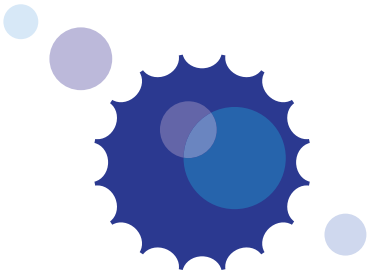
Australian Academy of Science



SCIENCE *at the* SHINE DOME 2011 PROGRAM 4–6 MAY

NEW FELLOWS | AWARDS | AGM | SYMPOSIUM

Contents

President's welcome

It is a great honour and pleasure to welcome Fellows of the Australian Academy of Science, special guests, teachers, early career researchers, policy makers and members of the general public to our flagship annual event *Science at the Shine Dome*.

Warm congratulations to the 17 new Fellows who were elected this year. We look forward to officiating at their formal admission to the Fellowship and to hearing them present highlights from their outstanding research.

Our 2011 celebration of Australian science will be launched with the Flinders Lecture presented by Professor Brian Kennett FAA. Established in 1957 to commemorate Matthew Flinders' scientific endeavour and maritime discoveries, this Lecture and Medal is awarded biannually and recognises physical scientists of the highest standing.

Three other medals will be presented to career researchers: the David Craig Medal for research in chemistry; the Hannan Medal in applied mathematics and computational mathematics; and the Jaeger Medal in Australian Earth science.

The Academy is committed to supporting young researchers to establish careers in science. Presentations by our 11 early career honorific award recipients will be another highlight of our proceedings.

We also welcome the participation of over 60 young researchers, 12 of whom were generously sponsored by the CSIRO, National Health and Medical Research Council, Department of Environment and Sustainability, Victoria, and the South Australian Department of Environment and Natural Resources. In addition we are delighted to host 6 of the 11 late doctoral and early post-doctoral students, whom the Academy is sending to this year's annual meeting of Nobel Laureates in Lindau, Germany.

We gratefully acknowledge the continued involvement of the Australian Science Teachers Association in promoting and judging the Academy's Science Teachers' Awards. Through the generosity of Professor David Craig FAA, the participation of nine science teachers and science communicators from all states and territories has been supported. We also welcome the recipient of the *2010 Prime Ministers Prize for Excellence in Science Teaching in Secondary Schools* and the national winner of the *2010 BHP Billiton Science Award*.

The teachers and young scientists will engage in professional development activities, as well as attending the highlights of the week and sharing with us their enthusiasm for science. We know from past experience that they share the enthusiasm of members of the Fellowship for science, and this will lead to many mutually rewarding and intellectually stimulating interactions.

Fellows Professor Bob Williamson and Professor Roger Short have brought together outstanding speakers from diverse fields for this year's Symposium *Australia 2050: Population Challenges to Sustainability*. Environmental issues associated with the size and rate of growth of the human population in Australia have long been a major concern of the Academy. The proceedings from the Academy's 1994 Symposium, *Population 2040: Australia's choice*, remain a key reference on this area, as does the 2004 Fenner Conference on the Environment, *Understanding the population–environment debate: bridging disciplinary divides*, held as part of the Academy's 50th anniversary celebrations. This was preceded by a report and online conference, *Population and the environment in Australia: 2003*, that were supported by the Population and Environment Fund established by longstanding benefactor, Dr Bill Gladstones. Sadly, the Academy and science lost Professor Frank Fenner FAA and Bill Gladstones at the end of 2010 and it is fitting that this year's Symposium will progress the examination of a theme so close to both men's hearts.

Science at the Shine Dome provides a wonderful opportunity to renew old acquaintances and make new ones while enjoying a program rich in cutting edge Australian science. This year, for the first time, much of the three day program will be live-streamed and recorded, enabling a much larger audience to be part of our flagship event. I am so pleased you could join us at this, the 57th annual general meeting of the Australian Academy of Science.

Suzanne Cory AC PresAA FRS

Program Wednesday 4 May

Matthew Flinders Medal and Lecture

9.30am **Welcome**
Professor Suzanne Cory AC PresAA FRS
President, Australian Academy of Science

9.35am **Matthew Flinders Lecture**
Professor Brian Kennett FAA FRS
Research School of Earth Sciences,
Australian National University
Probing subduction zones: seismic wave propagation and tomography

New Fellows Seminar

Chairs: Professor Peter Hall FAA FRS, Professor Graham Farquhar FAA FRS

SESSION 1

10.10am **Professor John Aitken FAA**
School of Environment and Life Sciences,
University of Newcastle
Our reproductive future

10.25am **Professor Marilyn Anderson FAA FTSE**
Department of Biochemistry,
La Trobe University, Melbourne
Safe sex in plants

10.40am **Professor David Black FAA**
School of Chemistry,
University of New South Wales
Molecular design and synthesis

10.55am **Professor Mark Blows FAA**
School of Biological Sciences,
University of Queensland
Why does evolution fail?

11.10am **MORNING TEA**

11.40am **Professor Mahananda Dasgupta FAA**
Department of Nuclear Physics,
Australian National University
Quantum dynamics in nuclear collisions: helping and hindering fusion

11.55am **Professor Trevor Hambley FAA**
School of Chemistry, University of Sydney
Targeting tumour microenvironments

12.10pm **Professor Staffan Kjelleberg FAA**
School of Biotechnology and Biomolecular Sciences, Centre for Marine BioInnovation,
University of New South Wales
The biofilm mode of life

12.25pm **Professor Thomas Maschmeyer FAA**
School of Chemistry, University of Sydney
Catalysis – a major key to sustainability

12.40pm **LUNCH**

SESSION 2

2.00pm **Professor Ross McPhedran FAA**
Centre for Ultrahigh bandwidth Devices for Optical Systems, School of Physics,
University of Sydney
Some useful physics

2.15pm **Professor Joseph Monaghan FAA**
School of Mathematical Sciences,
Monash University
The myriad uses of particles in simulation

2.30pm **Professor Ian Petersen FAA**
School of Engineering and Information Technology, University of New South Wales at the Australian Defence Force Academy
Robustness in feedback control systems: from nano-positioning to quantum control

2.45pm **Professor Bob Pressey FAA**
ARC Centre of Excellence for Coral Reef Studies, James Cook University
Towards effective marine protected areas in the Coral Triangle: linking regional-scale conservation design and local-scale conservation action

3.00pm **Professor Mathai Varghese FAA**
Director, Institute for Geometry and its Applications, School of Mathematical Sciences, University of Adelaide
On the versatility of index theory

3.15pm **AFTERNOON TEA**

3.45pm **Dr Colin Ward FAA FTSE**
Walter and Eliza Hall Institute for Medical Research
Unfinished business: the structures of the insulin and EGF receptors

4.00pm **Professor Emma Whitelaw FAA**
Department of Genetics and Population Health, Queensland Institute of Medical Research
Epigenetics – above or beyond genetics

4.15pm **Dr George Williams FAA**
School of Earth and Environmental Sciences, University of Adelaide
The rise of complex animals 570 million years ago: a flourishing after ice and impact?

4.30pm **Professor Aibing Yu FAA FTSE**
Department of Materials Science and Engineering, University of New South Wales
Computational particle technology

4.45pm **Professor Jonathan Borwein FAA**
Director, Centre for Computer Assisted Research Mathematics and its Applications, School of Mathematical and Physical Sciences, University of Newcastle
CARMA and me: an introduction?

5.00pm **CLOSE**
Professor Suzanne Cory

6.30 – 9.00pm Informal dinner for teachers and early career researchers
Jaeger Room, Shine Dome

2011 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 Brian Kennett FAA FRS

Professor of Seismology, Research School of Earth Sciences, Australian National University

Professor Brian Kennett is currently Distinguished Professor of Seismology at the Research School of Earth Sciences at the Australian National University. Brian's research has covered a very wide range of topics in seismology, from reflection seismology to studies of the deep Earth and from theoretical to observational studies. He has made seminal advances in understanding the Earth's internal processes, pioneered the development of influential new methods for understanding the propagation of seismic waves in complex media and made significant innovations in inversion methods for geophysical problems.

Brian received his PhD in theoretical seismology from the University of Cambridge in 1973. He was a Lindemann Fellow at the Institute of Geophysics and Planetary Physics, University of California, San Diego and then a lecturer at the University of Cambridge. He was president of International Association of Seismology and Physics of the Earth's Interior from 1999–2003 and director of the ANU Research School of Earth Sciences from 2006–10. Brian's research has been recognised with the Gold Medal in Geophysics from the Royal Astronomical Society, the Gutenberg Medal from the European Geosciences Union, the Murchison Medal from the Geological Society of London, and the Jaeger and Flinders Medals from the Australian Academy of Science. He is a Fellow of the Australian Academy of Science and the Royal Society (London).

Probing subduction zones: seismic wave propagation and tomography

Most of the world's earthquakes are associated with subduction zones where oceanic lithosphere descends into the Earth beneath an overriding plate. Growth of the sea floor through spreading at mid-ocean ridges is accommodated by recycling through the subduction process. The descending material is colder than its surroundings and the consequent variations in physical properties can be captured through their effects on the passage times of seismic waves between sources and receivers. Such seismic tomography is well suited to delineating the zones of faster wavespeed associated with the subducted plate.

By working with both compressional (P) and shear (S) waves we can develop multiple images of structure for each wavetype and so recognise changes within the subducting material. For the 2004 Sumatran-Andaman event (Mw 9.3) there is distinct segmentation of the earthquake that can be linked to changes in the physical properties of the subduction zone. More subtle features may well have controlled the source properties of the 2010 Mw 9.0 earthquake off the eastern coast of Japan that again produced a devastating tsunami.

High frequency energy from deep earthquakes carried up the subduction zone can cause significant ground shaking well displaced from the source. We would expect such energy to be rapidly shed from the zone of fast wavespeeds, but internal heterogeneity elongated along the plate is sufficient to trap the energy and bring it to the surface from even events as deep as 500 km. Such high frequency waves will be disrupted if the properties of the slab change, and provide useful probes to understand features in tomographic images. Thus, reduced wavespeed contrast might arise from tearing or thinning of subducted material with very different effects on wave propagation. Such effects will be illustrated by examples from the Japanese region.

New Fellows seminar

Professor John Aitken FAA

School of Environment and Life Sciences, University of Newcastle

John Aitken received his PhD in reproductive biology from the University of Cambridge under the supervision of RV Short. After a series of postdoctoral fellowships in Edinburgh, Geneva and Bordeaux, he moved to the MRC Reproductive Biology Unit, University of Edinburgh, to establish a research group studying the cell biology of fertilisation and early embryonic development. While in this position he received an honorary professorship from the Faculty of Medicine and in 1995 was elected a Fellow of the Royal Society of Edinburgh. In 1998 he was awarded an ScD degree by the University of Cambridge and in the same year moved to the University of Newcastle, NSW, as chair of biological sciences and, later, director of the ARC Centre of Excellence in Biotechnology and Development. He is currently Laureate Professor of Biological Sciences at the University of Newcastle and Co-Director of the Priority Research Centre in Reproductive Science.

Our reproductive future

Our species is a reproductive paradox. On the one hand, we are so infertile that couples require increasing access to assisted conception technologies in order to reproduce. On the other, we are so fertile that the planet groans when it registers another birth and our population continues its unprecedented and unsustainable march towards a crisis of Malthusian proportions. While these two faces of the reproductive coin touch all of our lives, the science of human reproduction remains a largely undiscovered land. There have been no radically new forms of contraception since the contraceptive pill was introduced in 1959 and even this approach to fertility regulation was based on the biochemistry of the 1920s. Furthermore this form of contraception was designed to meet the social mores prevailing in the 1960s, and times have changed.

One of the major challenges that we face today is to generate methods of fertility regulation that will protect the user simultaneously against both fertility and sexually transmitted disease. How such an objective might be achieved is the subject of ongoing research which, happily, has seen some exciting new leads. With respect to infertility, one in every 35 Australians is currently the product of assisted reproductive technology and the uptake of such therapy is increasing exponentially. The two major reasons for referral to IVF clinics are advanced maternal age and male infertility respectively. While the former could be readily solved by a change in social attitudes towards women and work, the latter is a more intractable problem because its origins are so poorly understood. Male infertility affects at least one in 20 of the male population and may even be on the rise. While there is consensus that this condition involves a complex mixture of genetic and environmental factors, elucidation of the specifics – which genes? what environmental factors? – will preoccupy explorers in the reproductive landscape for some time to come.

