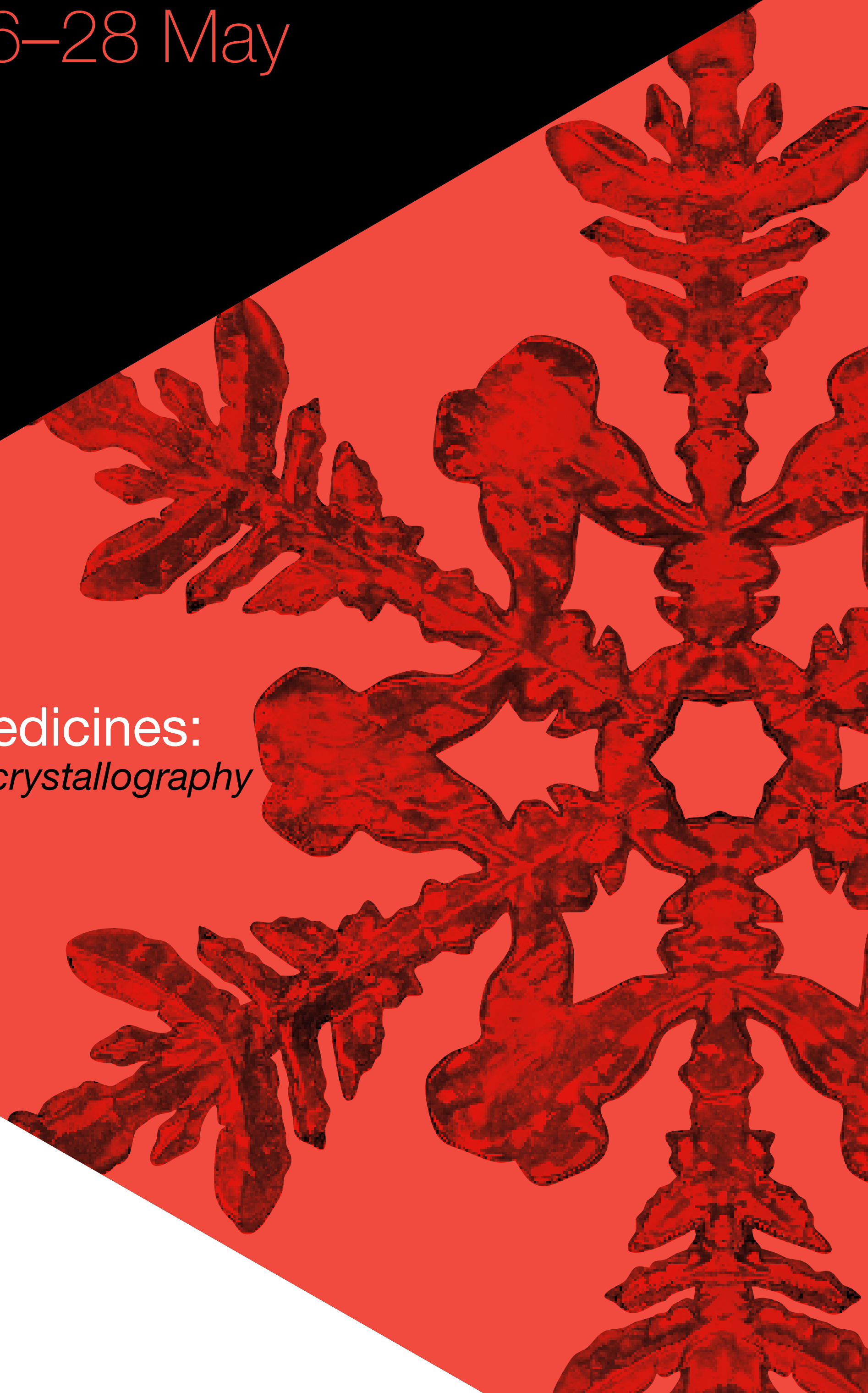
Australian Academy of Science

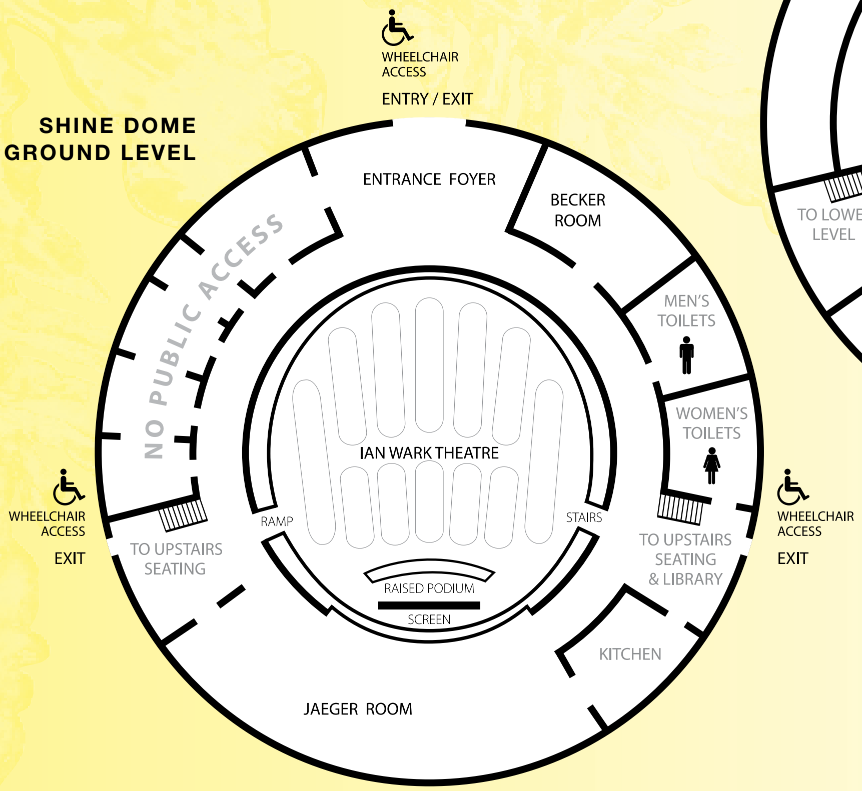
# Science at the Shine Dome 2015

## Program 26–28 May

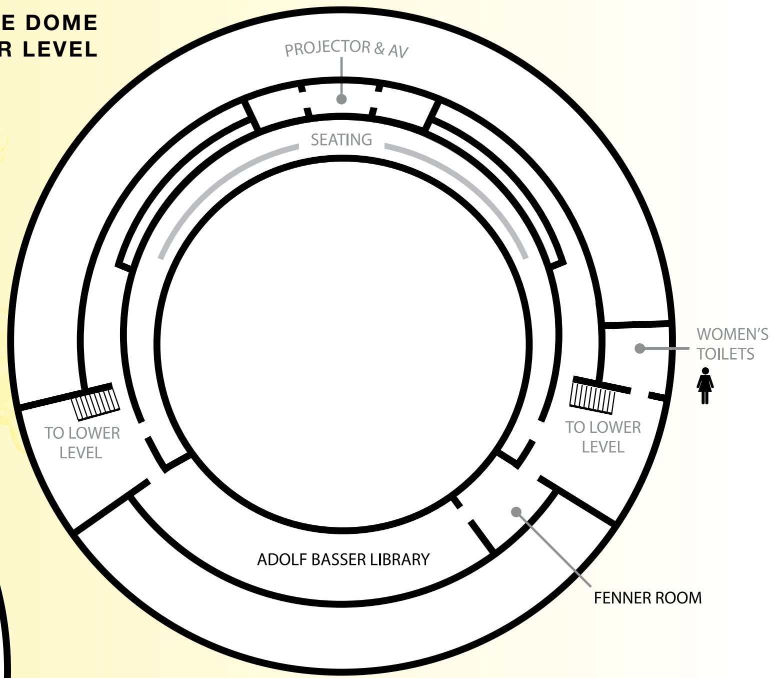


Minerals to medicines:
*100 years of X-ray crystallography*


SHINE DOME GROUND LEVEL




SHINE DOME UPPER LEVEL



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# President's welcome


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

At this year's event, we celebrate 100 years since the award of the Nobel Prize in Physics to Sir William Henry Bragg and William Lawrence Bragg for 'their services in the analysis of crystal structures by X-rays'. Bragg's law was first disclosed in 1912 and led to an entirely new field of endeavour. 2015 is also the International Year of Light. As knowledge-building has flourished over the past century and crystallography and other new areas of inquiry have grown, science has been—and will continue to be—a beacon of light as we push back the boundaries of what we know, to places hitherto unimagined. Our meeting here this week is a true celebration of that endeavour; a feast of ideas, inspiration and enlightenment.

Warm congratulations to the 21 new Fellows who were elected this year. Election to the Fellowship is a singular recognition of your important contributions to advancing the sum of human knowledge. I look forward to welcoming you formally to the Fellowship at your admission ceremony and to hearing you present the highlights of your outstanding work.

I look forward also to presiding over the awards ceremony: each year the Academy recognises a small number of scientists for extraordinary lifetime achievements, and for highly significant attainments in early to mid career. I am sure the 2015 awardees will enlighten us with stimulating expositions of their research.

The Academy is committed to nurturing the careers of young scientists. I welcome the participation of 56 early- and mid-career researchers from around Australia, 23 of whom have been supported to attend through the generosity of sponsors. You will find all our sponsors listed through the pages of this program, and on the back page. We are also delighted to host the 15 young scientists who have been selected through highly competitive processes to travel later this year to Germany, to participate in the annual meeting of Nobel Laureates in Lindau, or the annual meeting of Fields, Abel and Turing Laureates in Heidelberg.

As well as attending the science highlights, early- and mid-career delegates will engage in professional development activities. The week's activities provide a wonderful opportunity to form new friendships and initiate collaborative relationships that cross disciplinary, rank and geographic boundaries.

The grand finale of the week will be the Symposium organised by the National Committee for Crystallography. *Minerals to medicines: 100 years of X-ray Crystallography* brings together an impressive program of speakers to explore the world-changing impact of this important discipline and provide a glimpse of its future.

I am so pleased you could join us for this 61st annual meeting of the Australian Academy of Science.

