS over the past 25 years have greatly contributed to elucidation of the basic physical principles underlying mechanosensory transduction, which established the bacterial mechanosensitive channels as a major paradigm of mechanical force sensing in living cells.

Professor James Paton, University of Adelaide

James Paton obtained his PhD from the Department of Biochemistry, University of Adelaide, in 1979, and spent 20 years at the Women's and Children's Hospital, where he was Head of the Molecular Microbiology Unit. He took up the Chair of Microbiology at the University of Adelaide in 2000, and was awarded a NHMRC Australia Fellowship in 2007. He is currently a NHMRC Senior Principal Research Fellow and Director of the Research Centre for Infectious Diseases in the School of Molecular and Biomedical Science. His research team studies fundamental molecular events involved in the interactions between pathogenic bacteria and their hosts, with a view to development of more effective vaccines and novel therapeutic strategies for controlling bacterial infections in humans. A major research interest is pathogenesis and prevention of pneumococcal disease, and he has been a leading proponent of protein-based pneumococcal vaccines, which are now entering clinical trials.

Preventing pneumococcal disease in the 21st century

Streptococcus pneumoniae (the pneumococcus) is the world's foremost bacterial pathogen. It causes invasive diseases (pneumonia, meningitis and bacteraemia) that are responsible for 1–2 million deaths each year, principally in young children in developing countries. It is also the commonest cause of otitis media, which is extremely prevalent in both developed and developing countries, with a massive socio-economic impact. Rates of resistance to antibiotics are steadily increasing and vaccination represents the best prospect for managing pneumococcal disease in the 21st century. Existing pneumococcal vaccines target the capsular polysaccharide (CPS), which is the dominant surface antigen. However, protection is serotype-specific and the vaccines cover only 13 of the 93 known CPS serotypes. In countries where the vaccine is in widespread use, disease caused by included serotypes has been almost eliminated, but this has been offset by significant increases in disease caused by pneumococci belonging to other (non-included) CPS serotypes. Our research has focused on obtaining a better understanding of the interactions between the pneumococcus and its human host, with a view to identifying combinations of conserved protein antigens that elicit broad-based protection against pneumococcal disease, and are cheap enough to deploy in developing countries where the burden of disease is greatest.

Professor Stephen Powles, University of Western Australia

Stephen Powles was raised at Taree NSW and studied at Tocal and Hawkesbury Agricultural Colleges before undertaking an MSc degree at Michigan State University followed by a PhD at the Australian National University. Postdoctoral years were at Carnegie Institution of Science, Stanford University and CNRS, Paris, France. In 1983 Professor Powles commenced at the Waite Research Institute, University of Adelaide and built a large multidisciplinary research program focussed on many aspects of the evolution of resistance to herbicides in plants. From 1995–98 he was founding CEO of the Australian Weed Management CRC. In 1998 he commenced as founding Director of the Australian Herbicide Resistance Initiative and Professor at the University of Western Australia. Professor Powles leads a large multidisciplinary research team with interests from the underpinning science through to applied management of herbicide resistance in Australian agriculture.

Evolution in action: herbicide resistance in plants

In modern crop production in Australia and other industrialised agricultural nations, crop yield is protected against infesting weeds by the use of herbicides (chemicals that remove weeds without crop damage). Herbicides offer many advantages and therefore they can be used persistently across vast areas. In evolutionary terms herbicides are a strong selection force for any gene traits endowing survival in the presence of the herbicide. Especially in Australia, important weed species have rapidly evolved resistance to herbicides. Our research ranges from identifying the gene mutations and biochemical mechanisms endowing resistance through to the practical management of resistance in Australian and global agriculture. This presentation will give a brief overview of the science and practice of herbicide resistance and its management.

Dr Richard Richards, Plant Industry, CSIRO

Richard Richards is a CSIRO Fellow at CSIRO Plant Industry in Canberra. His research interests are to understand the genetic and physiological basis of variation in growth, development and yield of wheat, and then to apply this understanding to breed higher yielding wheats — particularly in water-limited environments. This research has resulted in more than 200 refereed scientific publications. In addition, nine wheat cultivars developed by Dr Richards and his group have been released commercially in Australia in the past decade. Dr Richards is also interested in understanding how breeding and crop management intersect to lead to improved yields. He is Principal Scientist for the wheat breeding company, HRZ Wheats Pty Ltd. In this role he works closely with industry to ensure adoption of suitable varieties. Dr Richards is an Adjunct Professor with the University of Western Australia and an elected member of the Australian Academy of Technological Sciences and Engineering.

Meeting future food requirements: designing better crops

The demand for cereals for food, feed and fuel in 2050 will be about 50% higher than current global production levels largely due to population growth. This increased production will need to come primarily from genetic improvements. Current rates of yield increase in cereals are well below the rates required to achieve the demand needed by 2050. My work is largely concerned with how we best increase cereal production using contemporary breeding technologies. It has focused on understanding the underlying physiological factors that regulate crop growth and yield, then understanding the genetic control of the most important factors, designing effective selection methods and implementing these to breed better wheat varieties. This approach is at variance to most crop improvement programs but complementary to them. With colleagues, we have identified the most important physiological factors as well as their genetic control. These include: timing of reproductive development, leaf area development and water use, exchange of CO_2 for water, carbon partitioning to reproductive structures, crop architecture and radiation interception and reflection, rooting vigour and depth and root vascular anatomy. Any one of these processes is unlikely to be universally important but each is likely to increase crop yield in defined environments. These processes can now be selected more precisely and effectively in crop improvement programs.