Professor Marilyn Anderson FAA FTSE

Department of Biochemistry, La Trobe University

After completing a BSc with honours at the University of Melbourne and a PhD in biochemistry at La Trobe University, Marilyn Anderson spent seven years in the United States working on diabetes at the University of Miami and oncogenes at Cold Spring Harbor Laboratory. She returned to Australia in 1982 to join the newly established Plant Cell Biology Research Centre at the University of Melbourne and worked with Adrienne Clarke to clone genes that control pollination in plants. She joined the Department of Biochemistry at La Trobe University in 1995. Her current work is focused on defence molecules produced by plants for protection against insect pests and pathogens. Her research spans from basic work on the structure and function of these molecules, to the practical application of creating crop plants which are protected from predation and disease. This practical application is being developed within the company Hexima

Limited of which Professor Anderson is a founding scientist and Chief Science Officer.

Safe sex in plants

Plants are amazing chemical factories. They can't run away from prey, don't have an adaptive immunity system and can't communicate as efficiently as animals, yet they have developed very sophisticated molecular systems for selection of sexual partners and to minimise infection by microorganisms and insect pests. This talk will describe strategies that plants use to reject unwanted suitors and to protect their valuable reproductive organs against fungal diseases and chewing insect pests.

Professor David Black FAA

School of Chemistry, University of New South Wales

David Black was born in Wollongong, Australia and graduated with a MSc from the University of Sydney and PhD from Cambridge (working with Lord Todd). David worked at Monash University from 1965–82 and was appointed to the chair of organic chemistry at UNSW in 1983. He has spent periods at Columbia University with Thomas Katz, ETH Zürich with Albert Eschenmoser, Würzburg University as an Alexander von Humboldt Fellow with Siegfried Hünig, and held visiting professorships in Tokyo, Auckland, Göttingen, Innsbruck and Kobe. He has been awarded the Rennie, Smith, Birch and Leighton Medals of the Royal Australian Chemical Institute. David is currently Secretary General of the International Union of Pure and Applied Chemistry. He has published more than 280 papers and a monograph on the synthesis of organic molecules.

Molecular design and synthesis

Synthetic organic chemistry is a creative area of science involving the transformation of existing molecules into completely new ones. Initially the design of a target molecule must be based on some hypothesis that the resulting structure will provide new insights into chemistry. For example the new molecule might be intrinsically desirable because of its shape, its reactivity, its physical and spectroscopic properties, or its anticipated biological activity. The desired products could lead to new drugs or new materials. Once the target structure has been chosen, a synthetic route must be determined: this can be based on known transformations or can pose a challenge to discover new transformations. In practice, a new target molecule must combine originality of structure with feasibility of synthesis. The overall process is one of molecular architecture followed by molecular construction. In addition to the science, there is an artistic element in this field of research. Simple buildings can easily be constructed using known principles: however something quite novel and beautiful, such as the Sydney Opera House, requires solutions to be found to fundamental construction problems.

These principles will be illustrated in the case of indoles, which are important molecules in the chemistry of life, as a consequence of the essential amino acid tryptophan. Over recent years, we have investigated the chemical reactions of specifically activated indoles, and these have generated a wide range of interesting, novel structures.

Professor Mark Blows FAA

School of Biological Sciences, University of Queensland

Mark Blows received his PhD in genetics from La Trobe University in 1994. He subsequently held an NSERC International Fellowship at York University and an Australian Postdoctoral Fellowship at James Cook University, before becoming a lecturer at the University of Queensland in 1998. Mark is currently Professor of Evolutionary Biology, and Head of School of the School of Biological Sciences, at the University of Queensland. His major interests are in quantitative genetics, with a particular focus on how genetic variance evolves, how genetic covariance structure biases evolutionary trajectories, and ultimately how genetic variation limits evolutionary change.

Why does evolution fail?

Evolution commonly fails when we don't expect it to. In many cases, a population will fail to respond to selection in the presence of the two necessary ingredients for evolutionary change; selection on a trait, and genetic variation for that trait. A fundamental issue in understanding evolutionary limits is determining how the genetic variance evolves under selection, a question that is ultimately related to how genetic variance is maintained in populations.

Although almost all individual traits display genetic variation, much of the multivariate phenotypic space of a set of functionally related traits tends to exhibit very little genetic variation. Experiments using sexual selection as an evolutionary force have shown that selection itself is likely to be responsible for the very low levels of genetic variation found in parts of the phenotypic space. The pleiotropic associations between sexually-selected traits and other traits under natural selection have been revealed to play a key role in causing evolution to fail in the presence of genetic variation and strong selection for continued evolutionary change.

Professor Mahananda Dasgupta FAA

Department of Nuclear Physics, Australian National University

Mahananda Dasgupta obtained her PhD from the Tata Institute of Fundamental Research in Mumbai, India. She then joined the Department of Nuclear Physics at the Australian National University, and was awarded a Queen Elizabeth II Fellowship to pursue her research in the field of nuclear reaction dynamics. Developing novel experimental techniques, and driving theoretical collaborations, she played a key role in demonstrating the enormous effects of quantum properties of nuclei on reaction outcomes through measurements of unmatched precision. Nanda was the 2004 Women in Physics Lecturer of the Australian Institute of Physics, and received the Pawsey Medal from the Australian Academy of Science in 2006.

Quantum dynamics in nuclear collisions: helping and hindering fusion

Understanding and controlling the interactions of quantum many body systems for practical applications is a major challenge in science. A nuclear collision is a 'mini-universe', isolated from external environments, and thus is a unique tool to probe the quantum dynamics of many-body systems. Nuclei are however completely invisible (<10–14m), and a collision of two nuclei takes only a few zeptoseconds (10–21s) – a challenge for experimentalists. I will describe how we unravel collision dynamics through ingenious experiments, providing 'snapshots' of this invisible world, to help understand irreversibility in quantum mechanics, the fusion of light nuclei, and fusion of heavy nuclei that create new superheavy elements.

Professor Trevor Hambley FAA

School of Chemistry, University of Sydney

Trevor Hambley is the Dean of Science at the University of Sydney and is a Professor of Chemistry. He studied at the Universities of Western Australia and Adelaide, and spent postdoctoral periods at ANU and CSIRO before moving to the University of Sydney in 1984. Professor Hambley was the recipient of the Edgeworth David Medal for contributions to Science by an Australian under the age of 35 and has received the 'Supervisor of the Year' award at the University of Sydney in 1997 and an Excellence in Teaching Award for Postgraduate Supervision in 1998.

His research interests are in the area of medicinal inorganic chemistry with an emphasis on platinum anticancer drugs, hypoxia selective cobalt complexes, and metal based anti-inflammatory compounds. The current focus of his research group is on the development of agents that selectively and effectively target cells in the different microenvironments of solid tumours. He has published more than 460 refereed journal papers, books, and book chapters.

Targeting tumour microenvironments

Solid tumours are difficult to treat because many of cancer cells lie at unusually large distances from blood vessels. Consequently, they receive low levels of nutrients, resulting in drug-resistant phenotypes, and low levels of anticancer agents, further reducing the effectiveness of the chemotherapy. We will describe our work aimed at targeting the action of the cytotoxic agents, both to tumours themselves and to the various microenvironments that exist in a solid tumour. Our approach is based on exploiting the chemical and biological features of the different tumour microenvironments including hypoxia, acidity, and enzyme over-expression. We will also describe our studies aimed at investigating and improving the penetration and effectiveness of anticancer agents throughout all regions of solid tumours. Such approaches have the potential to reduce the side effects that limit the application and effectiveness of anticancer agents and to generate more durable outcomes, including long term survival.

Professor Staffan Kjelleberg FAA

School of Biotechnology and Biomolecular Sciences, Centre for Marine BioInnovation, University of New South Wales

Staffan Kjelleberg joined the University of New South Wales in 1993, where he is currently Scientia Professor in the School of Biotechnology and Biomolecular Sciences, and Director of the Centre for Marine BioInnovation, an international focal point for interdisciplinary basic and applied research into chemically mediated interactions between organisms. Since 2008, he is also Visiting Professor at Nanyang Technological University in Singapore, and Director of the Singapore Centre on Environmental Life Sciences Engineering. Staffan obtained his PhD and Docent from University of Goteborg Sweden in Microbiology in 1981 and 1984, respectively, conducted postdoctoral work at the University of New South Wales, and was professor and chair at both the University of Goteborg and New South Wales.

As a microbial ecologist, Staffan has focused his research on bacterial adaptive responses and biofilm biology to understand the predominant modes of life of microorganisms in the environment. The discovery of naturally derived antagonists of bacterial communication systems has laid the foundation for both interdisciplinary programs on interkingdom signalling in a range of habitats and for novel biotechnology. His findings on mechanisms that regulate the biofilm life cycle have contributed not only to microbial ecology but also to environmental biotechnology, and to the uptake of microbial life sciences into environmental engineering.

The biofilm mode of life

The discipline of microbiology has undergone major conceptual shifts in recent times. While studies of microbiology, ever since the discovery of microorganisms some 300 years ago, have focused on single cells, in monospecies studies, the last decade has witnessed the realisation that communities of microorganisms organised as biofilms, of diverse community composition, are the predominant form of microbial life. Hence, biofilms which form on all surfaces, with significant positive as well as negative outcomes, also represent the main biomass and activity in all ecosystems, natural as well as man-made. The challenge in microbiology is therefore to understand biofilm biology rather than the biology of single cells, to describe ecosystem function and to harness and control biofilms across a range of applications. The capacity to apply high resolution imaging on tagged cells and genes, as well as to undertake whole community metagenomic analysis of complex biofilm consortia, now make it possible to scrutinise the diversity and function of biofilms and their impact. The presentation will highlight recent findings that have contributed to our understanding of the biofilm life cycle and illustrate key roles of biofilms in ecosystem responses.

Professor Thomas Maschmeyer FAA

School of Chemistry, 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 as well as 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.

Catalysis – a major key to sustainability

Our responses to the current global challenges that we face will have ramifications well beyond our life times. Indeed, the world is standing at the technological threshold of an energy and resources revolution. At current rates of resource usage, a world population operating with Australian standards of living would require between four to six planets. Clearly, this is untenable and, from a chemical viewpoint, the inherent challenges can only be met by devising strategies for increased use of renewable resources, waste reduction, energy optimisation and process intensification.

For modern civilisation to approach a sustainable existence, while at the same time not dramatically

decreasing the material quality of life, we need a four to ten fold increase in the efficiency with which we use our resources. In particular, as carbon emissions present a real problem and the world's fossil fuel reserves are consumed at an alarming rate, new sustainable, non-polluting sources for energy and chemicals must be found. This requires sophisticated and advanced catalysts. The chemistry these catalysts will perform will be extraordinary, as will be their design. Reactor and reaction systems will need to be intimately linked – often involving cascading catalytic reactions. This requires control from meters to picometers, ie across twelve orders of magnitude. The success of these new catalytic systems will be a bedrock for the technologies of the 21st century. Catalysts are a key to sustainability. This will be illustrated by examples from our work in photocatalysis (generating solar hydrogen from aqueous media) and biofuels (as derived from fibrous waste biomass).

Professor Ross McPhedran FAA

Centre for Ultrahigh bandwidth Devices for Optical Systems, School of Physics, University of Sydney

Ross McPhedran is a Chief Investigator in the CUDOS Centre of Excellence and holds a Personal Chair in Electromagnetic Physics at the University of Sydney. His research interests lie in the broad field of wave science, and in particular in the interaction of electromagnetic and elastic waves with structured materials. He has been a pioneer in the development of multipole methods for the calculation of the properties of composite materials for applications such as solar collectors, and for the study of photonic crystals and photonic crystal fibres. These are being developed for new applications in communication science and sensing, and were at the core of the initial research program of CUDOS. He is also an internationally recognised leader in the new fields of plasmonic nanostructures and metamaterials.

Ross has been at the University of Sydney since 1975, apart from periods of study leave taken at Caltech, the University of Bath and the Université Paul Cézanne in Marseille. He has over 270 reviewed scientific publications, which have attracted over 6,000 citations. He has served on the editorial boards of the international journals Optics Communications, Journal of Modern Optics, Proceedings of the Royal Society A and Waves in Random and Complex Media. As well as being a Fellow of the Australian Academy, he is a Fellow of the Australian Institute of Physics, the Institute of Physics (UK) and the Optical Society of America. He was awarded the Australian Optical Society Medal in 2004, and a doctorate honoris causa by the Universite Paul Cezanne in 2010.

Some useful physics

Ross has chosen a few of his research topics to illustrate the adage of James Clerk Maxwell that there is nothing more practical than a good theory. The design of an optical security device for the 1988 Australian ten dollar note, and of composite materials for solar energy absorbers will be discussed. The physics of microstructured optical fibres, which were first developed in the mid 1990s, and have enabled the construction of a new broadband light source will be described as will a similar optical system which exists in the hairs of a mud-dwelling sea creature, and which gives it a remarkable iridescence. Ross will conclude with an example of his work on a new type of optical material, which is being developed for a range of applications, including cloaking (the rendering of objects invisible to detection by electromagnetic waves).