**Professor Andrew Holmes** AM PresAA FRS FTSE

# **Program** Tuesday 26 May

• AWARD PRESENTATION • NEW FELLOW PRESENTATIONS

| | |
|---|---|
| 9.00 am | **Welcome**<br>Professor Andrew Holmes AM PresAA FRS FTSE<br>President, Australian Academy of Science |
| 9.05 am | **2015 Matthew Flinders Medal and Lecture**<br>**Professor Kurt Lambeck AO FAA FRS**<br>Research School of Earth Sciences<br>The Australian National University<br>*Deformations of the Earth: from hours to eons* |
| **Session one—New Fellow presentations** | |
| **Chairs** | **Professor Chennupati Jagadish FAA FTSE, Professor Marilyn Renfree AO FAA** |
| 9.35 am | Professor Martin Asplund FAA<br>The Australian National University<br>*Reading the cosmic story from starlight*<br><br>Professor Peter Bartlett FAA<br>Queensland University of Technology<br>*Advances in statistical learning theory*<br><br>Professor Christine Beveridge FAA<br>The University of Queensland<br>*Branching in new directions: A new plant hormone and a sweet starter*<br><br>Professor Jenefer Blackwell FAA<br>Telethon Kids Institute<br>*Using genetic variation to understand complex diseases* |
| 10.35 am | **Morning tea**<br>**EMCR group photo**<br>**EMCR awardees and Lindau participants group photos**<br>**Please meet in the foyer** |
| 11.00 am | Professor Alan Carey FAA<br>The Australian National University<br>*Non-commutative geometries*<br><br>Professor Christine Charles FAA<br>The Australian National University<br>*Expanding horizons to expanding plasmas*<br><br>Dr Susan Clark FAA<br>Garvan Institute of Medical Research<br>*Beyond the genome: Implications of epigenetics and disease?*<br><br>Professor Julian Gale FAA<br>Curtin University<br>*Computer simulation of crystallisation: From flops to success* |
| | Professor Edward Holmes FAA<br>The University of Sydney<br>*Pandemics past and present*<br><br>Professor Wendy Hoy AO FAA<br>The University of Queensland<br>*Renal disease as metaphor: An integrated view on chronic disease in transitional populations* |
| 12.30 pm | **Lunch**<br>**New Fellow group and individual photos**<br>**Please meet in the foyer** |
| **Session two—New Fellow presentations** | |
| 1.30 pm | Professor William Laurance FAA<br>James Cook University<br>*The global infrastructure tsunami: Avoiding a fatal synergism for nature*<br><br>Professor Helene Marsh FAA<br>James Cook University<br>*From carcasses to satellites: The development of marine mammal science*<br><br>Professor Geoffrey McLachlan FAA<br>The University of Queensland<br>*Finite mixture distributions: Statistical modelling and inference*<br><br>Professor Linda Richards FAA<br>The University of Queensland<br>*Wiring the brain for function*<br><br>Professor Malcolm Sambridge FAA<br>The Australian National University<br>*The Earth as a black box*<br><br>Professor Ian Small FAA<br>The University of Western Australia<br>*From biodiversity to synthetic biology: Using evolution to inform the design of synthetic RNA binding proteins* |
| 3.00 pm | **Afternoon tea**<br>**New Fellow individual photos continued**<br>**Please meet in the foyer** |
| 3.30 pm | Professor San Thang FAA<br>CSIRO Manufacturing Flagship<br>*RAFT: A process for making better polymers*<br><br>Professor Carola Vinuesa FAA<br>The Australian National University<br>*Managing autoimmune risk while maximising antibody diversity* |

**Colour code** New Fellows · Fellows · EMCRs/Lindau participants · Awardees · Symposium speakers

Professor Michael Waters FAA
The University of Queensland
*The molecular mechanism of growth hormone action*

Professor George Willis FAA
The University of Newcastle
*The scale on a disconnected symmetry group*

4.30 pm **Close**
Professor Andrew Holmes AM PresAA FRS FTSE
President, Australian Academy of Science

6.30 pm – 9.00 pm **EMCR and Fellow barbecue reception**
**Jaeger Room, the Shine Dome**
Participating early- and mid-career researchers are invited to a special barbecue dinner at the Shine Dome. This is an informal opportunity to get to know one another, make connections and perhaps even meet a mentor: some Fellows of the Academy will attend.

# **Program** Wednesday 27 May

• AWARDS PRESENTATIONS • EARLY- AND MID-CAREER RESEARCHER WORKSHOPS
• ANNUAL GENERAL MEETING • ANNUAL DINNER

8.30 am **President's address**
Professor Andrew Holmes AM PresAA FRS FTSE
President, Australian Academy of Science

**Career Honorific Award presentations**

9.00 am David Craig Medal
Professor Denis Evans FAA
The Australian National University
*Dissipation and the foundations of statistical thermodynamics*

Hannan Medal
Professor Gustav Lehrer FAA
The University of Sydney
*Braids and invariants*

Hannan Medal
Professor Alan McIntosh FAA
The Australian National University
*Harmonic analysis and first order systems*

Jaeger Medal
Professor Trevor McDougall FAA FRS
The University of New South Wales
*Ocean mixing and climate*

Thomas Ranken Lyle Medal
Professor Michelle Simmons FAA
The University of New South Wales
*Atomic-scale electronics for quantum computing*

10.10 am **Morning tea**
**Honorific Awardees (early morning session) individual photos**
**Please meet in the foyer**

**Early- and mid-career Honorific Award presentations**

10.30 am Dorothy Hill Award
Dr Nerilie Abram
The Australian National University
*Australia's changing climate from the perspective of the past millennium*

Inaugural Gustav Nossal Medal
Professor Nicholas Anstey
Menzies School of Health Research
*Towards the better treatment of severe malaria*

Inaugural Jacques Miller Medal
Professor Michael Cowley FTSE
Monash University
*How does obesity cause hypertension?*

Gottschalk Medal
Dr Peter Czabotar
Walter and Eliza Hall Institute of Medical Research
*Structural studies of cell death pathways*

Nancy Millis Medal
Professor Tamara Davis
The University of Queensland
*The dark side of the universe*

11.35 am **Short tea and coffee break**

11.45 am Christopher Heyde Medal
Associate Professor Catherine Greenhill
The University of New South Wales
*From sampling to counting and back again*

**Colour code** New Fellows · Fellows · EMCRs/Lindau participants · Awardees · Symposium speakers

| | |
|---|---|
| | **Christopher Heyde Medal**<br>Dr Scott Morrison<br>The Australian National University<br>*Topological matter* |
| | **Pawsey Medal**<br>Dr Naomi McClure-Griffiths<br>The Australian National University<br>*Exploring the Milky Way with the world's greatest radio telescopes* |
| | **Fenner Medal**<br>Dr Ian Wright<br>Macquarie University<br>*Making sense of global variation in plant traits* |
| | **Ruth Stephens Gani Medal**<br>Dr Jian Yang<br>The University of Queensland<br>*Understanding the genetic architecture of complex traits in humans* |
| | **Moran Medal**<br>Associate Professor Yee Hwa Yang<br>The University of Sydney<br>*Improving accuracy in cancer prognosis* |
| | **Anton Hales Medal**<br>Dr Yingjie Yang<br>Macquarie University<br>*The sound of the sea: 3D imaging of the Earth using noise from ocean waves* |
| 1.20 pm | **Lunch**<br>**Awardees group and individual photos**<br>**Please meet in the foyer** |
| 2.05 pm – 5.30 pm | **Early- and mid-career researchers workshops**<br>• Leadership in science<br>Becker Room, ground floor, Shine Dome<br>• Research and industry partnerships<br>Boardroom, ground floor, Ian Potter House<br>• Successful grant writing<br>University House<br>• Communication and collaboration in science<br>Boardroom, first floor, Ian Potter House |
| 2.30 pm – 5.00 pm | **Annual General Meeting**<br>(closed session for Fellows of the Academy) |
| 6.45 pm | **Annual dinner**<br>DRESS CODE: BLACK TIE/COCKTAIL<br>PRE-DINNER DRINKS AT 6.45 PM, DINNER AT 7.30 PM<br>QT Hotel, 1 London Circuit, Canberra<br>**Presentation**<br>**Matthew Flinders Medal**<br>Professor Kurt Lambeck AO FAA FRS |

**Colour code** New Fellows Fellows EMCRs/Lindau participants Awardees Symposium speakers

# **Program** Thursday 28 May

ANNUAL SYMPOSIUM: MINERALS TO MEDICINES: 100 YEARS OF X-RAY CRYSTALLOGRAPHY

| | |
|---|---|
| 9.00 am | **Morning session one** |
| **Chair** | **Professor Andrew Holmes AM PresAA FRS FTSE** |
| 9.00 am | **Welcome**<br>Professor Andrew Holmes AM PresAA FRS FTSE<br>President, Australian Academy of Science |
| 9:10 am | **Sponsor welcome and opening remarks**<br>*Crystallography in Australia: the role of ANSTO's landmark facilities*<br>Dr Adi Paterson<br>ANSTO |
| 9.30 am | *X-ray crystallography: Built on a foundation of theory and experiment in physics*<br>Professor Mark Spackman<br>The University of Western Australia |
| 10.00 am | *Mineralogy and X-ray crystallography: A symbiotic growth*<br>Professor Allan Pring<br>SA Museum |
| 10.30 am | *Crystallography that is out of this world!*<br>Dr Helen Maynard-Casely<br>ANSTO |
| 11.00 am | **Morning tea** |
| 11.30 am | **Morning session two** |
| **Chair** | **Professor Alice Vrielink** |
| | *Crystallography of molecules and materials*<br>Professor Stuart Batten<br>Monash University |
| 12.00 pm | *Biological crystallography: Wonder and awe*<br>Professor Jenny Martin<br>The University of Queensland |
| 12.30 pm | *Crystallography and new medicines: Examples from influenza and cancer*<br>Professor Peter Colman<br>Walter and Eliza Hall Institute |
| 1.00 pm | **Lunch**<br>**Symposium speakers group photo**<br>**Please meet in the foyer** |
| 2.20 pm | **Afternoon session** |
| **Chair** | **Professor Brendan Kennedy** |
| | *Electron—crystallography: Probing the atoms that matter*<br>Professor Joanne Etheridge<br>Monash University |
| 2.50 pm | *Imaging molecules with X-ray lasers*<br>Professor Henry Chapman<br>The University of Hamburg |
| 3.20 pm | **Conclusion and close of meeting**<br>Professor Mitchell Guss<br>Chair, National Committee for Crystallography |
| 3.30 pm | **Afternoon tea** |

**Colour code** New Fellows Fellows EMCRs/Lindau participants Awardees Symposium speakers

# New Fellow presentations

## Professor Martin Asplund FAA

*Mount Stromlo Observatory,*
*The Australian National University*

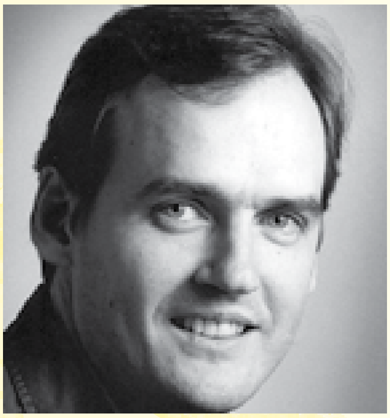
Professor Martin Asplund is an ARC Laureate Fellow at the Research School of Astronomy and Astrophysics at the Australian National University. He obtained his PhD in theoretical astrophysics at Uppsala University in 1997. After a postdoctoral fellowship at the Nordic Institute for Theoretical Physics (Nordita) he returned to Uppsala as an assistant professor. He joined the faculty at ANU in 2002 where he quickly was promoted to full professor in 2006. In 2007 he was headhunted for the directorship of the Max Planck Institute for Astrophysics in Germany, the leading European centre for theoretical and computational astrophysics. In 2011 he returned to ANU as an ARC Laureate Fellow. Professor Asplund has very broad research interests, covering topics from the Sun and extrasolar planets to our Milky Way and the early Universe using both theory, computations and observations. His work is among the most cited astronomy research worldwide over the past decade.

### Reading the cosmic story from starlight

The history of the cosmos is written in starlight. The lives and deaths of generations of stars, the complex events that shaped our Milky Way and other galaxies from their births to the present day and the presence of planets orbiting distant Suns are all imprinted in the radiation that stars emit. Reading this cosmic history is challenging but possible through a careful analysis of the starlight using sophisticated computer models of the stars and the atomic processes shaping the stellar spectrum in the surface layers of stars. Recent breakthroughs in such modelling has resulted in a major revision of the solar chemical composition—a fundamental yardstick in astronomy. The solar composition is unusual due to the formation of terrestrial planets in the solar system, opening new possibilities in identifying stars likely to host Earth-like planets. Professor Asplund will also describe ongoing efforts in Australia to search for the oldest stars that formed within 200 million years of the Big Bang, and to unravel the history of our Milky Way.