Professor Louise Ryan, University of Technology Sydney

After completing her undergraduate degree in statistics and mathematics at Macquarie University, Professor Ryan left Australia in 1979 to pursue her PhD in statistics at Harvard University. In 1983, she then took up a postdoctoral fellowship in biostatistics, jointly between Dana-Farber Cancer Institute and the Harvard School of Public Health. She was promoted to Assistant Professor in 1985, eventually becoming the Henry Pickering Walcott Professor and Chair of the Department of Biostatistics at Harvard. She returned to Australia in early 2009 to take up the role as Chief of CSIRO's Division of Mathematics, Informatics and Statistics. In 2012, Professor Ryan joined UTS as a distinguished professor of statistics in the School of Mathematical Sciences. She is well known for her methodological contributions to statistical methods for cancer and environmental health research, and loves the challenge and satisfaction of multidisciplinary collaboration.

Statistics — the science of uncertainty

With foundations in areas such as genetics, agriculture and the study of human populations, statistical science is all about finding predictable patterns in the rich and complex world in which we live. In our modern, information rich, times statistical science is more important than ever in terms of helping to find patterns in large volumes of complex data and in predicting trends that allow for more informed decision making. However, modern technological advances in computer science and molecular biology are posing a new generation of problems to be solved. Unlike the early pioneers in the field whose tools of trade were pencil and paper, today's statisticians need a sophisticated understanding of modern computational tools. Examples from molecular biology, medical and health sciences will be used to illustrate some cutting edge challenges and opportunities for the modern statistical scientist.

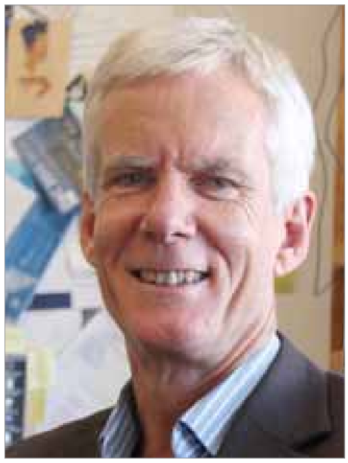
Professor Michael Sandiford, University of Melbourne

Michael Sandiford is a geologist whose research focus is tectonics and earth energetics. His research contributions extend across a range of geoscience sub-disciplines, including structural geology, metamorphic geology, geomorphology, earthquake geology and geothermics. His research has helped show how the evolution of intraplate stress fields and thermal regimes have shaped the continents over geological time. His work provides an important framework for understanding the extraordinary abundance of heat producing elements, such as uranium, and geothermal energy prospects of the Australian crust. He regularly contributes to the broader scientific debate through media appearances and public lectures related to geosciences and human energy systems. Professor Sandiford was appointed Chair of Geology at the University of Melbourne in 2010. He was an ARC Professorial Fellow from 2000-2009. In 2009, he was appointed inaugural director the Melbourne Energy Institute at the University of Melbourne.

Shaping the continents

Most of my work has touched on questions of why the continents are the way they are. Motivating questions have ranged from the specific, such as what controls the state of stress and temperature within the continents, to the general, such as why are the continents distributed so as to occupy about one third of the Earth's surface. Recently I have focused on the issue of whether we can use surface displacements in the continents to reveal the dynamics of the deeper mantle. The implications of my research range from basic questions about Earth energetics to more pragmatic questions concerning the occurrence of earthquakes through to the distribution of resources such as geothermal heat and uranium. My research also helps provide an illuminating context for understanding the geophysical scale of human activity.

Professor Geoffrey Taylor, University of Melbourne



Geoffrey Taylor is Director of CoEPP and Professor of Physics at the University of Melbourne. CoEPP is a $30 million collaborative research venture between the universities of Melbourne, Adelaide, Sydney and Monash, focusing the Australian high energy particle physics research community, both theoretical and experimental, on the scientific exploitation of the Large Hadron Collider (LHC) at CERN. Professor Taylor has been leading the Australian program at CERN for more than two decades, with major involvement in the design, development, construction and installation of the $600 million ATLAS experiment for operation at the LHC. ATLAS, along with the CMS collaboration, reported evidence for the discovery of the Higgs boson to much fanfare in July, 2012. This spectacular result was simultaneously announced at CERN and Melbourne during the field's premier conference, International Conference on High Energy Physics (ICHEP2012), chaired by Professor Taylor. Professor Taylor has worked on large experiments in the USA, Canada, Japan and Europe. At Melbourne he has also made major contributions to the establishment of the VLSCI (Victorian Life Sciences Computing Initiative) and NeCTAR (National eResearch Collaboration Tools and Resources) programs. He has more than 530 publications in international peer reviewed journals spanning 30 years, with 32,000 citations.