Professor Joseph Monaghan FAA

School of Mathematical Sciences, Monash University

Joe Monaghan completed his undergraduate degree at the University of Western Australia, and his MSc while working at the CSIRO's Division of Chemical Physics. He completed his PhD in theoretical astrophysics in 1965 at the University of Cambridge. He was a Fellow of Churchill College, Cambridge 1966 and a Morrison Post Doctoral Fellow at the University of Santa Cruz in 1967. In 1968 he joined Monash University where he was appointed to reader in 1971 and professor in 1989. While on sabbatical leave at the University of Cambridge he devised and named the Smoothed Particle Hydrodynamics (SPH) method and, with RA Gingold,

used the method to simulate the complex phenomena associated with star formation. SPH has proved to be a tool with many applications. In 1999 he was awarded the CSIRO Research Achievement medal.

The myriad uses of particles in simulation

Many of the materials around us, whether they be solid, liquid or gas appear to be continuous and this assumption forms the basis of the equations used to describe them. However, in most situations the equations are too complicated to solve by pure mathematics and progress can only be made numerical methods. The problems are not easy to solve because the phenomena can be very complicated. Think for example of the wave striking a rocky beach, or a chaotic cloud of gas in the galaxy evolving to form stars. Most of Joe's research career has been spent successfully extending the particle method SPH to these problems, and to many others in astrophysics, industry and engineering. Some of this work will be described.

Professor Ian Petersen FAA

School of Engineering and Information Technology, University of New South Wales at the Australian Defence Force Academy

Professor Ian Petersen is a Scientia Professor and Federation Fellow in the School of Engineering and Information Technology at the University of New South Wales (Australian Defence Force Academy). He received a Bachelor of Engineering degree in electrical engineering from the University of Melbourne in 1979 and a PhD in Electrical Engineering from the University of Rochester in 1984. From 1983 to 1985 he was a Postdoctoral Fellow at the Australian National University. In 1985 he joined the University of New South Wales at the Australian Defence Force Academy. From 2002 to 2003, he was executive director in Mathematics, Information and Communications for the Australian Research Council and in 2004 he was acting deputy vice chancellor (research) for the University of New South Wales. He has served as an associate editor for the IEEE Transactions on Automatic Control, Systems and Control Letters, Automatica, and SIAM Journal on Control and Optimisation. Currently he is an editor for Automatica. He is a Fellow of the IEEE. His main research interests are in robust control theory, quantum control theory and stochastic control theory.

Robustness in feedback control systems: from nano-positioning to quantum control

Feedback control systems are ubiquitous in many areas of technology and science. A critical requirement in any feedback control system is that of robustness. This is the ability of the control system to continue to work in the face of uncertain dynamics in the system being controlled. In particular, a critical requirement is that the feedback system maintains stability in the face of these uncertainties. Robust Control Theory has enabled the systematic design of feedback control systems to provide optimal control system performance in the face of specific uncertainties in the underlying dynamic models. One important class of robust control theory methods centres around H-infinity control in which a control system's performance is optimised for worst case uncertainties. Applications of this theory have included nano-scale positioning systems such as occur in atomic force microscopes, in which the control system must be robust to uncertainties in the resonant frequencies of the piezo-electric actuators. Recently, H-infinity control theory has been extended to problems of quantum feedback control in which the system being controlled is described by the laws of quantum mechanics rather than classical mechanics.

Professor Bob Pressey FAA

Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University

Distinguished Professor Bob Pressey leads a research group on conservation planning in the Australian Research Council Centre of Excellence for Coral Reef Studies at James Cook University. His group is exploring all aspects of planning in marine and terrestrial environments throughout the Asia-Pacific region and beyond. Research areas include data and modelling, decision support tools, costs of conservation, opportunities and constraints, and governance arrangements. Much of his group's research focuses geographically on the Great Barrier Reef, the Western Pacific, and the Coral Triangle. Bob is

relatively new to academia, having spent 19 years as an agency scientist involved in some of the watershed applications of systematic conservation planning to real-world decisions. He is also new to north Queensland and has embraced outdoor living and Bundaberg Rum, but has had trouble embracing Rugby League.

Towards effective marine protected areas in the Coral Triangle: linking regional-scale conservation design and local-scale conservation action

The Coral Triangle presents intriguing and urgent challenges to the science of systematic conservation planning. Our systematic approaches to designing marine protected areas (MPAs) typically identify large, contiguous tracts of sea and coast to achieve conservation objectives. Implementing these designs is difficult in the Coral Triangle because of three characteristics:

1. finely-textured ownership and management of inshore waters
2. high dependence on local marine resources for subsistence and commerce
3. limited occupational mobility.

On the other side, implementation of small, ad hoc MPAs is proceeding apace. These small MPAs might contribute to local objectives for fisheries, but they form collections, not systems that could contribute to broader objectives. Larger objectives are crucial, and include robustness to climate change and protection of wide-ranging species. We know that better integration of regional designs and local actions involves 'scaling down' and 'scaling up'. But, while these terms roll easily off the tongue, we are also painfully aware that our approaches to scaling need much improvement.

This presentation will explore some of the conceptual, operational, policy and institutional implications of scaling up and down, and what these mean for new ways of approaching marine spatial planning.

Professor Mathai Varghese FAA

Director, Institute for Geometry and its Applications, School of Mathematical Sciences, University of Adelaide

Mathai Varghese obtained his PhD from Massachusetts Institute of Technology (MIT) in 1986 under the supervision of the Fields medallist Professor Daniel Quillen, and was appointed a Dickson Instructor at the University of Chicago. He moved to the University of Adelaide in 1989 where he has been a professor since 2006 and is currently an Australian Professorial Fellow of the Australian Research Council, and Director of the Institute for Geometry and its Applications. In 2000, he was awarded the Australian Mathematical Society medal, in 2000–01, he was awarded a Clay Research Fellowship and position of visiting scientist for a year at MIT, in 2006 he was appointed a senior research fellow for a semester at Erwin Schrodinger Institute in Vienna. In 2006–09, he was appointed vice president (in charge of annual conferences) of the Australian Mathematical Society and has also been a member of several national committees. Much of his research work is concerned with geometric analysis involving the topology of manifolds, and mathematical problems that originate from physics, such as topological field theories, the fractional quantum Hall effect and String Theory.

On the versatility of index theory

The celebrated Atiyah-Singer index theorem relating the analytic index of a system of differential equations (which is an integer) to a topological invariant has striking applications to fundamental problems both in mathematics and in physics. The topological invariant referred to above can often be a fraction and what takes the role of the analytic index in this situation as well the corresponding 'fractional index theorem' relating the two notions, will be outlined and constitutes joint work with Melrose and Singer. The need for such a theorem arising from the renowned fractional quantum Hall effect will be explained.

Dr Colin Ward FAA FTSE

Walter and Eliza Hall Institute for Medical Research

Colin Ward obtained his BSc in wool technology in 1964 and his PhD in helminth biochemistry in 1967, both from the University of New South Wales. He did two years postdoctoral research at the Department of Zoology, University of Massachusetts working on lipid metabolic pathways in helminths before joining the CSIRO Division of Protein Chemistry in 1970. His work there included: insect proteolytic enzymes; structure and variation of influenza virus haemagglutinin and neuraminidase proteins; structure, variation and classification of the Potyviridae, the largest and most important family of plant viruses; the development of criteria for a higher taxonomy for all viruses; recombinant veterinary vaccines including a subunit vaccine for infectious bursal disease virus in poultry,

now commercialised by Merial. Since the early 1990s he has concentrated on the structure and function of the insulin receptor and epidermal growth factor receptor families, first at CSIRO and since 2007 at the Walter and Eliza Hall Institute.

Unfinished business: the structures of the insulin and EGF receptors

Ever since the discovery of insulin and its role in the regulation of sugar uptake and utilisation, there has been great interest in insulin, the insulin-like growth factors and their receptors. The insulin receptor and the closely related type 1 IGF receptor are large, glycoproteins that consist of an extracellular hormone binding region linked by a single transmembrane helix to an intracellular tyrosine kinase domain. Unlike other receptor families, these proteins exist on the surface of cells as preformed, chemically cross-linked dimers. In a manner that is still far from understood, hormone binding to the external portion of the receptor activates the intracellular kinase domain to initiate insulin/IGF signalling responses. Our progress to date in establishing the 3D structures of this family of receptors will be described along with our parallel studies on a related family of cell surface receptors, the epidermal growth factor receptor family. In addition to its role in normal sugar metabolism, one of the isoforms of the insulin receptor binds IGF-2 with high affinity and is implicated in certain cancers, as are the IGF-1R and EGFRs.

Professor Emma Whitelaw FAA

Department of Genetics and Population Health, Queensland Institute of Medical Research

Professor Emma Whitelaw is a molecular biologist working at the Queensland Institute of Medical Research. After completing her undergraduate degree at the Australian National University, she obtained a DPhil at the University of Oxford and remained working in London and Oxford for the next fifteen years. In 1991, she joined the University of Sydney and focused her research on transcription, using the mouse as a model organism. Her most notable research achievements are in the area of epigenetics. In particular, her studies on the transgenerational inheritance of epigenetic marks have stimulated a great deal of interest. More recently she has extended her studies to include the interaction between the environment and the epigenome. In 2008 she was awarded an Australia Fellowship.

Epigenetics – above or beyond genetics

Tremendous progress has been made in our understanding of genetics over the last century. I will discuss Watson and Crick's search for the molecular basis of genetics and the recent sequencing of the human genome. What makes us unique individuals is not just the set of genes that we inherit from our parents. It includes other molecules bound up with the DNA in chromosomes. These are called epigenetic marks. The field of epigenetics, introduced by Waddington in the 1940s, is undergoing a renaissance. Recent advances in this discipline will be discussed. Because the epigenetic state of the genome can be altered by the environment and this state can be inherited across generations, Lamackian-like modes of inheritance appear possible. There is now strong evidence for this in plants and worms and some evidence for it in mammals.

Dr George Williams FAA

School of Earth and Environmental Sciences, University of Adelaide

George Williams received an MSc in geology from the University of Melbourne in 1963 and a PhD from the University of Reading in 1966, where he held an 1851 Exhibition Overseas Scholarship. His subsequent work has been divided between industry and research based at the University of Adelaide with Queen Elizabeth II and ARC Professorial Fellowships, much in association with the CSIRO. He has contributed to numerous fields in the earth and planetary sciences through research in sedimentology, paleoclimatology, paleomagnetism and meteoritics, grounded principally in Australia and also in Scotland, North America, North Africa and India. His discoveries and studies of global relevance have illuminated Precambrian glacial environments, the geological and environmental effects of asteroid impact on the Earth, and the past dynamics of the Earth-Moon system. He was awarded the Royal Society of Victoria Research Medal in 1991 and a DSc by the University of Reading in 1998.

The rise of complex animals 570 million years ago: a flourishing after ice and impact?

The abrupt appearance in the fossil record at 570 Ma (million years ago) of a rich biota including large soft-bodied organisms representing the oldest definitive animals, after nearly three billion years of microbial life, marks a turning point in Earth history. Geological and paleomagnetic studies in Australia have shown that extreme climatic and environmental turmoil preceded this evolutionary milestone. Research at the CSIRO paleomagnetism laboratory provided the first firm evidence that widespread glaciation at 630 Ma occurred near the former equator. This finding stimulated work in other countries on the extent and nature of Precambrian (pre 542 Ma) glaciation. An asteroid impact in South Australia at ~580 Ma, which remarkably occurred during a further glaciation, was of sufficient magnitude to have adversely affected the global environment and was closely followed by a rapid radiation of diverse plankton. It may be asked whether release from the combined stresses of glaciation and impact influenced the path of evolution.

Professor Aibing Yu FAA FTSE

Department of Materials Science and Engineering, University of New South Wales

Aibing Yu specialised in process metallurgy, obtaining BEng in 1982 and MEng in 1985 from Northeastern University, PhD in 1990 from the University of Wollongong, and DSc in 2007 from the University of New South Wales (UNSW). Since 1992, he has been with UNSW School of Materials Science and Engineering where he is currently Scientia Professor and ARC Federation Fellow. He is a world leading scientist in particle/powder technology and process engineering, has authored more than 550 publications (including more than 300 collected in the *Web of Science*), delivered many invited plenary or keynote presentations at international conferences, and is on the editorial board of more than 10 learned journals. He is a recipient of various prestigious awards including Josef Kapitan Award from the Iron and Steel Society, Ian Wark Medal and Lecture from Australian Academy of Science, ExxonMobile Award from Australian and New Zealand Federation of Chemical Engineers, and NSW Scientist of Year 2010 in the category of engineering, mathematics and computer science. He is also an elected Fellow of Australian Academy of Technological Sciences and Engineering.