## Professor Peter Bartlett FAA

*Department of Mathematical Sciences,*
*Queensland University of Technology*



Professor Peter Bartlett's research is in statistical learning theory, an area that lies at the interface between statistics and computer science and is concerned with the development of the theoretical foundations for methods that use large and complex data to make effective decisions. He is professor in Mathematics at the Queensland University of Technology and professor in Computer Science and Statistics at UC Berkeley. He has been professor in the Research School of Information Sciences and Engineering at the Australian National University, Visiting Miller Professor at UC Berkeley, honorary professor at the University of Queensland, and visiting professor at the University of Paris. He was awarded the Malcolm McIntosh Prize for Physical Scientist of the Year in 2001, was an IMS Medallion Lecturer in 2008, and is an Australian Laureate Fellow and a Fellow of the Institute of Mathematical Statistics.

### Advances in statistical learning theory

Machine learning methods, which use large, complex data to make decisions, have had an enormous impact in a wide range of applications, from adjusting the focus of a digital camera by recognising faces in the image, to automatically translating documents between languages. The area of statistical learning theory is concerned with the analysis and design of these methods, and in particular with understanding how to make effective use of data and computational resources to solve decision problems. Professor Bartlett will give a taste of advances in this area, ranging from the role of convex optimisation in developing effective pattern classification methods, to the use of game theory in large-scale sequential prediction problems.

## Professor Christine Beveridge FAA

*School of Biological Sciences,*
*The University of Queensland*

Professor Christine Beveridge researches the hormonal control of plant development, particularly shoot architecture. She and her colleagues at the University of Queensland's School of Biological Sciences have made two major discoveries that have transformed the field. The first is the discovery of strigolactones, a new plant hormone. She has shown that this hormone affects shoot architecture and other important developmental traits such as lateral rooting, adventitious rooting and secondary growth (wood production). The second major discovery is causing a paradigm shift in thinking of shoot architecture, namely that the initial growth of axillary buds is prevented where sugars are limited; branch development only commences under conditions of sufficient sugar availability. These discoveries will be used in the tailoring of shoot branching for improving yield, productivity and ornamental value of crops, trees and shrubs.

### Branching in new directions: A new plant hormone and a sweet starter

Apical dominance is a well-known property of plants whereby the growing shoot tip reduces the growth of branches below. The extent of this inhibition is one of the main features that controls the architecture of plants, ranging from bushy to non-branched phenotypes. It was thought that apical dominance is predominantly controlled by the plant hormones auxin, which inhibits the growth of axillary buds into branches, and cytokinin which promotes branching. Professor Beveridge's team showed that neither of these hormones could explain the enhanced branching in particular branching mutants. This led to the discovery of strigolactones—plant hormones which play an important role in many developmental processes and have commercial potential in agriculture. Professor Beveridge's team has further shown that the mobile sugar, sucrose, is required for bud release, which is the first and essential stage of branch development. This discovery completely changes the hormonal dogma of apical dominance and provides a new framework to understand the myriad of different shoot architectures of genetically different and identical plants.

## Professor Jenefer Blackwell FAA

*Division of Genetics and Health and Winthrop, Telethon Kids Institute*

PHOTO: TONY MCDONOUGH

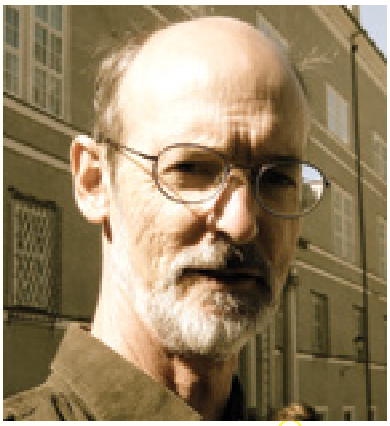
Professor Jenefer Blackwell's major research interest has been in using genetics to understand host susceptibility and resistance to infectious diseases, focusing on neglected tropical diseases. Her research has involved collaborations in many tropical countries, including India, Brazil and The Sudan. Her research has focused on the interplay between host and parasite genomes, and has included genome-wide approaches both to identifying genetic risk factors in humans, and in identifying potential vaccine candidates by screening hundreds of novel vaccine candidates based on the Leishmania genome sequence. After returning to Australia in 2007, she extended her interests into understanding obesity and type 2 diabetes in Aboriginal Australians through the use of genome-wide association studies, and has also been active in promoting the translation of next-generation sequencing for the diagnosis of rare diseases.

### Using genetic variation to understand complex diseases

Tuberculosis, leprosy and the leishmaniases are bacterial and parasitic infections of the tropics that are responsible for millions of deaths annually. They are all unicellular and share a common intracellular niche within macrophages, central cells of the immune system that function to kill invading microorganisms. For every child who contracts potentially fatal clinical disease, there are many more who become infected but remain asymptomatic. Along with familial clustering, high sibling risk ratios, and higher concordance rates of disease in monozygous compared to dizygous twins, this suggests a strong genetic component to disease susceptibility. Professor Blackwell will elucidate on her research in which her team has published the first genome-wide association study of visceral leishmaniasis across major foci of disease in India and Brazil, finding the most important genetic risk factor for visceral leishmaniasis lies at the heart of eliciting T cell immunity. The team is now working towards novel vaccines.

## Professor Alan Carey FAA

*Mathematical Sciences Institute, The Australian National University*
Elected to Fellowship 2014



The interaction of mathematics with physics has been one of the dominant influences in the development of the discipline. This interface between the disciplines has been Professor Alan Carey's central interest for more than 40 years. A professor of mathematics at the ANU, he has largely worked on mathematical questions that have their origins in the study of quantum phenomena. One theme which has evolved for nearly 100 years through this interplay is index theory. In its contemporary form it has been recast using the non-commutative point of view coming from theoretical models of quantum phenomena and this is the topic on which Professor Carey has worked almost exclusively for the last decade.

## Non-commutative geometries

The mathematical formulation of quantum mechanics and the fact that it has totally unintuitive consequences is usually credited to Heisenberg back in 1925. This mathematical theory matured and developed for 50 years but was changed quite suddenly in the 70s by advances in condensed matter physics and the mathematical theory of non-classical geometric structures. Professor Carey will give some examples and briefly explain his work in this area.

## Professor Christine Charles FAA

*Space Plasma, Power and Propulsion Laboratory, The Australian National University*

Professor Christine Charles is Head of the Space Plasma, Power and Propulsion laboratory at the Australian National University. Born in France, she has an engineering degree in applied physics, a PhD in plasma physics, a French Habilitation thesis in materials science and a Bachelor of Music degree in Jazz. For the past 25 years, she has been working on experimental expanding plasmas and their applications to astrophysical plasmas, electric propulsion, microelectronics, optoelectronics and hydrogen fuel cells. She is the inventor of the Helicon Double Layer Thruster, a new electrode-less magneto-plasma thruster for space use. She was the 2009 Australian Institute of Physics' Women in Physics Lecturer and a Finalist in both the 2011 Australian Innovation Challenge and the 2011 World Technology Awards. She has published over 180 articles in various international peer-reviewed journals and was elected a Fellow of the American Physical Society in 2013.

## Expanding horizons to expanding plasmas

Plasmas, hot ionised gases (stars and interstellar medium), have existed since the very first moments of the Universe. Expanding magnetised plasma plays an important role in astrophysical plasmas such as the solar corona, the aurora or neutron stars. Non-linear phenomena such as current-free electric double layers (localised electric fields and local violation of neutrality) may spontaneously occur yielding charged particle acceleration. When harnessed in the laboratory, these effects pave the path to new applications in communication and transportation on Earth—such as hydrogen fuel cells—and in space, where they might take the form of next generation electrode-less plasma thrusters.

## Professor Susan Clark FAA

*Cancer Division, Garvan Institute of Medical Research*

Professor Susan Clark is an international pioneer in the field of epigenetics and epigenomics. Head of genomics and epigenetics at the Garvan Institute, her research helped to revolutionise the field through her pivotal contribution to the advancement of new technologies for detection of DNA methylation in early development and cancer as well as the development of novel epigenetic biomarker assays for cancer detection and stratification. More recently, having demonstrated that aberrant DNA methylation of gene promoters is a consequence of prior gene inactivation and chromatin remodelling, she has turned her attention to understanding the epigenetic landscape of large-scale domains in cancer, using and developing new genome-wide sequencing and bioinformatic protocols to map DNA methylation, histone modification, nucleosome positioning and regulatory RNA profiles. The work has demonstrated that epigenetic changes in cancer are not restricted to individual genes but can encompass three dimensional genome-wide domains, resulting in global and co-ordinate gene silencing and activation.

## Beyond the genome: Implications of epigenetics and disease?

Cancer is a disease of DNA, including genetic mistakes in the DNA sequence and epigenetic mistakes in how the DNA is organised and interpreted in the cell. Epigenetic deregulation of coding and non-coding RNA expression is involved in cancer initiation and progression and provides new and exciting insights into disease etiology and treatment. In particular Professor Clark's work over the past 25 to 30 years has concentrated on understanding the role of epigenetic gene control in cancer. Through the development of novel gene-specific and genome-wide technologies, her team has been able to contribute to understanding the role of epigenetics in deregulation of cancer genes and more recently the deregulation of the three-dimensional architecture of the cancer genome. These findings have wide ramifications for novel cancer diagnosis, prognosis and epigenetic-based gene therapies.

## Professor Julian Gale FAA

*Department of Chemistry, Curtin University*

Professor Julian Gale graduated from the University of Oxford where he also obtained his PhD in the Department of Chemical Crystallography. After a postdoctoral position at the Royal Institution of Great Britain he moved to Imperial College London as a Royal Society University Research Fellow and subsequently Reader in Theoretical and Computational Chemistry. In 2003 he moved to Curtin University as a Premier's Research Fellow and now holds the position of John Curtin Distinguished Professor of Computational Chemistry. Research interests include the development and application of computational techniques to solve problems in areas including materials science, geochemistry and mineralogy. Particular topics of focus have included understanding the catalytic properties of nanoporous solids, materials for energy storage and most recently the mechanisms of crystal growth, especially those involved in the formation of minerals.

### Computer simulation of crystallisation: From flops to success

Formation of crystals is of fundamental importance in many areas of chemistry, from purification of pharmaceuticals through to long-term sequestration of carbon dioxide. Far from always being beneficial, such processes can be detrimental through the formation of scale or pathological minerals. The key to understanding the early stages of how molecules or ions begin to assemble, ultimately leading to the formation of a solid, often occurs at the nanoscale. This makes it particularly challenging to probe using experimental techniques alone. With the advent of machines that can now perform a staggering 1015 floating point operations per second (flops), it is possible to simulate how crystals are created in the virtual world of a computer. By augmenting experimental information with the insights that arise from such computer models, it offers the chance to develop new strategies to successfully control the nucleation and growth of materials.

## Professor Edward Holmes FAA

*Charles Perkins Centre,*
*The University of Sydney*

Professor Edward Holmes is an internationally renowned research scientist studying the evolution and emergence of infectious disease. He is an NHMRC Australia Fellow at the University of Sydney. The central goal of Professor Holmes' research is to reveal the fundamental patterns and processes of microbial evolution, emergence and epidemiology. He is particularly interested in determining the evolutionary factors that enable viruses to jump species boundaries and spread in new hosts, as well as their subsequent evolution including changes in virulence. Professor Holmes has examined a variety of major human pathogens, including HIV/AIDS and influenza virus, as well as ancient and contemporary bacterial pathogens including the plague bacterium *Yersinia pestis*. In recent years, Professor Holmes has used the deliberate release of viruses as biological controls against invasive pests as a means to understand basic aspects of pathogen evolution.

### Pandemics past and present

The potential for novel pathogens to emerge and cause large-scale human morbidity and mortality has inspired often frightening and sometimes fantastic tales, with a blurry distinction between fact and fiction. It is therefore no surprise that determining the origins of disease pandemics, as well as how best to prevent and control them, is one of the major challenges facing modern biomedicine. By using genomic sequence data sampled from a variety of viral and bacterial pathogens, Professor Holmes will briefly address how pathogens are able to jump species boundaries and spread in new hosts, including humans, and evolve key characteristics such as virulence. He will also demonstrate how the analysis of 'ancient DNA' from archival human remains can inform on the emergence and evolution of past infectious disease epidemics, focusing on one of the most important of all bacterial diseases—plague.