Search for the Higgs boson

The missing piece of the highly successful Standard Model (SM) of particle physics has been the target of the international physics community for decades. With extraordinary collaborative focus by thousands of physicists and engineers, and the sustained application of resources totalling billions of dollars of value, the evidence constituting discovery accumulated surprisingly rapidly with outstanding LHC operation. This presentation will describe the importance of the Higgs, and will present the data that resulted in its discovery. The techniques used to search through petabytes of data to extract the handful of 'interesting' events will be described. The key developments along the road to the Higgs will be presented, highlighting the Australian effort. The universities of Melbourne and Sydney are founding members of the ATLAS collaboration that built one of the two experiments in the Higgs boson co-discovery. Locally we contributed to the construction of the detector at the heart of the ATLAS experiment — the high-precision semi-conductor tracker (SCT). Physicists from Melbourne, Sydney and Adelaide have played important roles in the Higgs search. Since 2011, following the inauguration of the CoEPP, the University of Adelaide has joined the experimental program. Theorists in Melbourne, Adelaide, Monash and Sydney universities are focussed on interpreting the results and helping guide further analyses. The talk will conclude with an outlook for the LHC program, further studies of the Higgs properties, and the expanded searches for new physics such as the origin of the intriguing 'dark matter'.

Professor Andrew White, University of Queensland

Andrew White is a Vice-Chancellor's Senior Research Fellow and Director of the Quantum Technology Lab at the University of Queensland, Deputy-Director of the ARC Centre of Excellence for Engineered Quantum Systems, and a Program Manager in the ARC Centre of Excellence for Quantum Computing and Communication Technology. Professor White and his team are interested in exploring and exploiting the full range of quantum behaviours, notably entanglement — the passing strange correlations that Einstein referred to as 'spooky action at a distance' — with an eye to engineering new technologies and scientific applications.

Quantum biology, chemistry, maths and physics

Quantum information is the lovechild of quantum physics and computer science. We will look at the science of quantum information: what it is and isn't; why biologists, chemists, mathematicians and physicists might be interested in it; and where we are today. In principle, quantum mechanics can exactly describe *any* system of quantum particles — from simple molecules to unwieldy proteins — but in practice this is impossible as the number of equations grows exponentially with the number of particles. For example, the fundamental problem faced in quantum chemistry is the calculation of molecular properties, such as total energy of the molecule, which can be calculated by solving the Schrödinger equation. However, the computational resources required increase exponentially with the number of atoms involved. Recognising this, in 1982 Richard Feynman suggested using quantum components for the calculations but it wasn't until the 1990s that a quantum algorithm was proposed where the computational resources increased only polynomially in the molecular size. Despite the many different physical architectures that have been explored experimentally since that time — including ions, atoms, superconducting circuits, and photons — this appealing algorithm was not demonstrated until last year. I will discuss how we have taken advantage of recent advances in photonic quantum computing to present an optical implementation of the smallest quantum chemistry problem: obtaining the energies of H2, the hydrogen molecule, in a minimal basis. I'll also report on our recent results in simulating quantum systems in material science: phase transitions in topological insulators; and in biology: light-harvesting molecules in photosynthesis.

Professor Bryan Williams, Monash Institute of Medical Research

Bryan Williams has a distinguished research career spanning more than 30 years in the areas of innate immunity and cancer biology. He has published more than 300 peer-reviewed journal articles and reviews. He is internationally recognised for his work in innate immunity, and for his studies on protein kinase R, an important innate immune signalling molecule. He has also gained prominence in the field of RNA interference and was recently appointed as Fellow of the American Academy of Microbiology. Professor Williams is currently Director of the Monash Institute of Medical Research. In addition, he holds an appointment as a Professor in the Faculty of Medicine, Nursing and Health Sciences at Monash University.

Molecules and mechanisms in the innate immune system

Our innate immune system is the first line of defence against infection by viruses and bacteria. More recently it has been recognised that other danger signals also trigger innate immune mechanisms to protect against development of inflammation and cancer. Interferons were the first substances identified to provide natural protection against virus infections. They were subsequently developed for clinical use as antiviral and anti-cancer agents. Studies on the mechanism of action of interferons have revealed intricate biochemical reactions that control the antiviral response. They have also uncovered signal transduction pathways that are common to many cytokines and growth factors and have provided targets for therapeutic intervention. I will provide a brief history of the discovery of the 2-5A system, characterisation of the protein kinase R and the role this enzyme plays in maintaining homeostasis. I will also describe recent discoveries on the key roles played by two transcription factors, PLZF and ATF3, on fine-tuning innate immunity.

2013 Matthew Flinders Medal and Lecture for research in the physical sciences

recognises scientific research of the highest standing in the physical sciences, and honours the contributions of Australia's early scientific researchers.