Computational particle technology

Particle science and technology is a rapidly developing interdisciplinary research area with its core being the understanding of the relationships between micro and macroscopic properties of particulate/granular matter – a state of matter that is widely encountered but poorly understood. The macroscopic behaviour of particulate matter is controlled by the interactions between individual particles as well as interactions with surrounding gas or liquid and wall. Understanding the microscopic mechanisms in terms of these interaction forces is therefore key to leading to truly interdisciplinary research into particulate matter and producing results that can be generally used. This aim can be effectively achieved via particle scale research based on detailed microdynamic information such as the forces acting on and trajectories of individual particles in a considered system. In the past two decades, such research has been rapidly developed worldwide, mainly as a result of the rapid development of discrete particle simulation technique and computer technology. This talk will present an overview of the work in this direction in my laboratory 'Lab for simulation and modelling of particulate systems (SIMPAS)'. It covers, through demonstrative examples, the development of simulation techniques and their application to the study of particle packing and flow, transport properties and constitutive relationships of typical static or dynamic particulate systems related to mineral/metallurgical/materials industries. The examples will demonstrate that particle scale modelling and analysis has gradually emerged to be a useful tool not only for fundamental research but also for engineering application.

Professor Jonathan Borwein FAA

Director, Centre for Computer Assisted Research Mathematics and its Applications, School of Mathematical and Physical Sciences, University of Newcastle

Jonathan Borwein is Laureate Professor in the School of Mathematical and Physical Sciences at the University of Newcastle. He directs the Priority Research Centre for Computer Assisted Research Mathematics and its Applications (CARMA). Earlier awards include an honorary degree from Limoges (1999), and fellowships of the Royal Society of Canada (1994) and the American Association for the

Advancement of Science (2002). He has previously worked at Simon Fraser, Dalhousie, Waterloo, and Carnegie-Mellon Universities.

Borwein is recognised as a leading expert in optimisation theory and experimental mathematics, and has done breakthrough research in computational number theory. Highly regarded as a spoken and written expositor, Borwein's interests span pure mathematics (classical and functional analysis), applied mathematics (optimisation and nonlinear analysis), computational mathematics (numerical and computational analysis), and high performance computing. He has authored 350 research articles and a dozen books (recently on experimental mathematics, on variational analysis, and on convex functions).

CARMA and me: an introduction?

The emergence over the past two decades of sophisticated mathematical computing packages, very high bandwidth connectivity and massive computational powers is transforming mathematics and the sciences in ways that most mathematicians and scientists have not yet comprehended. In particular this is blurring the boundaries between traditional (inductive) science and classical (deductive) mathematics. This presentation will illustrate – primarily graphically – what has changed and what it promises to mathematics and the language of modern science and technology.

Program Thursday 5 May

Formal admission of new Fellows

9.00am **President's address**
Professor Suzanne Cory AC PresAA FRS
President, Australian Academy of Science

9.20am **Admission of new Fellows ceremony**
Professor John Aitken
Professor Marilyn Andersen
Professor David Black
Professor Mark Blows
Professor Jonathon Borwein
Professor Mahananda Dasgupta
Professor Trevor Hambley
Professor Staffan Kjelleberg
Professor Thomas Maschmeyer
Professor Ross McPhedran
Professor Joseph Monaghan
Professor Ian Petersen
Professor Bob Pressey
Professor Mathai Varghese
Dr Colin Ward
Professor Emma Whitelaw
Dr George Williams
Professor Aibing Yu

Honorific awards

9.45am **Career honorific awards**

2011 DAVID CRAIG MEDAL
Professor Ian Dance FAA
University of New South Wales
Adventures at some frontiers of chemistry

2011 HANNAN MEDAL
Professor Colin Rogers FAA
University of New South Wales
Only connect: a nonlinear journey

2011 JAEGER MEDAL
Professor Ian Jackson
Australian National University
Laboratory calibration of the seismological probe of the Earth's internal structure

10.25am **MORNING TEA**

10.45am **Early career honorific awards**

2011 FENNER MEDAL
Associate Professor Bryan Fry
University of Queensland
Venom breathing dragons

2011 RUTH STEPHENS GANI MEDAL
Dr Alicia Oshlack
Walter and Eliza Hall Institute of Medical Research
New genetic technologies and the evolution of gene expression in humans

2011 GOTTSCHALK MEDAL
Dr Stuart Tangye
Garvan Institute of Medical Research
The impact of gene mutations on the function of human lymphocytes

2010 GOTTSCHALK MEDAL
Professor James Whisstock
Monash University
A molecular arms race – membrane attack complex / perforin-like proteins in infection and immunity

2011 ANTON HALES MEDAL
Professor Craig Simmons
Flinders University
Variable-density groundwater flow: approaches, challenges and resolutions

INAUGURAL CHRISTOPHER HEYDE MEDAL
Dr Anthony Henderson
University of Sydney
Excedances and descents

2011 DOROTHY HILL AWARD
Dr Kirsten Benkendorff
Southern Cross University
Molluscan bioresources: applications in monitoring environmental health, disease resistance and human medicine

2011 MORAN MEDAL
Dr Scott Sisson
Dr Mark Tanaka
University of New South Wales
Advancing model-based statistical inference for contemporary scientific research

2011 PAWSEY MEDAL
Professor Bryan Gaensler
The University of Sydney
Magnets in the sky

2010 PAWSEY MEDAL
Professor Andrew White
The University of Queensland
Quantum biology, chemistry, maths and physics

1.00pm **LUNCH**

1.45pm – 5.00pm **Interactive workshop for teachers**

2.00pm – 5.00pm **Early career researcher workshops**
- Media and communicating science
- Grant writing skills
- Building successful collaborations

2.15pm – 4.30pm **Social program**
Not just Ned: the true history of the Irish in Australia (National Museum of Australia exhibition)

2.30pm – 5.00pm **Annual General Meeting**
(closed session for Fellows of the Academy)

6.40pm **Buses leave** for National Museum of Australia from University House and Diamant Hotel

7.00pm **Annual dinner** (pre-dinner drinks from 7.00pm, dinner at 7.30pm)
Venue: National Museum of Australia
Career honorific awards medal presentations
Dress code: Black tie/cocktail
Guest speaker: Professor Lord Robert May of Oxford OM AC FAA FRS

Honorific awards

2011 David Craig Medal for research in chemistry

recognises the outstanding contribution to chemical research of Emeritus Professor David Craig AC FAA FRS. Its purpose is to recognise contributions of a high order to any branch of chemistry by active researchers. The awardee will present public lectures in cities across Australia.

Professor Ian Dance FAA

Professor of Chemistry, School of Chemistry, University of New South Wales

Professor Ian Dance has led international research in four areas of fundamental chemistry. He pioneered the preparation and understanding of compounds containing metals and sulphur, he revealed the existence of a large number of basic inorganic compounds in gaseous form, he developed an understanding of the ways in which many molecules recognise and organise their surroundings, and he developed a chemical understanding of the long-elusive mechanism by which plants chemically convert unreactive nitrogen in the atmosphere to the forms required for life.

Ian had his early scientific education at the University of Sydney and in the laboratories of the NSW Department of Mines. After PhD research at the University of Manchester he was a researcher at the University of Wisconsin and at Massachusetts Institute of Technology in the USA. In 1975 he returned to Sydney at the University of New South Wales in the School of Chemistry, where he was appointed professor of inorganic chemistry in 1986, Faculty of Science professor in 2000, and emeritus professor in 2002. He has been the Royal Society of Chemistry lecturer (Australia and New Zealand), Liversidge lecturer (NSW), Burrows lecturer (Australia), Stranks memorial lecturer (Melbourne), Albright and Wilson lecturer (Warwick, UK), 3M lecturer (Canada), and Dwyer lecturer (UNSW).

Adventures at some frontiers of chemistry

Professor Ian Dance's research career has moved through several different fields of fundamental chemistry, with some linking themes. This short presentation will provide glimpses of his early research on metal-thiolate compounds and metal sulfide clusters, and some revelations of unusual metal-sulfide and metal-carbon compounds in the gas phase. This research necessitated theoretical investigations, also described briefly. A long-standing interest in biological phenomena involving similar clusters of metal atoms became a focused research project in 1992 when the structure of the active site of the enzyme nitrogenase was first reported. Nitrogenase converts unreactive nitrogen N_2 in the atmosphere to the forms required for life, under mild conditions in stark contrast to the harsh conditions of industrial of ammonia fertiliser production. The key question was, and is, 'how can the enzyme catalyse this difficult reaction, when all best human efforts are incomparable?' The active site of the mild enzymatic chemical catalysis is an iron-molybdenum-sulfide cluster. Experimental investigation of the chemical mechanism is thwarted by a number of factors, and so, theoretical molecular simulations have been used, based on insights from Ian's earlier research. Ian developed a complete mechanism, with 21 steps, for the catalysed conversion of N_2 to ammonia. In 2010 it was reported that nitrogenase containing vanadium instead of molybdenum could reduce carbon monoxide to small hydrocarbons: this unprecedented biological reaction is comparable with the industrial process producing most of the diesel fuel in South Africa and other countries. Ian has just published a mechanistic basis for this new enzymatic catalysis.

2011 Hannan Medal in the mathematical sciences

recognises research in any of the fields of statistical science, pure mathematics, applied mathematics and computational mathematics and is made in one of those three areas in turn at two-yearly intervals. It honours the contribution to time series analysis of the late Professor E J Hannan FAA. In 2011, the Hannan Medal is awarded for research in applied mathematics and computational mathematics.

Professor Colin Rogers FAA

Emeritus Professor and Visiting Professorial Fellow, University of New South Wales

Professor Rogers received his BA in mathematics from the University of Oxford in 1963 and his PhD in continuum mechanics from the University of Nottingham in 1969. In 1991 he was awarded a DSc from the University of Nottingham for his research in applied mathematics. Colin is a Fellow of the Institute of Physics, UK and the Australian Academy of Science. He was a professor of applied mathematics at the University of Waterloo 1981–88 and held the chair of mathematical engineering at Loughborough University of Technology, 1988–92. He held a chair of applied mathematics at the University of New South Wales (1992–2006) where he was head of the Department of Applied Mathematics for a substantial period. He has held visiting professorships at many institutions worldwide including inter alia the University of Cambridge, Universita di Roma, Georgia Institute of Technology and the Universita di Bologna. Colin has made major contributions in the detection of hidden invariance and symmetry properties in nonlinear mathematical systems descriptive of complex physical processes. He is recognised as a leading world authority on Bäcklund and reciprocal type transformations and has demonstrated their extensive application in nonlinear continuum mechanics in such diverse areas as elasticity, magnetogasdynamics liquid crystal and soliton theory.

Only connect: a nonlinear journey

Invariance, symmetry and geometric structure underlying physical systems play an important role in our understanding of complex processes in Nature. Remarkable links exist between the classical geometry of surfaces and the analysis of the propagation and nonlinear interaction of waves known as solitons which arise in a wide range of physical contexts, notably in oceanography and optical transmission devices.

Eisenhart, in the preface to his celebrated monograph Transformations of Surfaces, published in 1922 asserted that, 'During the past twenty-five years many of the advances in differential geometry of surfaces in euclidean space have had to do with transformations of surfaces of a given type into surfaces of the same type.'

Prominent among these are transformations which leave invariant systems descriptive of classes of surfaces associated with nonlinear equations which model solitonic phenomena. Superposition principles associated with these transformations describe the complex nonlinear interaction of such solitons. Here, a non-technical overview is presented of geometric links revealing hidden solitonic structure in hydrodynamics, magnetohydrodynamics and liquid crystal theory. In the latter case geometries have been isolated analytically which replicate those observed in classical experiments by Friedel and subsequently elaborated upon by Bragg.

2011 Jaeger Medal for research into Earth sciences

recognises the contribution of Professor John Conrad Jaeger FAA FRS to Australian Earth science. The award is made to a scientist for investigations of a high order into the solid Earth or its oceans carried out in Australia or having some connection with Australian Earth science.

Professor Ian Jackson

Research School of Earth Sciences, Australian National University

Professor Ian Jackson's research has centred on laboratory study of the physical properties of geological and analogue materials under conditions simulating those of the Earth's deep interior. This has involved the intensive development of novel methods for the measurement and analysis of elastic and near-elastic behaviour related to the speeds and attenuation of earthquake waves. Such laboratory-based insights find application in the interpretation of seismological models for the Earth's internal structure in terms of temperature and chemical composition.

Ian trained in physics and geophysics at the University of Queensland and the Australian National University, with subsequent post-doctoral experience at the California Institute of Technology. His research since 1978 in the ANU's Research School of Earth Sciences has focused 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 of the Australian Academy of Science, and elected in 2003 to Fellowship of the American Geophysical Union.