## Professor Wendy Hoy AO FAA

*Centre for Chronic Disease,*
*The University of Queensland*

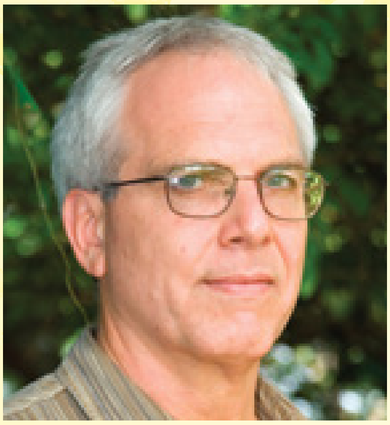
In her multidisciplinary research on kidney and related chronic disease in high risk populations, Professor Wendy Hoy has targeted American Indians, African Americans and Australian Aborigines, and promoted enquiry in many other groups internationally. She promotes community-based perspectives of risk and disease, has defined disease markers, developed multideterminant disease models, defined links to intrauterine growth retardation and infections, and showed that systematic treatment improves blood pressures and reduces dialysis needs, costs and deaths. That work helped transform Aboriginal health services and underpins evidence-based intervention programs globally. In collaborations, Professor Hoy has described sentinel features of Aboriginal biopsies Australia-wide, and, in the world's largest multinational autopsy study, the landmark significance of nephron number and glomerular volume in driving and marking disease susceptibility. She collaborates in studies of genetic determinants of kidney disease in Aborigines and APOL1-associated disease in African Americans, and leads Australia's first Centre for Research Excellence in Chronic Kidney Disease.

### Renal disease as metaphor: An integrated view on chronic disease in transitional populations

Chronic non-communicable diseases have overtaken infections and malnutrition as leading causes of adult death worldwide. Some Indigenous groups can provide a relatively distilled view of conditions, transitions and associations. Findings from study of the current epidemic of kidney disease in remote-living Aboriginal Australians have far-reaching implications. They show that kidney, cardiovascular disease and diabetes share markers, risk factors and susceptibility to interventions. They reflect birth weights, mortality, conditions and health services decades earlier, as well as increasing longevity. They have a common background of prenatal and early life malnutrition, infections, inflammation and stress, and are exacerbated by adverse environments over the life course, with over-nutrition and inactivity probably of little significance. New insights into disease expression and susceptibility derived from epidemiologic, morphologic and stereologic studies are promoting targeted micro-anatomical, molecular and genetic research in several populations, and development of novel imaging techniques. Findings have radically changed health care delivery systems, and fostered collaborative investigations of localised epidemics around the world.

## Professor William Laurance FAA

*Centre for Tropical Environmental Science, College of Marine and Environmental Sciences, James Cook University*



Professor William Laurance is a Distinguished Research Professor and Australian Laureate at James Cook University in Cairns. A tropical conservation biologist, his work spans the tropical world, including the Asia–Pacific region, the Amazon, and Equatorial Africa. He has written six books and over 400 scientific and popular articles. His professional honours include the Heineken Environment Prize, the BBVA Frontiers in Ecology and Conservation Biology Award, a Distinguished Service Award from the Society for Conservation Biology, and an Outstanding Conservation Achievement Award from the Zoological Society of London. He is a former president of the Association for Tropical Biology and Conservation, and is currently director of the Centre for Tropical Environmental and Sustainability Science at James Cook University. He also founded and directs ALERT—the Alliance of Leading Environmental Researchers & Thinkers—an international scientific group that advocates for environmental sustainability.

### The global infrastructure tsunami: Avoiding a fatal synergism for nature

The 21st century will see an unprecedented expansion of roads, dams, power lines and gas lines, as well as massive investments in mining and fossil-fuel projects. At least 25 million kilometres of new roads are anticipated by 2050. Nine-tenths of all road construction is projected to occur in developing nations, including many tropical regions that sustain exceptional biodiversity and vital ecosystem services. Roads penetrating into remote or frontier areas are a major proximate driver of habitat loss and fragmentation, wildfires, overhunting, and other environmental degradation, often with irreversible impacts on native ecosystems. Unfortunately, much road proliferation is chaotic or poorly planned and the rate of expansion is so great that it often overwhelms the capacity of environmental planners and managers. Professor Laurance will present a global scheme for prioritising road building. This large-scale zoning plan seeks to limit the environmental costs of road expansion while maximising its potential benefits, especially for agriculture. The plan provides a template for proactively zoning and prioritising roads during the most explosive era of road expansion in human history.

## Professor Helene Marsh FAA FTSE

*College of Marine & Environmental Sciences, James Cook University*

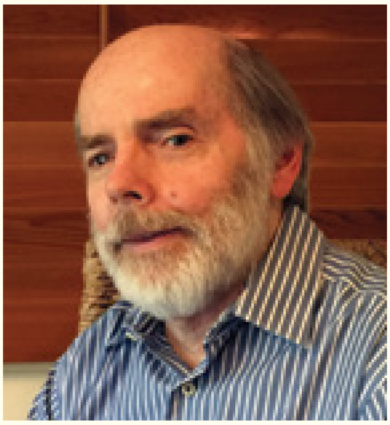
Professor Helene Marsh is Distinguished Professor of Environmental Science and Dean, Graduate Research at James Cook University. Her research group focuses on the ecology and conservation biology of tropical coastal marine megafauna, especially dugongs, and includes ecological research on life history, reproductive ecology, population dynamics, diet, distribution, abundance and movements. This research has been instrumental in advancing the scientific understanding and management of coastal marine megafauna in the global topics, including the Great Barrier Reef World Heritage Area. The research integrates studies of the ecology of species of conservation concern with a broader evaluation of the linkages between threatened species and the welfare of human societies, particularly in developing countries and among remote Indigenous Australian communities. The research, which is strongly cross-disciplinary and problem-focused, has contributed to policy outcomes in Australia and other tropical countries and has been recognised by several international awards. Marsh has mentored 54 doctoral and 20 Masters candidates to successful completion and 12 post-doctoral fellows.

### From carcasses to satellites: The development of marine mammal science

Marine mammal science started as fisheries science to inform the management of marine mammal harvests and was largely based on carcass analysis. This research provided important information on taxonomy, life history, distribution and diet. The focus of marine mammal science has gradually changed to conservation science with increasing emphasis on non-lethal methodologies to measure population sizes and trends, the genetic structure of populations, diet and animal behaviour including diving, movements and habitat use. Marine mammal science now uses sophisticated laboratory, field and analytical techniques and data are collected from blimps, aircraft and satellites as well as research vessels. The marine mammal scientist of the future will require advanced mathematical skills. Professor March will illustrate these changes using the research of her group on coastal marine mammals, especially dugongs.

## Professor Geoffrey McLachlan FAA


*Department of Mathematics, The University of Queensland*

Professor Geoffrey McLachlan is a University of Queensland Vice-Chancellor's Senior Research Fellow and has been an Australian Research Council Professorial Fellow. He has had a career-long interest in classification and pattern recognition and was elected President of the International Federation of Classification Societies for 2010–11. In other main fields of interest, his focus on statistical inference has been on the theory and applications of finite mixture models and on estimation via the EM algorithm. He has also been actively involved in bioinformatics with the focus on the statistical analysis of microarray gene expression data and on multiple testing. He has published extensively in these fields, including six monographs. He is an Institute for Scientific Information (ISI) Highly Cited Author in Mathematics. On the basis of his research, he was awarded a DSc in 1994, the Pitman medal of the Statistical Society of Australia in 2010, and the IEEE ICDM medal in 2011.

### Finite mixture distributions: Statistical modelling and inference

Finite mixture distributions provide a very flexible approach to the modelling of heterogeneous data and can be used to provide a probabilistic clustering of such data. An advantage of a mixture model approach to clustering is that it allows estimation and hypothesis testing concerning the shape and number of clusters to be undertaken within the framework of statistical theory. Professor McLachlan will give a brief account of recent developments on mixture modelling.

## Professor Linda Richards FAA


*Queensland Brain Institute, The University of Queensland*


PHOTO: NICK VALMAS

Professor Linda Richards is a developmental neurobiologist working on how brain precise wiring occurs during brain development. She completed her BSc(Hons) and PhD at the Walter and Eliza Hall Institute in Melbourne and postdoctoral training at the Salk Institute for Biological Studies in San Diego, USA. Professor Richards established her independent laboratory at the University of Maryland Medical School in Baltimore, USA in 1997. Her research is focused on understanding the developmental mechanisms regulating the formation of the corpus callosum, the largest fibre tract in the human brain. In 2005 she moved her research program to the Queensland Brain Institute. Professor Richards has established the fundamental principles underlying how the corpus callosum forms in humans and animal models, and in particular the role of glial cells in this process. She has applied her work in basic neuroscience to understanding the underlying causes of human malformations of the corpus callosum.

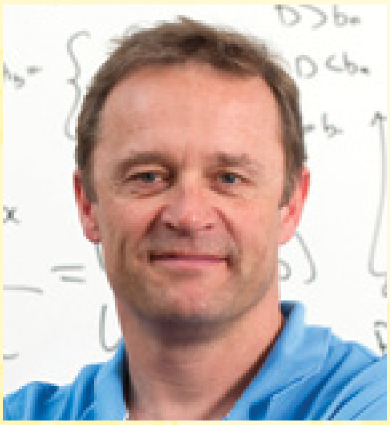
### Wiring the brain for function

The correct wiring of the brain is essential for function. Professor Richard's laboratory is working to discover the important genetic, molecular and cellular mechanisms regulating the development of brain wiring and how changes in brain wiring affect brain function throughout life. They study the largest connection in the brain, called the corpus callosum, which connects the two cerebral hemispheres. In addition to investigating the mechanisms involved in the formation of the corpus callosum, they are also striving to understand how other seemingly unrelated structural brain malformations that co-occur with callosal dysgenesis (malformation of the corpus callosum), could be due to the disruption of similar cellular and molecular mechanisms. Subtle changes in callosal targeting could represent a much larger and diverse group of subjects that have normal midline crossing, but disrupted targeting in the contralateral hemisphere. This area of research is in its formative stages but could offer potentially major breakthroughs in how the brain is normally wired during development and what mechanisms may be disrupted in disorders of brain connectivity.

## Professor Malcolm Sambridge FAA

*Research School of Earth Sciences, The Australian National University*

PHOTO: BELINDA PRATTEN



Professor Malcolm Sambridge's research contributions have been in geophysical inverse theory and methods of inference from indirect observations, together with their application across the Earth sciences. Specific research directions include the development and application of data inference techniques; theoretical seismology; imaging of the internal structure of Earth using seismic waves; robust inference and uncertainty estimation from Earth science data; and mathematical methods and numerical algorithms. Professor Sambridge is Head of Seismology and Mathematical Geophysics at the Australian National University's Research School of Earth Sciences.

### The Earth as a black box

Except for a very thin layer at the surface, all of our knowledge of the physical and chemical properties of the Earth is based on indirect observations. The rate at which tectonic plates sink into the interior, through a process called subduction, tells us that four billion years of Earth's history is now inside the Earth. The surface forces which create continents and ocean basins, which supply our mineral and energy reserves, and which create natural hazards such as earthquakes and volcanoes, are all linked to physical and chemical processes much deeper down. Therefore if we want to peer inside the Earth's black box we must probe its interior using indirect observations collected at the surface.