Professor Ken Freeman FAA FRS, Australian National University

Ken Freeman is Duffield Professor of Astronomy at the Australian National University in Canberra. He studied mathematics at the University of Western Australia and theoretical astrophysics at the University of Cambridge. His research interests are in the formation and dynamics of galaxies and globular clusters, and particularly in the problem of dark matter in galaxies: he was one of the first to point out (1970) that spiral galaxies contain a large fraction of dark matter. His more recent work is mainly on the formation and dynamics of the Milky Way. He has won the Dannie Heineman prize of the American Institute of Physics and the American Astronomical Society for 1999, the Prime Minister's Science Prize for 2012 and the Henry Norris Russell Lectureship of the American Astronomical Society for 2013.

He became a Fellow of the Australian Academy of Science in 1981 and a Fellow of the Royal Society of London in 1998.

Dark matter in galaxies

In large galaxies like our Milky Way, only about 5% of the mass is in the form of visible stars and gas. The remaining 95% is made up of dark matter. The dark matter does not give off any known radiation; it is detectable only through its gravitation field and is otherwise invisible. The nature of dark matter remains one of the great problems of contemporary astrophysics. Although we have known about dark matter in galaxies since the early 1970s, we still do not know what it is. I will give a brief overview of dark matter in large spirals like the Milky Way, and then turn to dark matter in the smallest dwarf galaxies. Some of these tiny galaxies are 10,000 times fainter than the Milky Way, but their dark matter is 1000 times denser, because the dwarfs formed very early in the life of the Universe when it was much denser than it is now. Depending on the nature of dark matter, there is a faint hope that their dark matter may give off some detectable gamma rays if the dark matter particles annihilate, because the dark matter is so dense in these dwarf galaxies.

Honorific awards

2013 Dorothy Hill Award for research in the Earth sciences

Dr Lisa Alexander, University of New South Wales

Lisa Alexander is a senior researcher in the Climate Change Research Centre at the University of New South Wales. She has an international reputation for her research on climate extremes in Australia and around the world and is Chair of the World Meteorological Organization's Expert Team on Climate Risk and Sector-specific Climate Indices. Her research contributed significantly to the conclusions of the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change Working Group I* on the physical basis of climate change and she is a lead author on the next report, due in September 2013. Dr Alexander uses weather station observations and climate models to understand the natural and anthropogenic processes that drive extreme rainfall and temperature events and has shown future changes in the frequency and intensity of heatwaves across Australia will strongly depend on the amount of anthropogenic greenhouse gases emitted. In 2011 she received the Priestley Medal from the Australian Meteorological and Oceanographic Society, which recognises excellence in research by younger scientists.

A land of droughts and flooding rains? how future greenhouse gas emissions will affect Australia's climatic extremes

Extreme events like heatwaves, droughts and floods have a significant socio-economic impact on Australia. Observations indicate that these types of extreme events have increased across large parts of Australia over recent decades and projections indicate further changes related to human emissions of greenhouse gases. In this talk I will present the evidence for changes in past extremes and will discuss the difficulties in 'detecting and attributing' changes that may be due to man-made interference in the climate system due to large natural variations in Australia's climate. Even so, the evidence points to significant future changes in extremes globally especially for those events that are temperature-dependent such as heatwaves. My own research shows that future changes in the frequency and intensity of extreme temperatures in Australia will be strongly dependent on the amount and rate of global anthropogenic greenhouse gas emissions. This is important information for policymakers who need to make relevant mitigation and adaptation strategy decisions.

2013 Pawsey Medal for research in physics

Associate Professor Christopher Blake, Swinburne University

Christopher Blake has worked in the Centre for Astrophysics and Supercomputing at Swinburne University since 2006. Before that he was a postdoctoral researcher at the University of British Columbia (Vancouver) and University of New South Wales. He was awarded his PhD in 2002 from the University of Oxford. His research is in the area of cosmology, which encompasses questions such as what makes up the Universe, how did it form and what are the physical laws which govern its evolution. His particular expertise is constructing large maps of how galaxies (the building blocks of the Universe) are scattered through space, and determining what their distribution tells us about the physics of the Universe. The most important question in the field being: what is the nature of the so-called 'dark energy' that is acting as an anti-gravity that propels the expansion of the Universe to speed up?

Dark energy and the accelerating Universe

Observations by astronomers over the past 15 years have produced the startling discovery that the expansion of the Universe, originally triggered by the Big Bang, has begun to speed up. I will talk about: how do we measure the expansion of the Universe? What might be causing it to speed up? And what does that mean for the laws of physics?

2013 Moran Medal for research in statistics

Dr Aurore Delaigle, University of Melbourne

Aurore Delaigle received her PhD in Statistics from the Catholic University of Louvain in Belgium, working in the area of nonparametric curve estimation from data measured with errors. After her PhD, she held, successively, a postdoctoral position at the University of California in Davis, funded by the Belgian American Educational Foundation, an assistant professor position at the University of California in San Diego, and a lecturer, then reader, position at the University of Bristol in the UK. Since 2009, she has been a QEII Fellow at the University of Melbourne. Dr Delaigle's current research interests include nonparametric deconvolution problems, regression with measurement errors, functional data analysis, analysis of high dimensional data, and group testing. She is particularly interested in developing new methodology that can solve at once problems originating from many practical applications, such as in both the biological and physical sciences.