Laboratory calibration of the seismological probe of the Earth's internal structure

Analysis of the travel times of elastic waves radiated by earthquakes yields models of the spatial variations of the speeds of compressional (cf sound) and shear waves – 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 through which the waves travel and the prevailing environmental conditions, for example, of pressure and temperature. 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, results in strain-energy dissipation and reduced wave speeds at sufficiently low frequencies, placing a premium upon laboratory measurements of rock properties at seismic frequencies (mHz – Hz). Our ANU Rock Physics laboratory has responded to that challenge by progressively developing laboratory equipment with which it is uniquely possible to determine the shear modulus (or rigidity, and hence shear wave speed) and associated strain-energy dissipation at low strain amplitudes and seismic frequencies, from torsional forced-oscillation measurements under conditions of simultaneously high pressure and temperature. Application of these techniques to olivine ([Mg,Fe]2SiO4)-rich rocks representative of the Earth's upper mantle is providing new insight into the frequency and grain-size dependence of the shear-wave speed and associated attenuation, and the effects of partial melting and prior/ongoing deformation.

2011 Fenner Medal for research in biology

recognises outstanding contributions to science by Professor Frank Fenner AC CMG MBE MD FAA FRS. Its purpose is to recognise distinguished research in biology, excluding the biomedical sciences.

Associate Professor Bryan Fry

School of Biological Sciences, University of Queensland

Associate Professor Bryan Fry completed his PhD at the University of Queensland. His research focused on the unique venom of the inland taipan, the world's most potently toxic snake, isolating and characterising unique toxic forms of natriuretic peptides in the venom that were more active and longer lasting than the normal version from which they evolved. The compounds were patented for use in the treatment of congestive heart failure. This work was followed by two years of postdoctoral research at the National University of Singapore on unique Asian snake venoms. Bryan returned to Australia to the University of Melbourne on an ARC postdoctoral fellowship to investigate rear-fanged snake venoms, and was then awarded a QEII Fellowship to develop a general theory of venom evolution. In the last ARC round, he was awarded an ARC Future Fellowship to look at the molecular adaptations to subzero water temperatures of the unique Antarctic octopus venoms.

Venom breathing dragons

The predatory ecology of the iconic komodo dragon has been a subject of long-standing interest and considerable conjecture. We investigated the roles and potential interplay between cranial mechanics, toxic bacteria, and venom. Our analyses pointed to the presence of a sophisticated combined-arsenal killing apparatus. We find that the lightweight skull is relatively poorly adapted to generate high bite forces but better adapted to resist high pulling loads. We reject the popular notion regarding toxic bacteria utilization. Instead, we demonstrate that the effects of deep wounds inflicted are potentiated through venom with toxic activities including anticoagulation and shock induction. Anatomical comparisons of the komodo dragon with the seven meter extinct Australian giant *Megalania* fossils reveals that the closely related extinct giant was the largest venomous animal to have ever lived.

2011 Ruth Stephens Gani Medal for research in human genetics

recognises distinguished research in human genetics, including clinical, molecular, population and epidemiological genetics and cytogenetics. Its purpose is to honour the contributions to science in human cytogenetics by the late Ruth Stephens Gani.

Dr Alicia Oshlack

Senior Research Officer, Bioinformatics Division, Walter and Eliza Hall Institute of Medical Research

Dr Alicia Oshlack studies gene regulation using high throughput genomic technologies where expression from tens of thousands of genes can be detected simultaneously. She has made major advances in understanding human evolution and the biology of human genomes by comparing changes in gene expression levels between humans and apes. She has developed methodology specifically for gene expression analysis that can be applied to many aspects of human biology and medical genetics. She is pioneering analysis of new DNA sequencing technology for studying gene expression.

Alicia is the Head of Bioinformatics at the Murdoch Childrens Research Institute. She completed a PhD in Astrophysics in 2003 and then made the dramatic change of discipline by joining the Bioinformatics Division at the Walter and Eliza Hall Institute under the guidance of Professor Gordon Smyth and Professor Terry Speed. She has pioneered work in analysis methodology for high-throughput genetic technologies with specific application to human evolution and medical research. Recently, she has been at the forefront of methodological research for new DNA sequencing technologies. She is a member of the editorial board of Genome Biology and an associate editor of BMC Bioinformatics.

New genetic technologies and the evolution of gene expression in humans

High-throughput genetic technologies are revolutionizing biology and medicine. It is now feasible for individual labs to sequence the DNA of entire genomes rapidly and at a tiny fraction of the cost of only 5 years ago. This is giving unprecedented amounts of information about individual genomes and their functions. However, there is a pronounced gap between data generation and meaningful biological interpretation of the information. This research works to fill in the space between the technology and biology using statistical and quantitative analysis to make meaning from the data deluge. By using statistical modelling techniques combined with specific knowledge of the difference in genomes between humans and their closest evolutionary relatives – apes, it was possible to study the evolution of gene expression on a genome-wide scale. The expression of transcription factors, genes that are responsible for regulating many other genes, have been found to evolve rapidly in humans suggesting a mechanism for many of the observed differences between primates.

2011 Gottschalk Medal for research in the medical sciences

The Gottschalk medal recognises outstanding research in the medical sciences. Its purpose is to honour the contributions to science by the late Dr A Gottschalk FAA.

Dr Stuart Tangye

NHMRC Senior Research Fellow, Group Leader, Principal Research Fellow, Immunology Program, Garvan Institute of Medical Research

During the past 15 years Dr Stuart Tangye has firmly established himself as one of Australia's preeminent medical scientists working in human immunology. His international reputation is based on contributions made to investigating the roles played by various white blood cell populations in health and disease. Of particular note in the former situation is his research on differentiation and effector function of T follicular helper cells, NK cells and B cells in normal subjects. Delineation of the underlying regulation of these distinct cell types formed the basis for his equally important work on the cellular and molecular defects associated with the inherited primary immunodeficiency states like X-linked lymphoproliferative disease and hyper-IgE syndrome which are characterised by exquisite sensitivity to infection with EBV and staphylococcus/candida respectively and defective antibody responses. In the future this work has the potential to underpin improvements in vaccine efficacy and targeted treatment of autoimmune and immunodeficiency disorders.

The impact of gene mutations on the function of human lymphocytes

Cell fate decisions are regulated by signals delivered through a variety of cell surface receptors.

Engagement of these receptors activate specific signal transduction pathways, resulting in expression of a suite of genes that mediate the differentiation process. However, the exact role(s) of particular receptors and their associated signalling pathways in human lymphocyte behaviour remains incompletely defined. Furthermore, it remains to be determined which pathways have physiological roles in vivo and which are redundant for lymphocyte function. Approximately 200 primary immunodeficiencies (PID) have been characterised and the causative gene mutation has been identified in ~140 of these conditions. Studies of such 'experiments of nature' have revealed critical and non-redundant roles of particular soluble and cell surface molecules, intracellular signaling pathways and/or transcription factors in the development, differentiation and function of human lymphocytes.

We have taken advantage of PIDs to identify critical regulators of human lymphocyte development and function. The PIDs we have investigated are characterised by impaired antibody responses and susceptibility to infection with specific pathogens due to mutations in the immunological genes SH2D1A, STAT3, DOCK8, STAT1, BTK and IL2RG. These analyses have allowed us to elucidate non-redundant roles for specific genes in human lymphocyte differentiation and determine intrinsic versus extrinsic defects in lymphocyte function in these different conditions. Most importantly, these studies have shed substantial light on the mechanisms underlying compromised immunity in PIDs, and this may result in improved therapies for individuals affected by such genetic mutations.

2010 Gottschalk Medal for research in the medical sciences

Professor James Whisstock

ARC Federation Fellow, The ARC Centre of Excellence in Structural and Functional Microbial Genomics, and Department of Biochemistry and Molecular Biology, Monash University

Professor James Whisstock studies how our bodies combat infection by bacteria and viruses. He has shown that an important family of human immunity proteins that eliminate cells infected with virus or pre-cancerous cells are related to toxins known to be used by bacteria to destroy human tissue. James's work may one day help develop new ways to control the unwanted activity of immune proteins in transplant rejection and diabetes.

James is an Australian Research Council Federation Fellow, leader of the NHMRC Program on protease systems biology and member of the ARC Centre of Excellence in Structural and Functional Microbial Genomics. James, and his team, uses protein crystallography and molecular genetics to understand the structure, function and biology of proteins that function in infection, immunity, development and cancer. James was awarded the 2006 Science Ministers prize for life scientist of the year and the 2008 Commonwealth Health Ministers award for excellence in Health and Medical Research.

A molecular arms race – membrane attack complex/perforin-like proteins in infection and immunity

A central role of mammalian immunity is to defend against attack by infectious organisms such as bacteria and to destroy cells that are infected with viruses. A key weapon in the armory of the mammalian immune system are an unusual family of pore forming toxins, the membrane attack complex / perforin (MACPF)-like superfamily. This unusual group of molecules was originally discovered in 1898 by the Belgium immunologist Jules Bordet. However, the molecular mechanism by which MACPF molecules function to form pores has, until recently, remained obscure.

We determined the first atomic structure of an MACPF protein (Rosado et al Science, 2007) as well as the structure of the pore form (Law et al, Nature, 2010). Together, these data revealed the surprising finding that MACPF proteins are structurally related to an ancient and lethal family of bacterial pore forming toxins, the cholesterol dependent cytolysins (CDCs). Despite this evolutionary link, our structural and molecular data reveal striking differences in how these molecules assemble to form pores. Taken together these data suggest approaches to control unwanted MACPF function in immune driven diseases such as transplant rejection.

2011 Anton Hales Medal for research in earth sciences

recognises research in the Earth sciences and honours the contributions to the Earth sciences by the late Professor Anton L Hales FAA. Professor Hales was the founding director of the Research School of Earth Sciences in the Australian National University.

Professor Craig Simmons

Professor of Hydrogeology, Director, National Centre for Groundwater Research and Training, Flinders University

Professor Craig Simmons is Director of the National Centre for Groundwater Research and Training, a Co-Funded Centre of Excellence of the Australian Research Council and National Water Commission. He is one of Australia's foremost groundwater academics and is an international expert in hydrogeology, recognised for his contributions to variable density groundwater flow phenomena – where the movement of groundwater is intimately affected by changes in its salinity and temperature, and hence its density. He was involved in pioneering work which first detected density driven convection in a field based groundwater system, developed innovative laboratory equipment for the visualisation of dense plume migration and has contributed to major theoretical advances on how geologic heterogeneity controls dense plume migration. His work continues to transform the discipline of hydrogeology.

Craig has published more than 200 scientific articles, including over 70 papers in leading international peer reviewed journals. As a highly distinguished groundwater scholar and widely recognised research leader, Professor Simmons' research and academic excellence has been recognised by numerous prestigious national and international research awards and he has served as editor and associate editor for *Journal of Hydrology*, *Hydrogeology Journal*, *Ground Water* and *Water Resources Research*.

Variable-density groundwater flow: approaches, challenges and resolutions

Groundwater is often called the forgotten resource. It lies beneath our feet and supplies wells, bores, springs and flow to our rivers. One-third of the world's population is dependent on groundwater. Groundwater flow beneath the Earth is often more complicated than we can ever imagine. For example, variable-density groundwater flow phenomena can occur where changes to the salinity and temperature of groundwater affect its density and profoundly alter groundwater dynamics and behaviour.

Over the last decade or two, there has been an explosion in the field of variable-density flow because of worldwide concern about the future of energy and water resources and environmental pollution. Applications in groundwater hydrology include seawater intrusion in coastal aquifers, dense contaminant plume migration beneath landfills, heat and fluid flow in geothermal systems, groundwater dynamics beneath salt lakes and flow and transport processes in high level radioactive waste disposal sites.

This presentation will discuss the importance of variable-density flow phenomena, the evolution of this field of research from early developments in classical fluid mechanics through to applications in groundwater hydrology and some of the important research challenges in this field of research. It will describe some of Professor Simmons' key contributions to this scientific discipline. These include, advances in our understanding of computer modelling used to solve variable-density flow problems, pioneering work which first detected density driven convection in a field based groundwater system, the development of innovative laboratory equipment for the visualisation of dense plume migration, and major theoretical advances on how geologic heterogeneity controls dense plume migration.

Inaugural Christopher Heyde Medal for research in pure mathematics

The Christopher Heyde Medal honours the contributions to mathematics by Professor Christopher Charles Heyde AM FAA FASSA. In recognition of Professor Heyde's broad interests in the mathematical sciences the award is offered in one of three fields on a rotating basis – pure mathematics; applied, computational and financial mathematics; and probability theory, statistical methodology and their applications. The 2011 Christopher Heyde Medal is for research in pure mathematics.