Inference problems of this kind involving multi-faceted sets of observations are increasingly common across the physical sciences, medicine, engineering, computer science and mathematics. Professor Sambridge will illustrate some new ways to construct solutions, estimate uncertainty and determine the limits of what may be known.

## Professor Ian Small FAA

*Plant Energy Biology, ARC Centre of Excellence, The University of Western Australia*

Professor Ian Small, Western Australia's 2014 Scientist of the Year, is interested in understanding plant genes and metabolism. His work towards understanding how plant energy processes are controlled is aimed towards optimising the use of plants in agricultural and environmental applications. Professor Small followed his PhD in 1988 at Edinburgh University with a career at France's National Agronomy Research Institute (INRA). In 2005, he was awarded a WA State Premier's Research Fellowship, moving to Perth to become Director of the Australian Research Council Centre of Excellence in Plant Energy Biology. Professor Small's early work contributed significantly to the development, patenting and commercialisation of technology now used globally to grow canola crops. He is perhaps best known for the discovery and characterisation of the pentatricopeptide repeat (PPR) family of proteins that are important for controlling plant fertility in hybrid crop breeding.

### From biodiversity to synthetic biology: Using evolution to inform the design of synthetic RNA binding proteins

Plant energy organelles drive major biological processes such as photosynthesis and respiration. Hundreds of RNA-binding proteins participate in the complex RNA processing that prepares for synthesis of the molecular machinery that catalyses energy metabolism. These large families of organellar RNA binding proteins share several interesting features from a synthetic biology viewpoint. They are modular, composed of arrays of repeated motifs, each of which probably contacts a single nucleotide. Using evolutionary patterns of variation in the protein sequences, Professor Small's team has shown that the largest of these families PPR family recognises single-stranded RNA sequence-specifically via a simple two-amino-acid code, with each combination preferring either A, C, G or U. This has made binding sites of the natural proteins predictable from amino acid sequence alone, and the protein sequence can be altered to change binding specificity. Synthetic RNA-binding proteins with predictable properties can now be constructed to target almost any RNA. These novel proteins can be used to control energy organelle function, for example to control fertility during the production of hybrid crops.

## Professor San Thang FAA FTSE

*CSIRO Manufacturing Flagship*

Professor San Thang came to Australia as a refugee from Vietnam in 1979. He completed his BSc (Hons) and PhD in chemistry at Griffith University in 1983 and 1987 respectively. He is an Honorary Fellow at CSIRO Manufacturing Flagship and Distinguished Professor (Research) at Monash University, School of Chemistry. Professor Thang has published more than 120 papers which have received more than 13 500 citations. His research on controlled/living radical polymerisation, particularly the Reversible Addition-Fragmentation Chain Transfer (RAFT) process, earned him the title of 2014 Thomson Reuters Citation Laureate. He is a Fellow of the Royal Australian Chemical Institute and of the Australian Academy of Technological Science and Engineering.

## RAFT: A process for making better polymers

Radical polymerisation is one of the most widely used processes for the commercial production of high-molecular-weight polymers. However, the conventional process has some notable limitations with respect to the degree of control over the molecular weight distribution, polymer composition and architecture. The advent of controlled/living radical polymerisation techniques such as the RAFT process developed at CSIRO has made accessible the preparation of polymers which were previously unobtainable. RAFT process is widely regarded as the most effective, versatile and convenient method for making better polymers. With appropriate selection of the RAFT agent, the process provides access to polymers of predetermined size and allows the synthesis of complex architectures. Applications of RAFT-made polymers range from novel surfactants, dispersants, coatings and adhesives, to biomaterials, membranes, drug delivery media and materials for microelectronics. The new materials have the potential to revolutionise a large part of the polymer industry.


## Professor Carola Vinuesa FAA

*The John Curtin School of Medical Research, The Australian National University*


PHOTO: STUART HAY, ANU

Professor Carola Vinuesa was born in Spain where she completed a medical degree. She undertook specialist clinical training in the UK, was awarded a PhD by the University of Birmingham (2000), and did postdoctoral work at The Australian National University's John Curtin School of Medical Research. Professor Vinuesa's work led to the discovery of genes important for immune regulation and antibody responses, and the identification of a novel pathway of posttranscriptional control of gene expression to prevent autoimmunity. Her team identified T-follicular helper (TFH) cells as an independent cell subset and demonstrated how failure to limit TFH cells causes rogue selection of B cells and autoantibody-mediated autoimmune diseases. She won the 2008 Science Minister's Prize for Life Scientist of the Year, the Australian Academy of Science 2009 Gottschalk Medal and the inaugural CSL-Young Florey Medal (2014). She is currently Professor of Immunology at the ANU and Head of the Immunology and Infectious Disease Department.

## Managing autoimmune risk while maximising antibody diversity

The immune system faces an incredible challenge: to rapidly and continuously generate the broadest possible repertoire of antibodies to efficiently protect against the most threatening microbial infections. An inherent risk in harbouring a diverse antibody repertoire is that antibodies may arise which will cause self-harm, such as allergy or autoimmune diseases. Professor Vinuesa's research has provided clues into the cells, pathways and genes that control selection of these antibodies and the mechanisms that act to prevent the production of damaging antibodies. She will speak about a dedicated subset of T cells—known as T follicular helper (Tfh) cells—which provide positive selection signals and need to be limited to maximise affinity-based competition amongst B cell clones.


## Professor Michael Waters FAA

*Institute for Molecular Bioscience, The University of Queensland*


Professor Waters is Group Leader, Cell Biology and Molecular Medicine Division at University of Queensland's Institute for Molecular Bioscience. Together with his collaborators, over 45 years Professor Michael Waters has elucidated the molecular basis of growth hormone (GH) action. Beginning with the knowledge that radio labelled GH binds specifically to liver membranes, he has been instrumental in identifying and cloning its receptor, in defining its ubiquitous tissue distribution and new physiological actions deriving from this. Professor Waters' team has shown that the receptor translocates to the cell nucleus, and that this confers specific abilities. They have created mice with targeted mutations in the receptor which have allowed them to define the signalling requirements for postnatal growth, including the suites of genes targeted by different receptor signalling elements. The team has shown that, as well as using the canonical JAK2 tyrosine kinase for signalling, the receptor uses an Src family kinase. Finally, they have elucidated the receptor activation mechanism for JAK2 at a molecular level, with clinical implications for cancer, diabetes and cognition.

### The molecular mechanism of growth hormone action

Professor Waters will review the structure of the growth hormone receptor, the first exemplar of type 1 cytokine receptors, and outline its widespread distribution and key physiologic roles. He will give an overview of the signalling processes used by this receptor to regulate postnatal growth and metabolism and describe the molecular events triggered by hormone binding to the extracellular part of the receptor, together with the transmission of the signal through the cell membrane and how the resulting movements of the receptor internally activate the associated JAK2 tyrosine kinase, allowing transmission of the growth signal to the DNA.

## Professor George Willis FAA

*Mathematical and Physical Sciences, The University of Newcastle*
Elected to Fellowship 2014

Professor George Willis is a Professor of Mathematics at the University of Newcastle, NSW. His research is developing techniques for analysing the symmetry of networks and other combinatorial structures. Professor Willis has a Bachelor of Mathematical Sciences from the University of Adelaide and a PhD in Mathematics from the University of Newcastle-upon-Tyne.

### The scale on a disconnected symmetry group

Symmetry is accounted for mathematically through the algebraic notion of a 'group': an abstract group gauges the symmetries of an object much as numbers measure its size. By understanding groups, mathematicians are able to categorise the types of symmetry that are possible. This understanding is well advanced in some cases. The possible symmetry groups of wallpaper patterns and crystals are completely classified, for example, and finite groups and so-called connected groups, which are symmetry groups of smooth objects such as spheres, are understood to a high level of sophistication following the work of numerous mathematicians over the last 150 years.

It is also known that a general group divides into a connected factor and a disconnected one. Our understanding of disconnected groups, which account for the symmetries of discrete objects such as networks, is now beginning to be informed by new techniques. One of the key new ideas is that of the scale function on the group, which takes positive integer values and may be used to analyse disconnected groups in an analogous way to that in which matrix eigenvalues are used to analyse connected groups. These new advances are the foundation of a sophisticated theory of disconnected groups that is only now being created.

## Absent new Fellows

Also elected this year, but unable to join us for the new Fellow presentations, are:

- Professor Maria Forsyth FAA, Deakin University
- Professor Michael McLaughlin AM FAA FTSE, The University of Adelaide
- Dr Ziggy Switkowski AO FAA FTSE, RMIT University

# 2015 Matthew Flinders Medal and Lecture

FOR SCIENTIFIC RESEARCH OF THE HIGHEST STANDING IN THE PHYSICAL SCIENCES

**The Matthew Flinders Medal and Lecture recognises scientific research of the highest standing in the physical sciences, and honours the contributions of Australia's early scientific researchers**

**Professor Kurt Lambeck AO FAA FRS**
**Research School of Earth Sciences**
**The Australian National University**

Professor Lambeck is a globally pre-eminent geophysicist who has made fundamental contributions to understanding Earth's rotation, the strength of Earth's mantle and its role in plate tectonics, and the complex global geometry of sea level variations associated with ice sheet melting. His work has fundamentally influenced a range of disciplines from geophysics to oceanography, glaciology and archaeology.

## Deformations of the Earth: from hours to eons

The study of the dynamics of the Earth is complex. Its interior is obscured and we are faced with an inverse problem in which, from observations taken on the surface inferences are drawn about the deeper structure and the processes that have led to this structure, using all the physical and chemical tools available. Professor Lambeck has focused on the planet's response to forces applied to it, or generated within it, so as to reach an understanding of its rheology—its elastic and non-elastic behaviour over a very wide range of time scales. The complexity of the problem is compounded by the fact that (i) the observations are often contaminated by what happens in the fluid surface regimes: the oceans, atmosphere, ice sheets, and (ii) to understand the underlying processes we often have to delve into non-traditional lines of observational evidence. In this Matthew Flinders Lecture Professor Lambeck will explore his journey through Earth science, examining the spectrum of the planet's deformations in search of an elusive earth-response function that describes the Earth's behaviour on time scales from millions of years to seconds. This starts with early analyses of satellite orbits to determine the planetary gravity field that provides a measure of the very long-term behaviour of the Earth's mantle; then jumps to the tidal and rotational deformations of the Earth that operate on periods from diurnal to annual; back to long-term regional tectonic questions on 100-million year time scales; and finally to the response of the earth-ocean system to glacial cycles on 10 000 to 100 000 year time scales. In most cases more insight has been gained into the fluid regimes than into the actual solid earth's response function and this will be illustrated by the last example: the ice-earth-ocean interactions and their consequences on sea level change.

# Academy Awards 2015

## CAREER HONORIFIC AWARDS

### David Craig Medal

**Professor Denis Evans FAA**

*Research School of Chemistry, The Australian National University*

Professor Denis Evans has made several outstanding contributions to classical statistical mechanics of nonequilibrium systems. He has long been credited with the derivation of Molecular Dynamics algorithms for computing transport properties of fluids and thermostats. Professor Evans' most outstanding theory contributions concern the thermodynamics of small systems observed over short time, for which he is internationally regarded as the 'Creator of the Fluctuation Theorems'.

#### Dissipation and the foundations of statistical thermodynamics

Thermodynamics is the theory that describes the interconversion of work into heat and vice versa. Thermodynamics is the most widely applicable sub-discipline in physics. It applies to astrophysics and to subcellular biology. However, it is not widely known that the foundations of statistical thermodynamics have, until very recently, been based on a series of postulates. The apparent increase in entropy appears to be in direct contradiction with the time reversible equations of motion in mechanics and electrodynamics. The discovery of the Fluctuation theorem in 1993, and its subsequent confirmation in experiments in 2002, began to change this situation. It is dissipation, not entropy, that is the key to understanding the foundations of statistical thermodynamics.