Introduction to functional data analysis in statistics

Functional data are data which can be naturally represented by curves. They arise in a variety of fields, as diverse as biosecurity, chemometrics, health studies and weather modelling. Examples of functional data are numerous and include growth curves of children, annual rainfall or temperature curves at Australian weather stations, ozone pollution curves, actual shape of arteries in the brain, and near-infrared spectra. It is attractive to be able to graph functional data such as growth curves of children, but a difficulty with such data is that their functional nature makes it challenging to extract the relevant statistical information. However, in problems such as classification and prediction we often do not need the entire curve, and it is possible to identify parts, or features, of the curve which contain the most important information. This talk will give a brief introduction to functional data and some of the modern statistical techniques that can be used to analyse them.

2013 Gottschalk Medal for research in the medical sciences

Dr Benjamin Kile, Walter and Eliza Hall Institute of Medical Research

Benjamin Kile is currently a Sylvia and Charles Viertel Fellow, NHMRC Senior Research Fellow, and Laboratory Head in the Cancer and Hematology Division at the Walter and Eliza Hall Institute of Medical Research (WEHI). After gaining his PhD at WEHI in 2001, Ben undertook postdoctoral studies at Baylor College of Medicine in Houston, Texas, where he was involved in one of the first large-scale mouse mutagenesis screens. He returned to WEHI in 2004, and in 2008 was appointed to the Institute's faculty. The Kile lab is focused on the molecular regulation of blood cell formation and function, with a particular emphasis on functional genetics. It has made significant discoveries in stem cell biology, oncogene function, and the development and survival of the megakaryocyte lineage. Dr Kile's achievements were recently recognised by the Australian Government in awarding him the 2010 Science Minister's Prize for Life Scientist of the Year.

Platelets, bleeding, and cancer therapy

When blood vessels are damaged, a blood clot forms at the site of injury, thereby sealing the wound and preventing bleeding. Platelets are the tiny blood cells that mediate the clotting process. Reductions in platelet number are a common side effect of cancer chemotherapy, leaving patients vulnerable to potentially fatal haemorrhage. Currently, the only treatment is a platelet transfusion. The effectiveness of platelet transfusions, and the ability to store platelets at the blood bank, is limited by the fact that these cells only live for a few days. The reasons for this finite existence have been a subject of speculation since the first transfusions were performed in the early 1900s. Our work has identified the molecular pathway that regulates the survival of platelets, and their precursor cells, the megakaryocyte. By manipulating this pathway in mouse models we have been able to double platelet life span, suggesting a new approach to improving the viability of blood bank platelets. In addition, our studies have shed light on the mechanisms by which cancer chemotherapy causes reductions in platelet number. This has aided the clinical development of a new class of cancer drugs called the 'BH3 mimetics'.

2013 David Craig Medal for research in chemistry

Professor Peter Lay FAA, University of Sydney

Peter Lay (PhD, ANU, 1981) was a CSIRO postdoctoral fellow at Stanford University and CSIRO, and an ARC QEII Fellow at Deakin University, before he joined the University of Sydney as a lecturer in 1985 where he progressed to a professorship in 1997 and Head of School (2001–2002). He was a visiting professor at the University of Bern (1991), the National University of Argentina, Rosario (1999) and the University of Sao Paulo (2011), and was Inorganic Lecturer to the Commission Scientifique pour L'enseignement du 3e Cycle en Chimie, Switzerland in 2011. Professor Lay has been awarded two Australian Research Council Professorial Fellowships (2002–2007 and 2009–2013).

Biospectroscopic studies and microscopic imaging of cells and tissues: understanding the biomolecular basis of human diseases and their treatments

The combined use of X-ray microprobe techniques: synchrotron-radiation-induced X-ray emission (SRIXE) and micro-X-ray absorption near-edge structure (μ-XANES) spectroscopy, with other microspectroscopies (e.g., vibrational spectroscopies), enables enhanced insights into disease processes and their potential treatments. Individual mammalian cells can be grown and differentiated directly on a silicon nitride substrate in order to perform biospectroscopic microprobe imaging on the cell in its normal morphology. SRIXE and μ-XANES spectroscopy can also be conducted on protein gels in order to speciate the biotransformations of pro-drugs and toxins in blood and cell lysates. Examples will include: cerebral malaria; the effects of metal anti-diabetic pro-drugs/supplements on adipocytes (fat cells), and their speciation in blood and cells; and similar studies on ruthenium anti-metastatic pro-drugs for the treatment of invasive cancers. The results will be discussed in terms of understanding the mechanisms of diseases and of efficacy and toxicities of treatments. Such an understanding can lead to more rapid and targeted design of new drugs, as well as assisting in the development of existing drugs.