Dr Anthony Henderson

Senior Lecturer, School of Mathematics and Statistics, University of Sydney

Dr Anthony Henderson has made fundamental contributions in representation theory, an area which concerns the algebraic patterns underlying collections of geometric transformations. Anthony has invented geometric spaces which give new

information about common symmetry types, and has introduced new methods for performing calculations in existing geometric spaces which take their symmetry into account. His work combines ideas from different areas of mathematics, and provides explicit formulae for use in a wide range of problems which involve observations on spaces with symmetry.

Anthony was interested in mathematics from a young age, and represented Australia three times in the high-school International Mathematics Olympiad. His undergraduate study at the University of Sydney culminated in his winning the Convocation Medal. He then moved to America to do his PhD thesis at the Massachusetts Institute of Technology, specialising in the field of pure mathematics known as representation theory. Since graduating in 2001, he has worked at the University of Sydney as a postdoctoral researcher, lecturer, and now senior lecturer. He won a Faculty of Science Citation for Excellence in Teaching in 2009, and has active research collaborations with mathematicians in Australia, USA, France, and Japan. Aside from mathematics, his interests include classical music, cricket, and cryptic crosswords.

Excedances and descents

Imagine a street running West–East with n houses along one side, whose inhabitants decide to exchange houses in such a way that no-one stays where they lived before. How many households move to the East? Of course, this depends on what permutation of houses they use, so a better question is how many such permutations result in 1 household moving to the East, how many result in 2, in 3, and so on. There is a symmetry here: the number where k move to the East is the same as the number where k move to the West, which is the same as the number where n-k move to the East. It is also not hard to show that the distribution is unimodal, meaning that the number of such permutations where k move to the East increases as k increases up to n/2 and then decreases again. Somewhat surprisingly, if you allow permutations where some households don't move, the distribution is still symmetric and unimodal but with a different centre of symmetry: the number of permutations where k move to the East equals the number where n-1-k move to the East. It turns out that you get exactly the same distribution if, instead of counting how many households move East, you count how many pairs of neighbouring households cross over when they move. A recent paper of mine, joint with Michelle Wachs, explains what happens to the unimodality when you consider both measures of a permutation at once.

2011 Dorothy Hill Award for research in the Earth sciences

recognises research by women in the Earth sciences including reef science, ocean drilling, marine science and taxonomy, and honours the contribution to the field of Earth science by the late Professor Dorothy Hill FAA and her work in opening up tertiary science education to women.

Dr Kirsten Benkendorff

Lecturer, School of Environmental Science and Management, Southern Cross University

Dr Kirsten Benkendorff is an acclaimed Australian malacologist whose research contributions span from the molecular to the ecosystem scales of marine biology and ecology. Her research approach involves applying sound experimental design, along with the tools of immunology and natural products chemistry to investigate molluscan evolutionary adaptations, thus providing new leads for the development of novel bioresources. Through this approach, she has made significant advances across a range of research disciplines that can be grouped under the themes of environmental, aquaculture and human health.

Kirsten graduated with an interdisciplinary PhD in biological sciences and chemistry from the University of Wollongong in 1999. She received the 2000 Young Australian of the Year Award in Science and Technology for her discovery of a novel antibiotic from a local marine snail. She then undertook an Australian Postdoctoral Fellowship before accepting a lectureship at Flinders University in 2003. She was promoted to senior lecturer in 2006, then moved to Southern Cross University to commence a new lectureship in 2010. She manages a productive research laboratory focused on molluscan biodiversity and bioresources and has attracted over $1.5 mill in research funding over the last 5 years. She has published 44 peer reviewed journal articles and three invited book chapters.

Molluscan bioresources: applications in monitoring environmental health, disease resistance and human medicine.

The phylum Mollusca (snails, slugs, oysters, octopus etc) represents an enormous diversity of species that are often under-appreciated as human resources. My

research reveals that molluscs are not only valuable as indicators of environmental health, but they also produce secondary metabolites with potential applications in human medicine. As soft-bodied, slow moving ectothermic invertebrates, molluscs are highly susceptible to changes in their environment, such as ocean warming, acidification and desalination discharge. They also lack acquired immunity and thus rely on innate antibacterial and antiviral factors to defend themselves against the constant onslaught of pathogens in the sea. Using a complementary set of immune assays, my laboratory has demonstrated that antimicrobial defenses are significantly impacted by environmental stressors. These studies provide an important insight into the increasing global frequency of disease epidemics in molluscan populations.

The secondary metabolites produced by molluscs as part of their innate immunity are also active against human pathogens and diseases. Whilst a range of alternative medicines are derived from molluscs, there is little data to substantiate their application. A good example is the Murex homeopathic remedy, used to treat a range of women's problems, including uterine cancer. No evidence was found for anticancer activity in the Murex remedy, although the source molluscs do produce bioactive brominated indoles, with anticancer activity. My laboratory has developed an optimised extract from this mollusc, which is undergoing preclinical trials and appears to prevent tumor formation in a rodent model for colorectal cancer. This holds good promise for the future development of novel scientifically substantiated alternative medicines from marine molluscs.

2011 Moran Medal for research in statistics

The Moran Medal recognises outstanding research by scientists in one or more of the fields of applied probability, biometrics, mathematical genetics, psychometrics and statistics. Its purpose is to honour the contributions to science of the late PAP Moran FAA. The 2011 Moran Medal is awarded jointly.

Dr Scott Sisson and Dr Mark Tanaka – University of New South Wales

Dr Scott Sisson

ARC Queen Elizabeth II Research Fellow, School of Mathematics and Statistics, University of New South Wales

Dr Scott Sisson has made highly significant contributions to computational statistics and extreme value modelling. His research in approximate Bayesian computation has enabled researchers at the leading-edge of many scientific disciplines to examine realistic models and hypotheses, rather than be forced to use simpler, less credible alternatives. His research on extreme value modelling has enabled improved inferential procedures and highlighted the dangers of poor statistical modelling. In applying these techniques to challenging problems in other disciplines, Scott has had a very positive impact on furthering scientific research in a wide range of applications. Scott is a QEII Fellow (ARC) and senior lecturer at the University of New South Wales' School of Mathematics and Statistics. He gained his PhD from the University of Bristol and his BSc and MSc degrees from Lancaster University in the United Kingdom (UK). He works in the areas of Bayesian and computational statistics, and is focused on developing improved methods for statistical inference in challenging contemporary applications. His applied work spans many disciplines, although he has a particular interest in genetics and climate extremes. Dr. Sisson is currently president of the Australasian Society of Bayesian Analysis and chairs the Bayesian Statistics Section of the Statistical Society of Australia. He is an associate editor for three academic journals and sits on the research section committee of the Royal Statistical Society UK.

Dr Mark Tanaka

Senior Lecturer & ARC Queen Elizabeth II Fellow, School of Biotechnology & Biomolecular Sciences, University of New South Wales

Dr Mark Tanaka's research concerns the evolution and population biology of microorganisms. He uses mathematical and statistical methods to study the dynamics of bacteria and viruses. A particular focus of his research is the transmission patterns of infectious diseases. He has investigated key parameters in the epidemiology of tuberculosis in published research which has led to conclusions with public health policy implications that were hitherto unavailable. Tanaka's research is highly original and excellent, judged by the highest international standards. Mark is a QEII Fellow (ARC) and senior lecturer at the University of New South Wales' School of Biotechnology and Biomolecular Sciences. His research

concerns the evolution and population biology of microorganisms; he uses mathematical and statistical methods to study the dynamics of bacteria and viruses. A particular focus of Dr Tanaka's research is the study of epidemiology of pathogens such as the bacterium causing tuberculosis, through statistical analysis of genetic data. His PhD, from Stanford University, is in mathematical biology and his BSc(Hons), from the University of Sydney, is in genetics. He was a postdoctoral researcher at Emory University in the USA, before joining UNSW as a lecturer in 2002. He is an associate editor of PLoS Computational Biology.

Advancing model-based statistical inference for contemporary scientific research

Modern scientific research is asking increasingly sophisticated questions about complex systems, particularly in biological disciplines. As large amounts of data become available, such as in the growing field of genomics, it will become more important than ever to understand underlying processes generating them. One way to achieve this is through robust model-based inference; however this often produces severe statistical and computational challenges. We describe the importance of model-based approaches in interdisciplinary research, with particular illustration through the population genetics of pathogens. For example, development of new models and methods have enabled a better understanding of the epidemiological properties of pathogens such as Mycobacterium tuberculosis. The transmission rates and relative success of drug-resistant strains can be characterised using model-based inference. We then discuss how the frontier of statistical modelling and computation is forced to advance to keep pace with the questions raised by contemporary scientific enquiry. These considerations have prompted the development of new computational methods to estimate parameters within a Bayesian framework, allowing inference from data in conjunction with complex models of biological or other phenomena.

2011 Pawsey Medal for research in physics

The Pawsey Medal recognises outstanding research in physics. Its purpose is to honour the contributions to science in Australia by the late Dr JL Pawsey FAA.

Professor Bryan Gaensler

ARC Federation Fellow and Professor of Physics, School of Physics, University of Sydney

Dr Bryan Gaensler is an Australian Laureate Fellow at The University of Sydney, and is Director of the newly-established ARC Centre of Excellence for All-sky Astrophysics (CAASTRO). His pioneering research on cosmic magnetism, the search for transient radio signals, and the demography of black holes and neutron stars in the Milky Way have opened a new window on the universe. Bryan has derived detailed three-dimensional maps of large-scale magnetic fields throughout the cosmos, and is now using these results to understand what has created and sustained cosmic magnets over billions of years of the Universe's evolution.

Brian received his PhD from The University of Sydney in 1998, and subsequently held positions as a NASA Hubble Fellow at MIT (1998–2001), the Clay Fellow at the Smithsonian Insitution (2001–02), assistant / associate professor at Harvard University (2002–06), and ARC Federation Fellow at The University of Sydney (2006–11). He was the 1999 Young Australian of the Year, gave the 2001 Australia Day Address to the nation, and was named a 2008 Young Tall Poppy. He has published more than 180 papers in refereed journals, and is Editor-in-Chief of Publications of the Astronomical Society of Australia, Australia's highest impact non-medical journal.

Magnets in the sky

Planets, stars, gas clouds, and even entire galaxies are all magnetised. Furthermore, these magnetic fields typically do not have a random, tangled, morphology, but are surprisingly organized and coherent. However, the processes that create and then sustain this large scale magnetism are not yet understood, mainly because magnetic fields are not directly observable even through our most powerful telescopes. I will describe innovative new studies of radio polarisation and Faraday rotation that have overcome these longstanding challenges. These data reveal stunning new views of the magnetic structure of astronomical turbulence, interstellar gas clouds and the overall Milky Way. These experiments pave the way to the opening of the full magnetic Universe with the next generation of radio telescopes, culminating in the Square Kilometre Array.

2010 Pawsey Medal for research in physics

Professor Andrew White

ARC Federation Fellow, School of Mathematics and Physics, University of Queensland

Professor Andrew White is an Australian Research Council Federation Fellow, 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. Andrew, and his team, is 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 optics – the study of the quantum nature of light – provides a technological platform for quantum computing in which the individual quantum bits of information are carried by single photons. Andrew White is a pioneer in the experimental development of the quantum optical approach to quantum computing. He performed the first unambiguous experimental demonstration of an entangling quantum-logic gate with photons in 2003.

Quantum biology, chemistry, maths and physics

Quantum information is the lovechild of quantum physics and computer science. In this talk we 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 than 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 H_2, 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.