### Hannan Medal

**Professor Gustav Lehrer FAA**

*School of Mathematics and Statistics, The University of Sydney*

Professor Gustav Lehrer has made highly influential contributions to algebra and geometry. Among the highlights are his co-invention of the theory of cellular algebras in the decade's most highly cited Australian mathematical work, his development of 'Howlett-Lehrer theory' to solve decomposition problems in algebra and geometry, and his development of 'Springer-Lehrer theory', with geometric and algebraic applications. His recent joint solution of the second fundamental problem of invariant theory has resolved a question of 75 years standing.

#### Braids and invariants

Invariants are things which remain the same under transformations. Knowing all invariant quantities of a system is important in mathematics, physics and other branches of science and economics. Professor Lehrer will give a glimpse into the ideas used to study and resolve these questions. Surprisingly, the ability to tie knots is an advantage.

### Hannan Medal

**Professor Alan McIntosh FAA**

*Mathematical Sciences Institute, The Australian National University*

Professor Alan McIntosh works at the boundary between harmonic analysis and partial differential equations, two pillars of modern mathematics and physics. He is famous for having given with his collaborators the final answer to the Kato conjecture, a question raised in 1961 which puzzled specialists for 40 years. The techniques that he and his co-workers have developed have revolutionised the way we analyse the fundamental operators of physics.

#### Harmonic analysis and first order systems

Over 200 years ago, Fourier solved the heat equation in solids by representing the solution as a sum of sine functions. This led to representations of a signal as a sum of waves of fixed frequency, and more recently as a decomposition into other basic components such as wavelets. The theory behind such decompositions is known as harmonic analysis, which forms a deep and beautiful part of mathematics with surprisingly powerful applications. In applications to the heat equation or the wave equation associated with discontinuous physical media, the decomposition can be correspondingly adapted. Underlying such second order equations, there are often first order systems, such as the Cauchy-Riemann equations of complex function theory, and Maxwell's equations of electromagnetism. It can be edifying to apply the harmonic analysis directly to the first order systems, rather than via the second order equations, as Professor McIntosh will outline in his presentation.

## Jaeger Medal

### Professor Trevor McDougall

FAA FRS

*School of Mathematics and Statistics, The University of New South Wales*

Professor Trevor McDougall is internationally renowned for his ground-breaking work on ocean mixing processes and the thermodynamics of seawater. He has identified new mixing processes; defined neutral density surfaces along which mesoscale eddies mix; shown how lateral mixing processes should be included in ocean models; and redefined all the thermodynamic variables used in oceanography. His discoveries have improved ocean climate models and changed the way oceanographic data are analysed, increasing the accuracy of the science and confidence in models of the coupled atmosphere-ocean-ice climate system.

### Ocean mixing and climate

The ocean's role in the climate system is predominantly to store and to transport heat and carbon dioxide. The ocean acts as a giant 'flywheel', reducing the impacts of humanity's ongoing greenhouse gas experiment. The ocean's ability to do this is sensitive to the strengths of interior mixing processes which allow seawater to move vertically through 'density' surfaces, leading to the vertical overturning circulation. Professor McDougall will introduce some newly discovered ocean mixing processes and explain his team's attempts to quantify their importance.

## Thomas Ranken Lyle Medal

### Professor Michelle Simmons

FAA

*ARC Centre for Excellence for Quantum Computation and Communication Technology, The University of New South Wales*

Professor Michelle Simmons has pioneered a radical new technology for creating atomic-scale devices producing the first ever electronic devices in silicon where individual atoms are placed with atomic precision and shown to dictate device behaviour. Her ground-breaking achievements have opened a new frontier of research in computing and electronics globally. They have provided a platform for redesigning conventional transistors at the atomic-scale and for developing a silicon-based quantum computer: a powerful new form of computing with the potential to transform information processing.

### Atomic-scale electronics for quantum computing

Down-scaling has been the leading paradigm of the semiconductor industry since the invention of the first transistor in 1947. However, miniaturisation will soon reach the ultimate limit, set by the discreteness of matter, leading to intensified research in alternative approaches for creating logic devices. Professor Simmons will discuss the development of a radical new technology for creating atomic-scale devices which is opening a new frontier of research in electronics globally. She will introduce single atom transistors where both the charge and spin of individual dopants with unique capabilities in controlling the quantum world can be measured. She will discuss how it's now possible to demonstrate atom by atom the best way to build a quantum computer—a new type of computer that exploits the laws of physics at very small dimensions in order to provide an exponential speed up in computational processing power.

## Dorothy Hill Award

### Dr Nerilie Abram

*Research School of Earth Sciences, The Australian National University*

Dr Nerilie Abram's pioneering research addresses the past behaviour of the Earth's climate system, and implications for anthropogenic climate change. Her outstanding research portfolio has generated unique new records of past climate and environmental impacts from regions spanning the tropics to Antarctica, and assessing these alongside state-of-the-art climate models. Her high-impact work has led to groundbreaking advances in understanding how climate change is impacting Southern Ocean winds, Antarctic temperatures and Australian rainfall patterns.

### Australia's changing climate from the perspective of the past millennium

Australia is known as a land of 'droughts and flooding rains', but how unusual were recent extremes like the millennium drought and the 2011 floods? And to what extent is human-induced climate change altering Australia's rainfall patterns? To answer these questions we need long reconstructions of the climate modes that impact Australian climate (such as the El Niño-Southern Oscillation and Southern Annular Mode). Dr Abram will look at ways in which evidence can be unlocked from natural archives, such as corals and ice cores, to understand how different climate modes have evolved and interacted over the past millennium. These records can be compared with state-of-the-art climate models to test hypotheses around how various natural and anthropogenic factors affect climate. They also provide the critical context for understanding the likely impacts of future climate change in the Australian region.

## Inaugural Gustav Nossal Medal

### Professor Nicholas Anstey

*Head, Global and Tropical Health Division, Menzies School of Health Research*

Professor Nicholas Anstey has undertaken clinical research in malaria and tuberculosis with partners in the Asia–Pacific. He has identified new ways that parasites cause severe malaria, translating these findings to clinical trials of agents to improve blood supply to vital organs. He has also undertaken clinical trials of drugs to treat all three major species causing malaria in the Asia–Pacific region. He uses these results to contribute to policy change nationally, regionally and globally.

### Towards the better treatment of severe malaria

Professor Anstey's team has been working for 18 years to reduce deaths from severe malaria, by trialling newer antiparasitic drugs and identifying new mechanisms that underlie severe disease. The team has undertaken clinical trials identifying better antimalarial drug treatments for both uncomplicated (early) and severe (late) malaria from the three major parasite species which cause disease in humans. In field studies in Indonesia, Malaysia and Tanzania they have also identified new mechanisms underlying the reduced organ blood supply in severe falciparum malaria, including a profound deficiency of a key protective molecule, nitric oxide (NO), in the endothelial cells lining blood vessels. Multiple causes and consequences of NO deficiency have been identified. Professor Anstey will talk about how the team has used these findings to design and undertake clinical trials of agents to improve blood vessel function in severe malaria.

## Inaugural Jacques Miller Medal

### Professor Michael Cowley FTSE

*Monash Obesity & Diabetes Institute, Monash University*

Professor Michael Cowley has discovered how the body informs the brain about how much body fat we have, and how much sugar there is in our blood. Through his understanding of these pathways in the brain he has devised new drugs to treat obesity, and he has recently discovered why obesity causes high blood pressure. He has received several awards for his research, and now leads a global effort to find new diabetes drugs.

### How does obesity cause hypertension?

Professor Cowley has discovered how the body informs the brain about how much body fat we have, and how much sugar there is in our blood. Through his understanding of these pathways in the brain he has devised new drugs to treat obesity, and he has recently discovered why obesity causes high blood pressure. He has shown that a hormone secreted by body fat acts in the brain to increase the activity of the sympathetic nervous system and directly increase blood pressure. This explains the often observed rates of high blood pressure in obese people.

## Gottschalk Medal

### Dr Peter Czabotar

*Structural Biology Division, Walter and Eliza Hall Institute of Medical Research*

PHOTO: CZESIA MARKIEWICZ

Dr Peter Czabotar's research is delivering new insights into the molecular control of programmed cell death, an important biological defence mechanism that removes dangerous cells from the body including those involved in tumourigenesis. He has played a key role in the development of therapeutics that induce cell death in tumours and his recent work provides new strategies for developing agents to treat disorders characterised by excessive cell death such as neurodegeneration.

### Structural studies of cell death pathways

Programmed Cell Death, a process the body uses to remove superfluous, damaged or dangerous cells, plays a crucial role in the development of the embryo and in the maintenance of homeostasis. An understanding of the interactions between proteins regulating the cell death pathways is vital for the development of therapeutics aimed at treating disease associated with aberrant cell death such as cancer, degenerative disorders and inflammatory disease. Crystallographic studies of the Bcl-2 family of proteins, which regulate the mitochondrial pathway to apoptotic cell death, have allowed us to understand at the atomic level the interactions occurring between the functionally opposing members of this family that govern a life/death switch in the cell. These studies have directly informed the development of therapeutics capable of re-initiating this death pathway in cancer cells resistant to apoptotic stimuli.

## Nancy Millis Medal

### Professor Tamara Davis

*School of Mathematics and Physics, The University of Queensland*

Professor Tamara Davis uses astrophysics to test our fundamental laws of physics, and study the nature of dark energy and dark matter. She is one of the most highly cited astrophysicists in the world. Her contributions include testing advanced theories of gravity, measuring time-dilation of distant supernovae, using galaxies to measure the mass of the lightest massive particle in nature (the neutrino), and discovering that active galaxies fuelled by black holes can be used as standard candles.

### The dark side of the universe

Observations of the universe over the last few decades have thrown researchers some curve balls. We thought we had the basic picture—the universe is expanding, and all the structure we now see formed under the influence of gravity out of over-dense clumps in the hot, dense, early universe. That's all true, but we've since realised it's not the end of the story. There's a dark side to the universe that we don't usually see, and it seems that everything we thought we knew makes up only 5% of the universe. Dark matter and dark energy make up the rest. Professor Davis will explain why we are so certain of such a seemingly ludicrous proposition, and what we can hope to learn by studying these phenomena.

## Christopher Heyde Medal

### Associate Professor Catherine Greenhill

*School of Mathematics and Statistics, The University of New South Wales*

PHOTO: UNSW

Associate Professor Catherine Greenhill is internationally recognised as a leading expert in asymptotic, probabilistic and algorithmic combinatorics, undertaking research at the interface between combinatorics, probability and theoretical computer science. By studying fundamental combinatorial objects, such as graphs, she tackles problems of major significance to pure mathematics. Her highly-cited research achievements include new formulae and algorithms that have found broad application in many areas, from statistics to computer science, physics and cryptography.

### From sampling to counting and back again

Graphs (also called networks) are combinatorial structures which are very good at modelling relationships between objects in a complex system. For this reason, graphs are used by researchers in many different fields including physics, biology, computer science and sociology. Often the focus is on the family of graphs which satisfy certain properties, such as having a fixed number of edges or a specified degree sequence. Typical questions include 'How many graphs are there with these properties?' and 'How can I choose a typical (or random) graph with these properties?'. Finding mathematically rigorous answers to these apparently simple questions is a challenging task, although progress can be made by exploiting the connections between sampling and counting.

## Christopher Heyde Medal


### Dr Scott Morrison

*Mathematical Sciences Institute, The Australian National University*


The interaction of quantum particles or quasi-particles in two dimensions involves a so-called 'fusion category' which describes the possible outcomes of collision between the quasi-particles. Diagrams describing the fusion category are analogous to the Feynmann diagrams well known in quantum field theory. Dr Scott Morrison has made remarkable discoveries especially in this diagrammatic description of such low-dimensional processes. In particular he has classified the least complicated such theories that mathematics permits.