2013 Fenner Medal for research in biology

Dr Ulrike Mathesius, Australian National University

Ulrike Mathesius grew up in Germany where she was motivated by a high school teacher to study biology at the Technical University of Darmstadt. An exchange year at the Australian National University during her undergraduate degree enabled her to carry out a range of research projects at the Research School of Biological Sciences. Excited by doing research, she returned to ANU to undertake her PhD (1996–1999) to study the molecular signaling between symbiotic nitrogen-fixing bacteria and legumes. This was followed by postdoctoral research in the area of plant proteomics between 1999 and 2001. In 2002 she moved to the School of Biochemistry and Molecular Biology with a Postdoctoral Fellowship from the Australian Research Council and set up her own group on root-microbe communication. Dr Mathesius then held an ARC Research Fellowship to unravel the roles of flavonoids in symbiotic and parasitic root-microbe interactions and is now an ARC Future Fellow working on the developmental similarities and evolution of symbiotic and parasitic root structures in plants.

Plants control microbes — microbes control plants

Plants have co-evolved with microbes that actively colonise the outside and inside of plants. Plant-associated bacteria of particular importance are nitrogen-fixing 'rhizobia' that form symbioses with legume plants and provide fertiliser for plants from atmospheric nitrogen. A central question is how plants recognise specific microbial partners among the millions of species present in the soil, and how plants use this information to decide how to respond. To communicate with their plant partners, rhizobia have evolved chemical signalling molecules that initiate symbiosis, determine the specificity between plant and bacterial partners and regulate feedback during the course of symbiosis. Bacteria also communicate with each other using so-called quorum-sensing signals, which coordinate bacterial behaviours important for infection. While this communication was thought to be exchanged between conspecific bacteria, we discovered that plants can 'eavesdrop' on this bacterial 'chatter' and respond by altering their readiness for symbiosis and by actively interfering with the bacterial communication. Plants also use information of quorum-sensing signal structure to differentiate between distinct bacterial species around them. These discoveries have implications for utilising microbes to improve crop productivity, both through engineering of plants with altered signals to bacteria and by targeting microbes and their chemical 'language' to manipulate plant-microbial interactions.

2013 Thomas Ranken Lyle Medal for research into mathematics or physics

Professor Cheryl Praeger AM FAA, University of Western Australia

Cheryl Praeger is Winthrop Professor of Mathematics, and Director of the Centre for the Mathematics of Symmetry and Computation, at the University of Western Australia. Her work on groups, networks and algorithms brings an area of mathematics with a proud history of 200 years, firmly into the 21st century. Her new theories, algorithms and designs have advanced every field seeking to exploit the symmetry of large complex systems. Cheryl is a member of the Order of Australia, Fellow of the Australian Academy of Science, Executive Committee member of the International Mathematical Union, Vice-President of the International Commission for Mathematical Instruction, foundation board member of the Australian Mathematics Trust, Chair of the Australian Mathematics Olympiad Committee, former president of the Australian Mathematical Society, former Chair of the Australian Council of Heads of Mathematical Sciences, former Australian Research Council Federation Fellowship and, in 2009, Western Australian Scientist of the Year.

Symmetry: more of the same!

Symmetry is all around us, and at every scale, from the beautiful structure of snowflakes to the awe-inspiring symmetry of a spiral galaxy. By symmetry, information from a small portion of a complex structure governs the whole system, for example: (1) symmetrically reproducing a small protein cluster enables viruses to replicate using a minimal amount of compactly encoded genetic information; (2) search engines that retrieve information from the World Wide Web exploit the symmetry in graphical models of the internet to work efficiently. Group theory is the mathematical study of symmetry, and to advance both this fundamental theory and its applications in studying huge finite structures, Professor Praeger exploits two extremely powerful modern tools: the finite simple group classification, and fast digital computation. Her approach identifies a small number of basic types of symmetry, and in turn classifies basic network types which shed light on huge families of symmetrical networks. Use of the simple group classification in designing randomised algorithms allows the computer to bypass laborious checks and yet correctly recognise 'classical groups'.

2013 Anton Hales Medal for research in Earth sciences

Dr Wouter Schellart, Monash University

Wouter Schellart received his PhD in Geodynamics and Tectonics from Monash University in Melbourne in 2003. In 2004 he moved to the Australian National University to start an Australian Research Council (ARC) Postdoctoral Fellowship, which was followed by an ARC QEII Fellowship in 2007. In 2008 he moved back to Monash University to combine his QEII Fellowship with a Monash Fellowship to set up a new Geodynamic Modeling Laboratory. Wouter is currently an ARC Future Fellow and leads a research group that focuses on dynamic modeling of the tectonic plates and the underlying mantle. His main research interest is in subduction zones, places on Earth where one tectonic plate dives below another plate into the mantle. Dr Schellart's current research projects examine subduction dynamics, mantle flow, giant subduction zone earthquakes, continental deformation in East Asia, and the tectonic evolution of the Southwest Pacific.