Program Friday 6 May

Annual symposium
Australia 2050: population challenges to sustainability

Morning session

Chair, Professor Suzanne Cory AC PresAA FRS

8.40am *Opening remarks*
Professor Suzanne Cory AC PresAA FRS

8.50am **OFFICIAL OPENING OF SYMPOSIUM**

Getting the politics right on population: engaging the political mind on long term factors
The Hon Dr Barry Jones AO FAA FTSE
University of Melbourne

9.10am *Hard choices and tomorrow's Australia*
Professor Lord Robert May of Oxford OM AC FAA FRS
University of Oxford

9.50am *Australia's contemporary population growth and the outlook: challenges and opportunities*
Professor Graeme Hugo
University of Adelaide

10.20am **MORNING TEA**

10.50am *Is continued economic prosperity in Australia dependent on significant population growth?*
Simon McKeon
Chair, CSIRO Board
(Australian of the year 2011)

11.25am *Decarbonising the built environment: can our cities accommodate an increasing population while reducing their carbon footprint?*
Vanessa Rauland
Curtin University

11.45am *Population growth in our cities: is there a tipping point for health and infrastructure?*
Professor Robyn Norton
The George Institute for Global Health

12.10pm *Determining an optimum, sustainable population for Australia*
Professor Tim Flannery
Macquarie University

12.45pm **LUNCH**

Afternoon session

Chair, Professor Jenny Graves AO FAA

1.45pm *The relationship between Australia's water and her sustainability*
Dr Tom Hatton
Director, Wealth from Oceans Flagship CSIRO

2.15pm *Thirsty people and less water: can we sustain the freshwater environment?*
Dr Alison King
Arthur Rylah Institute
for Environmental Research

2.35pm *Australian agriculture and the challenge of population growth*
Dr Tony Fischer
CSIRO Plant Industry

3.05pm **AFTERNOON TEA**

3.30pm *Global family planning for our future*
Maria Deveson Crabbe
CEO, Marie Stopes International Australia

4.00pm *The demographic storm – direct and indirect implications for human health*
Professor Sir Peter Gluckman FRS
Chief Scientist of New Zealand

4.45pm **CONCLUSION AND CLOSE OF MEETING**

Closing remarks
Professor Roger Short AM FAA FRS
University of Melbourne

Social program

9.45am – 3.30pm
- Calthorpe's House
- Royal Australian Mint
- Podfood

Australia 2050: population challenges to sustainability

Official opening of the symposium

Dr Barry Jones

University of Melbourne

The Hon Dr Barry Owen Jones AO FAA FAHA FTSE FASSA is one of Australia's living treasures as well as a writer, broadcaster and former Labor politician. His career has spanned education, film, politics, civil liberties, constitutional change and 'the knowledge society'.

Barry represented the federal seat of Lalor (1977–98), in the Hawke Government became Australia's longest serving Science Minister (1983–90). He twice served as National President of the Australian Labor Party. In 1985 Barry became the only Australian Minister invited to address a Summit meeting of the 'Group of Seven' northern industrial powers, in Ottawa. In 1987 he chaired OECD's review of the Yugoslavian economy. In June 1990 he was part of an international think tank invited to investigate 'perestroika' in the USSR and make recommendations to Mikhail Gorbachev. He was a member of the Executive Board of UNESCO in Paris 1991–95, vice president, World Heritage Committee 1995–96 and a consultant for OECD.

His books include *Macmillan dictionary of biography* 1981, *Sleepers wake! Technology and the future of work* 1982, *Living by our wits* 1986, *Barry Jones' dictionary of world biography* 1994, 1996, 1998. His autobiography, *A thinking reed*, was published in October 2006. Barry currently serves on the boards of CARE Australia, the Burnet Institute, Montsalvat Ltd and Victorian Opera. He chairs Vision 2020 Australia and the Port Arthur Historic Site Management Authority, is currently a Professorial Fellow at the University of Melbourne and is a Fellow of all four Australian learned Academies.

Getting the politics right on population: engaging the political mind on long term factors

Australia, as Bob Carr reminds us, is not North America but North Africa, where population is overwhelmingly in a coastal strip. Australia's population footprint has severely damaged the environment, compounded by serious deforestation since the 19th Century, a robust tradition of 'wreck and move on' because land was cheap, and our urban tradition where huge cities consume fuel at almost Texan levels. Environmental damage is not determined by numbers alone but population factored by per capita resource use, expressed in a formula proposed by CSIRO, *I= PLOT* in which *I* stands for *Impact*, *P* for *population*, *L* for *life-style*, *O* for *organisation*, *T* for *technology*. If Australian population is to rise significantly, then we have to give something up – urban sprawl, cars, even diet. The United Kingdom supports 62,000,000 people in an area 30 per cent of the size of New South Wales, demonstrating far more successful spatial management than Australia. Unique problems of soil, water, extremes of flood and drought, are compounded by climate change, which require deep serious national debate – and a high quality of national leadership to avoid short-term panicky over-reactions. Our universities and Academies must play leadership roles too, 'telling truth to power'.

Symposium speakers

Professor Lord May of Oxford

University of Oxford

Robert McCredie May, Lord May of Oxford OM AC FAA FRS, holds a professorship at Oxford University and is a Fellow of Merton College, Oxford. Robert was president of The Royal Society (2000–05), and before that chief scientific adviser to the UK Government and head of the UK Office of Science and Technology (1995–2000). His career includes a personal chair in physics at Sydney University aged 33, class of 1877 professor of zoology at Princeton, and in 1988 a move to Britain as Royal Society research professor. Robert's particular interests include how dynamical systems are structured and respond to change, particularly with respect to infectious diseases and biodiversity. His

honours include the Royal Swedish Academy's Crafoord Prize, the Swiss-Italian Balzan Prize, the Japanese Blue Planet Prize, and the Royal Society's Copley Medal, its oldest (1731) and most prestigious award.

Hard choices and tomorrow's Australia

In both developed and developing worlds, humans on average live longer and healthier lives, with more energy subsidies and food per person than in earlier times. All this results from our ever-increasing understanding of how the natural world works. But increasingly we are finding that our well-intentioned applications of that understanding are having unintended adverse effects. This talk will briefly survey some of the consequent challenges that confront us. These include: still increasing human numbers, mainly in dense urban aggregates (whose slums differ in many important ways from those of the West's 19th century industrialisation); the emergence of new diseases (witness HIV/AIDS); rising demands for water (estimated to exceed sustainable supplies around 2050); how to manage increasing demands for energy, when today's input of greenhouse gases into atmosphere are already changing the global climate in serious ways; and, looking beyond our own species, the sixth great wave of mass extinctions which seems likely to unfold over the next few centuries. Most of these problems are particularly evident in Australia. This talk – which will combine a survey of global trends with an Australian focus – will document the above claims, and the effective actions we should be taking to address the threats.

Professor Graeme Hugo

University of Adelaide

Professor Graeme Hugo is ARC Australian Professorial Fellow, Professor of the Department of Geographical and Environmental Studies and Director of the National Centre for Social Applications of Geographic Information Systems at the University of Adelaide. His research interests are in population issues in Australia and South East Asia, especially migration. He is the author of over three hundred books, articles in scholarly journals and chapters in books, as well as a large number of conference papers and reports. In 2002 he secured an ARC Federation Fellowship over five years for his research project, 'The new paradigm of international migration to and from Australia: dimensions, causes and implications'. His recent research has focused on migration and development, environment and migration, and migration policy. In 2009 he was awarded an ARC Australian Professorial Fellowship over five years for his research project 'Circular migration in Asia, the Pacific and Australia: empirical, theoretical and policy dimensions'.

Australia's contemporary population growth and the outlook, challenges and opportunities

Australia's population is growing faster than at any time since the 1960s. This presentation analyses the processes behind this growth and assesses the outlook for Australian population growth over the next thirty years. This presents the nation with both challenges and opportunities. On the one hand, growth in the number of jobs outpacing the net growth in the local workforce and the passage of the baby boom bulge into retirement means there is a need for some population growth. On the other hand, the environment and the impending impacts of climate change place constraints on expansion. Careful balancing of those considerations is essential to meeting national sustainability, prosperity and equity goals. Australia needs to develop a vision and policy toward its future population which is soundly based on an integration of the best physical and social science knowledge and is inclusive of the interests of all Australians.

Simon McKeon

CSIRO Chair, CSIRO Board

Simon McKeon is the 2011 Australian of the Year. He is also Executive Chairman of Macquarie Group's Melbourne office. Simon is Chairman of the Board of CSIRO and of Business for Millennium Development. Simon is a director of VisionFund, World Vision International's microcredit arm, Global Poverty Project and Red Dust Role Models. He is an Australia Day ambassador for the Victorian Government and serves on the Federal Government's Human Rights Grants Scheme advisory panel. He previously served as founding president of the Federal Government's Australian Takeovers Panel, founding chairman of MS Research Australia and founding president of the Federal Government's Point Nepean Community Trust. Simon is the helmsman of Macquarie Innovation which in March 2009 became the first sailboat in the world to sustain more than 50 knots and in so doing, peaked at a speed of 100 km/h (54 knots). He is also a Patron of the Australian Olympic Sailing Team which

won two gold and a silver medal at the 2008 Beijing Olympics.

Is continued economic prosperity in Australia dependent on significant population growth?

There is often a call for population growth on the basis that this leads to overall economic growth for the nation. The case usually rests there. Surely, however, the ultimate benchmark ought to be the quality of life and wellbeing of the nation's inhabitants, both collectively and individually. The debate about the relationship between economic prosperity and population growth has been explored by economists, ecologists and other scientists for at least 200 years. This work has made important contributions to our understanding on some key dynamics. Simon's talk will explore the prosperity / population relationship in the context of a contemporary Australia.

Vanessa Rauland

Curtin University

Vanessa Rauland is a project coordinator at Curtin University Sustainability Policy Institute (CUSP) currently working on an ARC funded Linkage Project titled 'Decarbonising cities and regions'. She is also undertaking her PhD as part of the project in the area of carbon neutral land development. She has a BA in nature tourism from La Trobe University and a MSc in environment and resource management from the Vrije Universiteit in Amsterdam, with specialisations in energy and carbon management as it relates to policy. She is particularly interested in the built environment, energy efficiency, renewable energy and emissions trading and how these areas can help to address climate change.

Decarbonising the built environment: can our cities accommodate an increasing population while reducing their carbon footprint?

While issues relating to population are incredibly diverse and span a variety of areas including health, immigration, environment and economics, the increasing focus on climate change and the imminent price on carbon raise an important question – can Australia increase its population while decreasing its carbon emissions? This talk addresses the debate from the perspective of the built environment and examines Australia's current infrastructure, the carbon implications associated with it along with the resources needed to sustain this current way of life. It is argued that to answer the above question, it is necessary to examine the opportunities for emission reductions through various new technologies, infrastructure, urban planning and policy options and analyse the effect these could have on Australia's population. Whilst acknowledging the inescapable carbon impact of population growth, the talk discusses how growth can be turned to advantage in transforming our cities and demonstrates how this can help to decarbonise the world.

Professor Robyn Norton

The George Institute for Global Health

Professor Robyn Norton is Principal Director of the George Institute for Global Health, a not-for-profit medical research institute with over 350 staff in offices in Sydney, Beijing, Hyderabad and Oxford. The institute undertakes large-scale clinical, population health and health systems research, working across four major themes: chronic and critical conditions; injury, frailty and disability; health care innovation; and disadvantaged populations. Robyn also holds the positions of Professor of Public Health and Associate Dean (Global Health) within the Sydney Medical School at the University of Sydney, James Martin Professor of Global Health as well as an Honorary Professorship at Peking University Health Science Center. She is an international authority on the causes and prevention of injuries, particularly road traffic injuries. Robyn was the foundation chair and is currently Chair Emeritus of the Road Traffic Injuries Research Network, an initiative supported by the WHO and the World Bank, aimed at increasing research and research capacity to address the current and growing burden of road traffic injuries in low and middle-income countries.

Population growth in our cities: is there a tipping point for health and infrastructure?

On average, urban residents have much better health than rural residents. They have much greater access to essential infrastructure, including water, sanitation and transport systems, better quality housing and greater access to health care services. Consequently, on average, their life expectancies are higher than those living in rural areas. The best available evidence suggests, therefore, that increasing population growth

in our cities will be associated with continuing overall improvements in infrastructure and population health. However, in most countries in the world, it is clear that the benefits of urbanization are not evenly distributed, with health outcomes of the urban poor being even worse than the rural poor. The urban poor are most likely to suffer the triple burden of increased exposure to infectious disease, poorer lifestyles leading to a greater prevalence of chronic disease and greater exposure to injuries and violence. The tipping point for health and infrastructure, associated with population growth in our cities will thus likely emerge if there is a failure to recognise and address these intra-urban inequalities in health.

Professor Tim Flannery

Macquarie University

A paleontologist, mammalogist and explorer, Professor Tim Flannery has published more than 130 peer-reviewed papers and many books including the landmark works *The Future Eaters* and *The Weather Makers*. Currently Panasonic Professor in the Faculty of Science at Macquarie University and Chief Commissioner of the Federal Government's Climate Commission, he serves pro bono on the board of directors of WWF International and the Australian Wildlife Conservancy, and on the Sustainability Advisory Boards of Siemens (Munich) and Tata Power (Mumbai). He spent a year teaching at Harvard in the Department of Organismic and Evolutionary Biology (1998–99) and is a former director of the South Australian Museum (1999–2006). From 2006–09 he was chair of the Copenhagen Climate Council. He was named 2007 Australian of the Year and in 2010 was awarded the Academy of Natural Science Joseph Leidy Medal for research in the natural sciences.