### Topological matter

Topology is a field of pure mathematics concerned with the shapes of things, without measuring lengths, angles, or areas. The standard joke is that a topologist can't tell the difference between a coffee mug and a donut. What could this have to do with real world physics? Recent discoveries in condensed matter physics reveal that certain exotic phases of matter are described by 'topological field theories'. A topological field theory has an alternate description as a 'higher category', which is an algebraic gadget in which the algebraic operations are indexed by the ways we can glue topological shapes together. Dr Morrison studies and attempts to classify topological field theories. They turn out to be most interesting in dimensions 2, 3, and 4—and whether or not that's a coincidence, those are the dimensions that matter in our world.

## Pawsey Medal


### Professor Naomi McClure-Griffiths

*Research School of Astronomy and Astrophysics, The Australian National University*


Professor Naomi McClure-Griffiths is an internationally-recognised radio astronomer, who has used 'The Dish' at Parkes and other Australian telescopes to make stunning new discoveries about our home Galaxy, the Milky Way. Her research has provided unprecedented insights into how the Milky Way is structured, lives its life, and interacts with its neighbours. She has unravelled the complicated pinwheel-like structure of our home Galaxy and has helped explain how the Milky Way keeps finding fresh gas to make new stars.

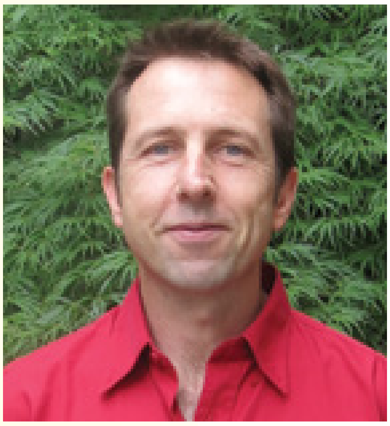
### Exploring the Milky Way with the world's greatest radio telescopes

Our own galaxy, the Milky Way, gives us a local laboratory to study how the big spiral galaxies of the Universe formed, and how they live their lives. Radio telescopes, like the iconic Parkes 'Dish', give a unique view of the gas and magnetic fields that form the atmosphere for galaxies and control the formation of the stars within. To keep up its voracious habit of star formation, the Milky Way must receive a steady trickle of fresh gas from intergalactic space. Professor McClure-Griffiths will give an overview of some recent insights into how the Milky Way acquires this fresh gas and the lifecycle of the gas within the Milky Way. These questions and the techniques she is developing for answering them will pave the way to the world's next great radio telescope, the Square Kilometre Array.

## Fenner Medal


### Dr Ian Wright

*Department of Biological Sciences, Macquarie University*

Plants grow by investing in leaves, which return revenue by photosynthesis. Working through Australian field studies and also through international collaboration, Dr Ian Wright has elucidated major patterns governing investment in leaves. There is a leaf economic spectrum running from cheap to expensive leaf construction, with returns correspondingly running from quick to slow. On low nutrient soils more expensive construction is found which confers longer leaf lifespan. In dry environments more nitrogen is invested which economises on water use.

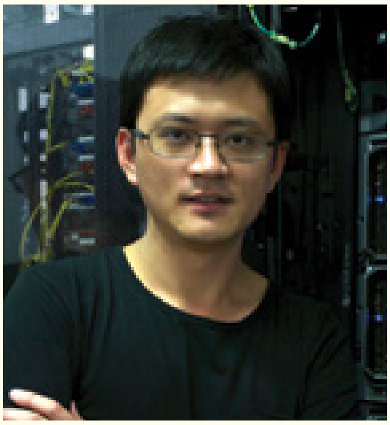
### Making sense of global variation in plant traits

There are approximately 300 000 species of land plants. In some properties (traits) there is very conspicuous variation among species, such as the size and texture of leaves and their nutrient concentrations and physiological rates; the dimensions of vascular elements in sapwood; and the typical maximum height. In other traits there is far less variation, such as the density of sapwood or the leaf-internal operating concentration of $CO_2$ during photosynthesis. Similarly, in some properties plants show striking convergence related to site climate despite millions of years of evolutionary separation; in other ways, closely-related species show great diversity in form. Plant geographers (more recently known as ecologists) have been trying to make sense of all this variation for 150 years. In this talk Associate Professor Wright describes some exciting advances in this research area from work that draws together elements from global trait ecology, fine-scale ecophysiology, microeconomic theory and vegetation modelling.

## Ruth Stephens Gani Medal

### Dr Jian Yang

*Queensland Brain Institute, The University of Queensland*



Dr Jian Yang has developed novel statistical analysis methods to show that individual differences between people for many characteristics, such as height and whether they are more or less susceptible to disease than others, are due to the cumulative effect of many genes each with a small effect. He solved the problem that genes identified from recent large-scale genetic studies explained only a small part of the genetic basis of such characteristics. He has distributed his software tools widely and many other researchers now apply his statistical genetic methods to their data.

### Understanding the genetic architecture of complex traits in humans

Most human complex traits such as height and obesity are influenced by multiple genetic factors, and pedigree analyses imply that the heritability for these traits is high. Yet genes identified from recent large-scale genome-wide association studies (GWAS) using single-nucleotide polymorphisms (SNPs) only explain a small fraction of the heritability. Dr Yang has solved this apparent paradox through the development and application of novel statistical genetics methods that quantify the contribution to variation from all the SNPs jointly, irrespective of statistical significance. His highly-cited work, which spans molecular, population and epidemiological genetics, caused a paradigm shift and a re-appraisal of experimental designs to map genes that influence complex traits.

## Moran Medal

### Associate Professor Yee Hwa Yang

*School of Mathematics and Statistics, The University of Sydney*

Associate Professor Yee Hwa Yang is an applied statistician who has made significant contributions to the development of statistical methodology for analysing molecular data arising in contemporary biomedical research. Her work on removing extraneous variability for microarray data has been incorporated in major software packages used worldwide to identify gene expression patterns. She has also developed novel methods for integrating molecular and clinical data and has already made an impact on melanoma research by identifying potential genes that help with predicting survival outcome.

### Improving accuracy in cancer prognosis

Ongoing research in cancer continues to highlight the extensive genetic diversity both within and between tumours. This intrinsic heterogeneity poses one of the central challenges to predicting patient clinical outcome as well as the personalisation of treatments. Recent work examining molecular biomarkers of prognosis has shown that individual patient samples can often be partitioned as a function of how 'easy' they are to classify by a particular biomarker. Associate Professor Yang has demonstrated in melanoma, breast, and colorectal cancer that clinico-pathologic variables can be used to point to which patients can be correctly classified by a biomarker. She will explain how including this information not only improves classification performance but also points to specific clinical attributes which can explain the heterogeneity in each cohort and paves the way for a new generation of interpretable prognostic biomarkers for complex disease.

## Anton Hales Medal


### Dr Yingjie Yang

*Department of Earth and Planetary Sciences, Macquarie University*


PHOTO: GEMOC MACQUARIE UNIVERSITY

Dr Yingjie Yang is responsible for a major breakthrough in the treatment and interpretation of seismic data, which has opened up the use of ambient noise signals to decipher structures in Earth's crust and upper mantle. Up to now, earthquakes or explosions had been necessary to generate seismic data; with Dr Yang's method the background creaks and groans of Earth can be used to make images of the internal structure of Earth.

### The sound of the sea: 3D imaging of the Earth using noise from ocean waves

Seismic tomography is the main technique used to visualise the subsurface structure of the Earth, helping to understand the thermal structure and chemical composition of the Earth's interior. Seismic tomography is similar in principle to CT scans used in medicine. In a CT scan, doctors can 'see' organs and bones inside human bodies; through seismic tomography, we can 'see' different Earth structures. Conventional seismic tomography depends on the seismic waves emitted by earthquakes, but these are unevenly distributed and make it difficult to decipher smaller structures in seismically quiet continents.

Recently, ambient noise tomography (that exploits ubiquitous noise from ocean waves to generate seismic data) has revolutionised seismic tomography because it overcomes the limitations of conventional earthquake tomography. Dr Yang will discuss this innovative technique and its applications in deciphering regional- and global-scale lithospheric structures.

# Early- and mid-career researcher workshops

2.05PM – 5.30PM, WEDNESDAY 27 MAY

Early- and mid-career researcher (EMCR) participants are invited to attend one of four workshops, delivered by experts and targeted to their specific needs.

## Topic 1: Leadership in science

**Becker Room, ground floor, Shine Dome**

**Chaired by Dr Sharath Sriram and Professor Tamara Davis**

Success in science often comes through vision and by creating and leading a team to share this vision. This implies leadership skills in strategy and people management are important to a successful research career. Through a mix of presentations and group activities, this workshop aims to provide EMCRs with examples and tools that can support a postdoctoral researcher to become a science leader.

### Professor Tamara Davis

Professor Tamara Davis uses astrophysics to test our fundamental laws of physics, and study the nature of dark energy and dark matter. Her contributions include testing advanced theories of gravity, measuring time-dilation of distant supernovae, using galaxies to measure the mass of the lightest massive particle in nature (the neutrino), and discovering that active galaxies fuelled by black holes can be used as standard candles. She's on the executive of the ARC Centre of Excellence in All-sky Astrophysics and the winner of this year's Australian Academy of Science Nancy Millis Medal.

### Dr Sharath Sriram

Dr Sharath Sriram is the joint leader of the Functional Materials and Microsystems Research Group at RMIT University in Melbourne. He is also the Deputy Director of the University's Micro Nano Research Facility. Dr Sriram's expertise includes the synthesis of functional thin films (at thickness scales 1/1000th to 1/100th of a human hair) and micro/nanostructures and devices. He is also the Chair of the Australian Academy of Science's Early- and Mid-Career Researcher Forum.

## Topic 2: Research and industry partnerships

**Boardroom, ground floor, Ian Potter House**

**Chaired by Dr Laura Dan and Dr Peter Czabotar**

Partnerships between academia and industry are an important mechanism for the translation of basic scientific findings to outcomes that can benefit the wider community. This workshop will explore pathways to establishing industry partnerships and identify issues unique to these collaborations. This will be followed by group discussions and exercises aimed at providing participants with an understanding of the opportunities and challenges associated with working with industry partners.

### Dr Peter Czabotar

Dr Peter Czabotar is a laboratory head at the Walter and Eliza Hall Institute of Medical Research. His research focuses on understanding the pathways that regulate programmed cell death at the molecular level using X-ray crystallography and biochemistry. Dr Czabotar was a member of an international academic–industry drug discovery collaboration aimed at developing compounds capable of reinstating cell death in cancer cells. This collaboration developed a new drug, Venetoclax, currently in phase III clinical trials for the treatment of acute myeloid leukaemia and chronic lymphocytic leukaemia.

### Dr Laura Dan

Dr Laura Dan joined the Australian Research Council in 2011 and is its Chief Program Officer, leading the operations and strategy of the National Competitive Grants Program. Prior to joining the ARC, Dr Dan spent six years in research leadership roles at the Australian National University. She also served as Convener of the ACT Chapter of the Australasian Research Management Society (ARMS) between 2009 and 2011and is currently a member of the ARMS Accreditation Council. Dr Dan's interests are strategic research management and leadership. She has published two books and lectured across several disciplines, including linguistics, French, and international business.

## Topic 3: Successful grant writing

**University House**

**Chaired by Professor Naomi McClure-Griffiths and Associate Professor Nicolas Cherbuin**

Professor Naomi McClure-Griffiths and Associate Professor Nicolas Cherbuin will discuss funding opportunities and preparing successful applications to the Australian Research Council and the National Health and Medical Research Council. The workshop will focus on strategies for applying for national funding, insights into the review process, skills in grant writing, and responding to reviewers, followed by group discussion and feedback from delegates. There will be opportunities for networking with other participants and scientists during the workshop.