Control of subduction zone size on plate tectonics and mantle flow

Subduction zones are places on Earth where one tectonic plate (subducting plate) dives below another plate (overriding plate) into the mantle. Subduction zones provide a major control on plate motion and mantle flow and they source most volcanoes. They can cause devastating earthquakes (e.g. Japan 2011), and they are linked to massive mountains (e.g. Andes) and ocean basins (e.g. North Fiji Basin). In this presentation I will demonstrate how the size (width) of subduction zones and the presence of subduction zone lateral edges provide a major control on plate velocities, plate boundary velocities, the style of subduction and mantle flow, and the style of overriding plate deformation. In the central part of wide subduction zones, subduction is an approximately three-dimensional process (two-dimensional space + time), where mantle flow is dominantly poloidal. This causes subduction to be accommodated mostly by subducting plate motion, and leads to mountain building though poloidal mantle tractions. At narrow subduction zones and near subduction zone edges, subduction is a four-dimensional process (three-dimensional space + time), where mantle flow has a large toroidal component, subduction is accommodated significantly by backward migration of the subduction zone, and ocean basins form in the overriding plate through toroidal mantle tractions.

2013 Hannan Medal for research in applied mathematics and computational mathematics

Professor Matthew Wand FAA, University of Technology Sydney

Matthew Wand was born in Wollongong in 1963. He majored in Pure Mathematics and Statistics at the University of Wollongong and received a PhD in Statistics from the Australian National University in 1989. He has held previous academic appointments at Texas A&M University, Rice University, Harvard University, the University of New South Wales and the University of Wollongong. He was elected as a fellow of the Australian Academy of Science in 2008. Since 2010 he has been a Distinguished Professor in Statistics at University of Technology Sydney. His main research interest is non-linear models and methodology for high-dimensional and complex data, including streaming data. Professor Wand is a strong advocate for the use of statistical methodology in science, business and other sectors and for its continual development in the face of rapid technological change.

Regression analysis of streaming data

Regression analysis has been a mainstay of statistics for at least 150 years. Ever-increasing computing power has been partnered with the development of highly sophisticated regression models and fitting algorithms. We describe new challenges for regression brought about by streaming data — delivered to office and laboratory computers via modern telecommunications technologies. Such data may be so voluminous that they are not storable in standard computer memory and therefore need to be processed rapidly on arrival and then discarded. Regression summaries may be thought of as dynamic webpages or 'iDevice' apps rather than static tables and figures on a piece of paper. Some early approaches to sophisticated regression analysis for streaming data will be demonstrated.

Early and Mid Career Researcher workshops

Workshop 1
Media and communicating science

Becker Room, Shine Dome

Presenter: Dr Paul Willis

Dr Paul Willis, Director, RiAus

RiAus Director Dr Paul Willis is well known as a science broadcaster with the Australian Broadcasting Corporation, presenting and producing on ABC television science shows including *Quantum* and *Catalyst*.

Paul is passionate about informing, educating and amusing people of all ages and backgrounds about science and is keen to seize the opportunity to talk about science in a variety of public forums. He was rewarded for his passion in 2000 when he was joint recipient of the Eureka Prize for Science Communication.

Dr Willis brings a solid research career in vertebrate palaeontology to his work as a science communicator and now as Director of RiAus. He has produced many academic reports and papers, has authored or co-authored seven books on dinosaurs, rocks and fossils, and has written many popular science articles for a variety of publications.

Paul was the resident palaeontologist on seven Antarctic expeditions. His enthusiasm and keen sense of adventure make him ready and willing to engage with non-scientists and to stimulate community conversations about science, life, and everything.

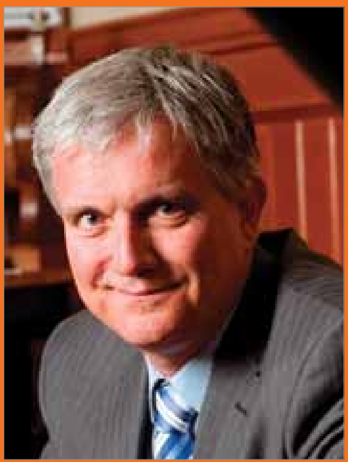


PHOTO: DAVID MARIUZ

Workshop 2
Grant writing and how to find funding opportunities

Ground floor boardroom, Ian Potter House

Presenters: Dr Aurore Delaigle (page 27), Dr Ulrike Mathesius (page 28)

Workshop 3
Successful scientific collaborations

Level 1 boardroom, Ian Potter House

Presenters: Associate Professor Christopher Adam Blake (page 26), Dr Benjamin Kile (page 27)

Teachers program

Thursday afternoon presents a unique opportunity for Science at the Shine Dome educators to 'get up close' and experience the latest research and teaching laboratories on the Australian National University campus.

Following lunch, teachers will be able to choose 'WOW' sessions as follow:

1.00 pm LUNCH

Receive box lunches and depart for the ANU campus

1.30 pm

Session One

Hands on WOW: Engaging kids in the classroom with Anita Trenwith

Location: ANU Chemistry teaching lab

OR

WOW Tour: Lasers and the coolest matter in the universe, Bose Einstein Condensate. Tour the amazing labs, ask questions and meeting leading physics researchers.