Determining an optimum, sustainable population for Australia

In an era of mass migration, human population and some of its most important effects are global. Yet it is generally the responsibility of nations to develop population policies. With the recent appointment of a Minister for Population, Australia has moved towards the development of an explicit population policy. This offers new opportunities to assess our population growth and its impact. By way of stimulating debate, it is suggested that an effective population policy must have the following characteristics:

1. capacity for Australia to contribute towards population measures through development aid
2. feed-back mechanisms that limit or foster national population growth, depending on how well the nation is coping with that growth.

This must be done through the establishment of clear metrics resulting from population impacts, eg travel times in major cities, water and food security. It will be argued that such a policy approach is only achievable through the establishment of an independent body, akin to the Reserve Bank Board, tasked with setting and revising long-term population targets.

Dr Tom Hatton

Wealth from Oceans Flagship, CSIRO

Dr Tom Hatton is Director of CSIRO's Wealth from Oceans Flagship, delivering science to help Australians access the resources of our oceans in a way that balances economic, social and environmental benefits. Previously, Tom directed the CSIRO Water for a Healthy Country Flagship, which developed into the largest water research effort in Australia. Tom has 30 years of research experience in ecology, bushfire science, eco-hydrology, salinity and catchment hydrology. Tom joined CSIRO in 1988, following a postdoctoral fellowship in mathematics with the University of New South Wales. Tom chairs the Australian Government's 2011 State of Environment Committee and the National Centre for Groundwater Research & Training advisory board. He has previously served on the Conservation Commission of Western Australia, the Premier's Water Foundation and the Western Australia Water Forever Science Panel. For his research leadership on water sustainability, Dr Hatton won the 2008 CSIRO Chairman's Medal and the Australian Public Service Medal.

The relationship between Australia's water and her sustainability

Appreciating Australia's position with respect to water and our future sustainability is a challenging undertaking due to a host of apparent contradictions. Clearly, Australia as a nation could not exist without taking water out of the natural environment and using it for domestic and productive purposes. In doing so,

we use only about 5 per cent of our total renewable freshwater resources, compared to about 20 per cent for the United States and 43 per cent for Italy. On a per capita basis, however, we used more than all OECD countries except New Zealand, Canada and the United States.

Almost every inland ecological system in Australia is either perennially or seasonally water-limited; to permanently abstract water from these systems is to inevitably change their character in some way and degree. Conversely and as a generality, this same water-limited ecology and our highly variable climate makes these systems relatively resilient to small or short-term reductions in water availability. There is no question that diversions of water for productive use have greatly compromised the ecological character of much of the southern half of the continent (the parts where most of us live). In return, Australian agriculture, manufacturing and mining industries add about $1.2 trillion of gross value for the water we use each year.

As demand for water, on already stressed ecosystems, continues to grow, and in the face of serious climate uncertainties, a general strategy has emerged, among water utilities and managers, of developing water security through a mixture of demand management, decreasing reliance on natural fresh water resources, increased development of manufactured water sources and the use of water markets to shift water to higher-value uses. This trend offers the potential to somewhat decouple economic and population growth from pressures on our freshwater environments.

Dr Alison King

Arthur Rylah Institute for Environmental Research

Dr Alison King is a senior research scientist at the Arthur Rylah Institute for Environmental Research in Melbourne. Her major research interest is in the ecology of river systems, with a focus on the reproduction and recruitment of freshwater fish. Alison's research is primarily targeted at developing applied science principles to underpin river restoration and management, particularly around environmental flows. Her expertise is regularly sought for committee's and expert panels undertaking management of aquatic fauna. Alison currently leads a team of researchers investigating the role of flow in the ecology of fish, particularly in the Murray-Darling Basin and south eastern Australia. She has authored more than 25 peer-reviewed publications and numerous technical reports.

Thirsty people and less water: can we sustain the freshwater environment?

Freshwater is an essential resource for all organisms, and provides critical social, economic and biodiversity values for all Australians. Humans have caused profound alterations to Australia's freshwater ecosystems, with many already showing signs of serious decline. An increasing population is likely to place further demands on this finite resource, placing our freshwater ecosystems at further increasing risk. While Australia's aquatic fauna has evolved an amazing resilience to periods of drought, they are adapted to cycles of both flood and drought. Many species require specific flows (eg spring or summer floods) to trigger breeding and enhance survival of their young. Loss of these specific flows and an increase in low flows will most likely favour 'generalist' species over 'specialist' species. This talk will provide examples of what we are currently know about the water requirements of aquatic fauna, particularly native freshwater fish, and what we need to understand to have a chance at sustaining this unique environment for future generations.

Dr Tony Fischer

CSIRO Plant Industry

Dr Tony Fischer grew up on a wheat-sheep farm in the Riverina of NSW, with which he maintained a close link until recently. Tony completed his secondary education in Melbourne, graduating with a BAgric Sci in 1961 and then a masters degree in 1964 from the University of Melbourne. Tony went on to receive a PhD in plant physiology from the University of California (Davis) in 1967. His research interest has always been the physiology, agronomy and genetic improvement of wheat, and has gradually expanded to include the role of crop science in international agricultural development.

Tony has worked for the New South Wales Department of Agriculture, CSIRO, as the director of the wheat program at Centro Internacional de Mejoramiento de Maiz y Trigo – Mexico, and for the Australian Centre for International Agricultural Research. He has been a member of the Board of Trustees of Grains Research and Development Corporation (GRDC, Canberra), the International Centre for Agricultural Research in Dry

Areas (ICARDA, Syria), and the International Rice Research Institute (IRRI).

He is currently an honorary research fellow at CSIRO Plant Industry and has over 120 refereed publications. He is a Fellow of the Australian Institute of Agricultural Science and Technology, the Australian Academy of Technological and Engineering Sciences, the American Society of Agronomy, and the Crop Science Society of America. Tony received the CM Donald Medal in 2004, the William Farrer Memorial Medal in 2007, and became a Member of the Order of Australia (AM) in 2007 for services to agricultural research.

Australian agriculture and the challenge of population growth

While population (and income) growth presents a dire and unprecedented challenge to world agriculture, even doubling of Australia's population presents little direct challenge to Australian agriculture continuing to meet the bulk of our staple food needs. Population growth will be largely urban, land area for field cropping and grazing will suffer little, and further yield increases can be anticipated. The greater challenges are indirect, arising from increased competition for blue water, manpower, capital, and energy. Even greater are the typical consequences of further urbanisation. Agriculture could continue to shrink in the national psyche and in the corridors of political power. This means more competition for public funds for research and development, and for rural infrastructure, and more largely ill-informed criticism of and restraints on agriculture. But with a better informed population, these challenges can become opportunities, helping us graft environmental stewardship onto continuing research-based productivity increases. This will permit our dominant rain fed agriculture to maintain its global position as a significant and efficient food exporter and a source of modern environmentally-sound agricultural technology, of special relevance to the developing world.

Maria Deveson Crabbe

Marie Stopes International Australia

Maria Deveson Crabbe is the CEO of Marie Stopes International Australia – a not for profit organisation providing vital sexual and reproductive healthcare services and education to women in need all around the world.

Marie Stopes globally operates in over 40 countries. Here in Australia, Maria oversees our developing country programs in Asia Pacific and our sexual health centres that are located throughout Australia. Last year Marie Stopes had the impact of preventing 9.3 million unintended pregnancies, as well as 35, 600 maternal deaths and 2.06 million abortions. Maria's passion for good health and nutrition expands for almost two decades. Her previous achievements include founding Aussie Bodies, a protein supplement brand designed to improve nutrition, physical performance and emotional health. Aussie Bodies is Australia's leading protein food supplement developer, creating innovative products consumed by thousands of Australians every day. Maria is also an author of the book *Your body, your life*, which provides insight into the basics of nutrition in achieving optimal health and wellbeing. Maria was a finalist in the Telstra Business Woman of the Year Award 2005.

Global family planning for our future

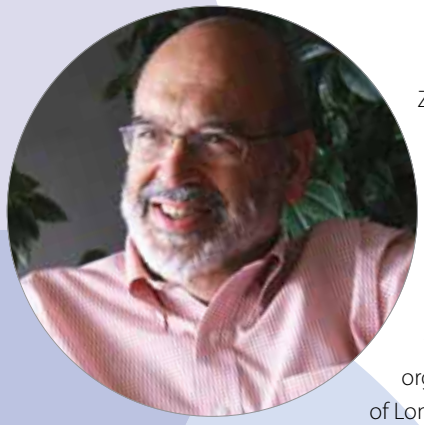
Around the world there are 215 million women that want to plan their family but cannot access contraceptives and 50 per cent of all Australian women will experience an unplanned pregnancy in their lifetime. We know when women are given access to family planning they tend to have smaller families and smaller families put less pressure on precious resources and local environments.

Marie Stopes is at the global forefront in providing voluntary family planning to those who need it. To measure the impact of our work we have developed an innovative tool, the Impact Calculator. The Impact Calculator measures the value of our work in preventing unplanned pregnancies, cost savings to local healthcare systems and national government budgets, as well as, ecological and carbon footprint impacts. Maria Deveson Crabbe will present the Marie Stopes Impact Calculator and how giving global access to contraceptives and family planning will reduce spiralling fertility rates and unchecked population growth. Both of these outcomes impact upon reducing poverty, making development sustainable and saving women's lives. Ms Deveson Crabbe will discuss how what we learn and implement overseas, has a direct influence on how successful we can be in Australia.

Professor Sir Peter Gluckman

Office of the Prime Minister's Advisory Committee; University of Auckland

Professor Sir Peter Gluckman FRS was the founding director of the Liggins Institute and is one of New



Zealand's best known scientists. His research has won him numerous awards and international recognition including Fellowship of the Commonwealth's most prestigious scientific organisation, The Royal Society of London. He is the only New Zealander elected to the Institute of Medicine of the National Academies of Science (USA) and the Academy of Medical Sciences of Great Britain. In 2009 he became a Knight of the New Zealand Order of Merit replacing the 2008 Distinguished Companion of the NZ Order of Merit, for services to medicine and having previously been made a Companion of the Order in 1997. In 2001 he received New Zealand's top science award, the Rutherford Medal. In July 2009 he was appointed as the first Chief Science Advisor to the Prime Minister of New Zealand. Professor Sir Gluckman is an international advocate for science, promoting the translation of discoveries in biomedical research into improvements in long term health outcomes. He is the author of over 500 scientific papers and reviews and editor of eight books, including three influential textbooks in his subject area.

The demographic storm – direct and indirect implications for human health

Sustainability can be considered at multiple levels. At the planetary level there is increasing concern about the conflation of water security, food security and energy security driven by a global population increase to at least 9 billion by 2050, climate change and rising incidences of non-communicable disease. In turn each of these issues is reflected at the regional level and indeed many solutions, either mitigatory or adaptionary, will have to be regional and local in nature. There are inevitable tensions that will emerge and already inhibit finding solutions. These may be geopolitical, ideological, philosophical or economic. These may occur at global, regional or local levels and generate the real risk of inadequate responses. Human health will be directly affected through the continuing rise in the prevalence of non-communicable disease, the consequences of food and water insecurity, the increased risk of zoonotics as population densities increase. We cannot discount the role of increased population density and technological development on mental health. Indirectly human health is put at further risk a result of the changed zoonotic ecology arising from global warming. The potential for this demographic storm to generate disruptive internal migration and regional and sub-regional conflict is real. Yet the type of science needed to address these issues often involves 'post-normal' science. In such science predictions may have high levels of uncertainty making the science easier to reject or ignore. It also invites exaggerated claims. We do not live in Platonic society and conveying an understanding to the public is complex. The issue of public engagement/understanding is already a challenge and will grow. Technological choices will have to be made to address these multiple issues and conveying an understanding of the inevitable balance of risks and benefit to any action will challenge the scientific and political leadership.

Conclusion and close of meeting

Professor Roger Short

University of Melbourne

Professor Roger Short AM FAA FRS is an Honorary Professorial Fellow in the Faculty of Medicine, Dentistry and Health Sciences at the University of Melbourne. An Anglo-Scottish-Australian, he has spent his life studying the reproductive biology of animals and humans. Ever since reading *The limits to growth* in 1972, he has focused on the problem of how to contain excessive human population growth. He has travelled extensively in Asia, Africa and North and South America, and spent a year as a consultant to the World Health Organization in Geneva. His ambition is to ensure that all the women of the world have the knowledge and means to ensure that every birth is a wanted birth.

Closing remarks

Sir John Beddington, the UK Government's Chief Scientist, has recently pointed out that the world is facing a Perfect Storm, caused by an ever-growing human population plus our ever-increasing per capita consumption. Australia is one of the world's most affluent and most effluent nations, so it is at the forefront of the problem. Unless we can learn to live in equilibrium with our environment, human activities may well initiate the earth's sixth mass extinction. There is a sinister new meaning to that dismissive phrase, 'the sky's the limit'; climate science has taught us that the sky *is* the limit. So wake up, Australia.