Location: ANU Physics Oliphant Building

3.00 pm

Afternoon tea and science education at the Academy

Professor Denis Goodrum (*Science by Doing*), Shelley Peers (*Primary Connections*) and Carol Conway (*NOVA* and *Interviews with Australian Scientists*) will showcase the education initiatives of the Academy of Science.

Location: Little Pickle Cafe @ The ANU / Chemistry teaching seminar room

4.00 pm

Session Two

WOW Tour: 'Behind the scenes' tour of John Curtin School of Medical Science with Dr Madeleine Nicol

OR

Hands on WOW: The science behind making ice-cream with liquid nitrogen, and other cool experiments.

Location: ANU Chemistry teaching lab

5.00 pm

Depart for the Shine Dome / hotel — short walk

Science by Doing — Engaging students with science

PrimaryConnections® — Linking science with literacy

NOVA — SCIENCE IN THE NEWS

interviews with Australian scientists

Science by Doing Online (free) curriculum units

To assist teachers implement the *Australian Curriculum: Science* Years 7 to 10, eight *Science by Doing* curriculum units will be available from July 2013 with further units in 2014. These inquiry based units will be freely available to all Australian teachers and educators. A teacher needs to simply register online and they will have access to these exciting units.

Each curriculum unit consists of three distinct parts; student guide, student digital and teacher's guide. The student guide provides information about the student activities while the student digital has a rich array of interactive activities, film clips and notebooking questions to assist learning. The teacher's guide provides an overview of the unit and information about each lesson including worksheets and assessment items.

The units have been developed by the Australian Academy of Science through funding from the Australian Government.

For further information go to the foyer of the Shine Dome or see www.science.org.au/sciencebydoing

Anita Trenwith

Anita has been teaching science for 16 years. After a number of leadership positions including acting science coordinator, literacy/numeracy coordinator and year level manager Anita moved her focus back into the classroom. In 2006 Anita started working with students with disabilities, initially teaching Auslan, then science the following year. A number of programs evolved from this opportunity including running science shows at primary schools and developing an agriculture class that runs on site at a local farm. Anita's work has been recognised with a number of awards including 2009 SA Science Excellence Awards School Science Educator of the Year, 2011 Australian Museum Eureka Award for Secondary Science and Mathematics Teaching, 2012 City of Salisbury Living Legend and 2012 Prime Minister's Prize for Excellence In Science in Secondary Teaching. Anita is eager to share what she knows and regularly works with early career teachers across the state and presents at numerous workshops and conferences.

Dr Madeleine Nicol

Madeleine holds a Bachelor of Science degree from The University of Wollongong, an Honours degree in Neuroscience from The Australian National University, and a PhD from ANU in Neuroscience and Electron Microscopy. Her PhD studies were of dorsal spinocerebellar tract cells in the spinal cord (which assist in the control of movement and posture).

More recently, she has taken on the role of Communications and Outreach Manager for The John Curtin School of Medical Research at The Australian National University.

Housekeeping

Twitter

Follow us on twitter
@Science_Academy #ShineDome2013

Wi-fi

Wireless internet access is available throughout the Shine Dome. The networks are Shine-01 and Shine-02, a password is not required.

Group photos

Please consult the TV located beside the registration desk in the foyer for your allocated group photo time.

Replacement silk ties and scarves

Replacement silk ties and scarves with the Academy logo are available for purchase by Fellows through the Academy's website www.science.org.au/academy/tiesandscarves.html

Registration desk

A registration desk is located in the main foyer and will be occupied at all times should you have any questions.

Luggage

Please note that a large luggage cabinet is located in the main foyer of the Shine Dome. Please drop your luggage off at the registration desk and wait until you have received a claim number.

Taxi

Canberra Elite 13 22 27

The Shine Dome
Gordon Street
Canberra ACT 2601

Please use the phone located in the foyer.

Bus routes

The following bus routes drop off within walking distance of the Shine Dome — 3, 4, 5 and 7
www.action.act.gov.au/timetables_and_maps

Parking

The forecourt area of the Shine Dome is 'set down and pick up only'. Limited free car parking is available in the Academy's car park off Gordon Street. Additional pay parking areas are marked on the Academy area map on the inside front cover of this program.

Disabled access

Two disabled parking spaces are available within the Academy car park.

The Shine Dome is also equipped with wheelchair access and disabled facilities.

Quiet spaces/hearing loop

You will find a quiet space to check your email (using your own device) in the Fenner Room or the Basser Library located on level 1 of the Shine Dome.

Please be aware that the Ian Wark Theatre is equipped with a hearing loop, should you require it during your time at the Shine Dome.

Contacts

The following Academy staff will be available at the Shine Dome to assist you, please don't hesitate to call them with general or specific enquiries:

General enquiries
Mitchell Piercey 0466 271 430
Samires Hook 0412 438 626

Teacher delegates
Kerrie Wilde 0417 411 032

Lindau delegates
Meaghan O'Brien 0438 458 637

Early career researchers
Camille Couralet 0425 699 259

New Fellows
Jen Nixon 02 6201 9406

Awardees
Dominic Burton 02 6201 9407

Media inquiries
Kylie Walker 0405 229 152
Cameron Williams 0447 679 612

Notes

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