### Associate Professor Nic Cherbuin

Associate Professor Nic Cherbuin is an ARC Future Fellow and heads the NeuroImaging and Brain Lab (NIMBL) at the Centre for Research on Ageing, Health and Wellbeing. His main research interests are the investigation of contributors to brain and cognitive ageing and the identification of risk factors for dementia. He was awarded a PhD in 2006 at ANU. From 2006 until 2008 he was the recipient of an Alzheimer's Australia Research and CMHR Fellowship. In 2007, he was awarded an NHMRC Fellowship to investigate associations between pre-frontal brain function and structure and cognition. Nic's current Future fellowship is focused on investigating theoretical models of age- and disease-related changes in brain structure and cognition. Nic is also a member of the Dementia Collaborative Research Centre II, a federal initiative focused on dementia early detection and prevention, and a chief investigator on the large, NHMRC-funded PATH Through Life epidemiological study.

### Professor Naomi McClure-Griffiths

Professor Naomi McClure-Griffiths joined the Research School of Astronomy and Astrophysics of the Australian National University in early 2015 after 13 years with CSIRO. Her research uses radio telescopes in Australia and around the world to study the structure and evolution of our own galaxy, the Milky Way, and its near neighbours, the Magellanic Clouds. She is also involved in science planning for the Square Kilometre Array. Professor McClure-Griffiths earned her PhD at the University of Minnesota in the US in 2001, received the 2006 Prime Minister's Malcolm McIntosh Prize for Physical Scientist of the Year, and is the 2015 winner of the Pawsey Medal of the Australian Academy of Science. She was a member of the Australian Research Council College of Experts from 2012 to 2014.

## Topic 4: Communication and collaboration in science

**Boardroom, first floor, Ian Potter House**

**Chaired by Dr Scott Morrison and Dr Will Grant**

Dr Scott Morrison and Dr Will Grant will host a discussion on collaboration as an early career researcher. They will invite everyone to contribute their experiences—both in building successful collaborations, and struggling with the difficulties in establishing these. Building on the discussion, they will talk about strategies and skills that may support career development through better collaboration.

### Dr Scott Morrison

Dr Scott Morrison is a mathematician working at the Australian National University. He's interested in the interplay between topology and algebra, particularly studying 'topological field theories' in 2, 3, and 4 dimensions. It's a new subject in mathematics, and there's still much that we don't know. Already there are connections with condensed matter physics and quantum computation. By studying topological field theories, we learn about the possible topological phases of matter, and hopefully discover (or even engineer) topological phases which could support quantum computation.

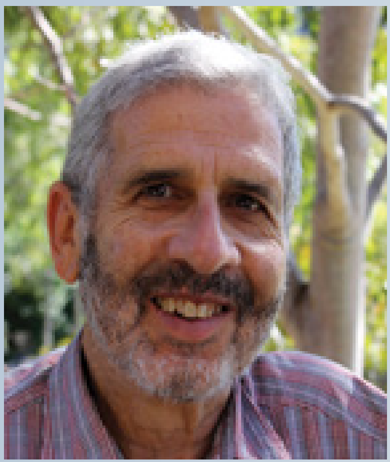
Dr Morrison received his PhD at UC Berkeley in 2007, and since then has worked at Microsoft's Station Q, as a postdoc at UC Berkeley, and since 2012 at the Australian National University. He's a founder and moderator of the collaborative website 'MathOverflow', hosting a question-and-answer format forum for research mathematicians.

### Dr Will Grant

Dr Will Grant is lecturer, researcher and Graduate Studies Convener at the Australian National University Centre for the Public Awareness of Science.

Dr Grant's research and writing has focused on the intersection of society, politics and science, and how the relationships between these are changing with new technologies.

# Symposium speakers



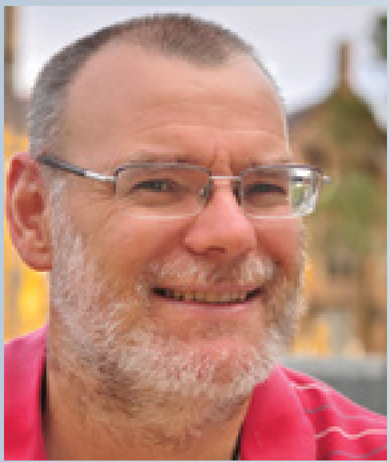
Mitchell Guss

## CONVENOR

### Professor Mitchell Guss

Professor Mitchell Guss has spent his research career of nearly 50 years solving the structures of molecules of biological interest with a particular focus on metalloproteins and enzymes. He worked with Professors Hans Freeman and Peter Colman on the first protein structures solved in Australia. In recent years he has taken an active interest in establishing publication standards for structural biology, including requirements for the deposition and access to primary data and guidelines in the area of small angle scattering. He is currently an executive member of the International Union of Crystallography, Chair of the Australian National Committee for Crystallography and recently Chair of the Scientific Advisory Committee of the Australian Synchrotron.

Mitchell Guss collaborated with the National Committee for Crystallography and Professor Peter Colman to convene the 2015 Symposium.



Brendan Kennedy

## CHAIRS

### Professor Brendan Kennedy

Professor Brendan Kennedy is currently Professor of Solid State Chemistry at the University of Sydney. He completed his PhD under the supervision of Keith Murray at Monash University and after post-doctoral positions at Oxford and ANU moved to Sydney in 1988. He has held visiting positions at Kyoto University and Brookhaven National Laboratory. His research focuses on structural transitions in metal oxides and studies the impact of temperature and pressure. Professor Kennedy makes extensive use of major synchrotron and neutron scattering facilities. He has served on advisory committees for both the OPAL reactor and Australian Synchrotron as well as for international facilities in Japan and US.

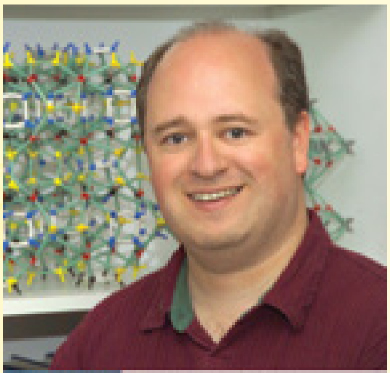
PHOTO: GLEN EARNSHAW

Alice Vrielink

### Professor Alice Vrielink

Professor Alice Vrielink obtained her Bachelor of Science in Chemistry and Masters of Science in Physical Chemistry at the University of Calgary in Canada. She then completed a PhD in Physics at the University of London and a Diploma in Crystallography from Imperial College of Science and Technology, London. From 1994 to 2001 Professor Vrielink was an Assistant and Associate Professor at McGill University in Canada. She then continued her research as a Research Professor at the University of California, Santa Cruz. In 2007 she joined the faculty at the University of Western Australia as Professor of Structural Biology. Her research focuses on how enzymes carry out their highly specific chemical reactions in life systems. Currently a major focus is on understanding processes by which bacteria evade the host immune system and generate drug resistance.

## Professor Stuart Batten



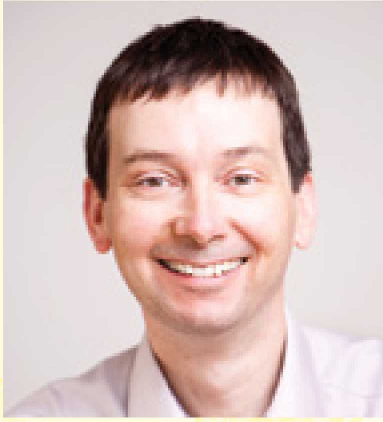
SPEAKER SPONSOR MONASH University

Professor Stuart Batten is a Professor of Chemistry at Monash University and the current President of the Society of Crystallographers in Australia and New Zealand (SCANZ). He is also the chair of the Structural Chemistry commission of the International Union of Crystallography. His research focuses on coordination chemistry, with particular interests in crystal engineering, coordination polymers (also known as metal-organic frameworks, or MOFs) and supramolecular chemistry. This research has attracted over 18 000 citations (h-index = 65) and been recognised by the recent awarding of Highly Cited Researcher status (2014, Thomson Reuters), the Le Fèvre Memorial Prize (2008, Australian Academy of Science), the Rennie Memorial Medal (2002, Royal Australian Chemical Institute), and several other awards.

### Crystallography of molecules and materials

The properties of molecules, including their reactivity, depends on how the atoms are arranged within the molecule. Similarly, the properties of solid materials depend on how the constituent atoms and molecules are packed together. The most powerful technique for determining the structures of both molecules and materials is crystallography. Professor Batten will explore examples of how crystallography has advanced our understanding of why molecules and materials behave as they do, how that understanding has been crucial in improving and targeting our chemistry better, and even how crystallography has led to completely new areas of chemistry.

## Professor Henry Chapman



Professor Henry Chapman is a director of the Center for Free-Electron Laser Science at the Deutsches Elektronen-Synchrotron and the University of Hamburg in Germany. He carried out his PhD in X-ray optics at The University of Melbourne with Keith Nugent and Steven Wilkins, work for which he was awarded the Bragg Gold Medal from the Australian Institute of Physics. Professor Chapman develops methods in coherent X-ray imaging, which began at Stony Brook University in New York with the crystallographer David Sayre. Later, at Lawrence Livermore National Laboratory in California, he led a team to demonstrate that an intense X-ray free-electron laser pulse could capture information about the structure of an object before its destruction by that pulse. He then led a large international collaboration to continue this work to the atomic scale with the method of serial femtosecond X-ray crystallography, which promises to overcome current bottlenecks in protein structure determination.

### Imaging molecules with X-ray lasers

The short wavelength of X-rays allows us to image structures at the atomic scale, giving detailed pictures of biological macromolecules. However, X-ray radiation is energetic enough to ionize matter—the very act of measurement destroys the structure being investigated. Crystallography has been used to work around this limitation by spreading out the damage over billions of molecules, but it can often take years of trial and error to grow macromolecular crystals of sufficient quality. X-ray free-electron lasers produce pulses that are a billion times more brilliant than achievable at conventional sources, and which can be focused to intensities approaching conditions similar to stellar interiors. Nevertheless, pristine structural information can be obtained using pulses shorter than several femtoseconds. This concept of outrunning radiation damage has now been verified to atomic resolution by macromolecular 'nanocrystallography'. It appears feasible to determine the structures from uncrystallized single molecules.

## Professor Peter Colman

**FAA FRS FTSE**

PHOTO: CZESIA MARKIEWICZ

Professor Peter Colman took his PhD in physics at the University of Adelaide before embarking on a career in structural biology. Postdoctoral studies with Robert Huber in Munich on the molecular structure of antibodies led to a collaboration with Graeme Laver at ANU on influenza virus antigens. During a twenty year period at CSIRO Professor Colman described the first structures of antibodies bound to viral antigens and led a team that discovered zanamivir, a first-in-class antiviral agent for influenza. Now at the Walter and Eliza Hall Institute, Professor Colman investigates the molecular events leading to the programmed death of cells. The cell death machinery is frequently dysfunctional in cancer and agents that re-awaken it are in clinical trials for certain blood cancers.

### Crystallography and new medicines: Examples from influenza and cancer

The idea that crystallography could influence drug discovery goes back at least to the 1970s, and the first practical demonstrations appeared in the 1980s. Visualising, atom-by atom, the interaction between a drug-like molecule and its target-site in the body shapes both the thinking of a medicinal chemist and the type of molecule he seeks to make. Professor Colman will discuss his experiences with historical and contemporary examples.

## Professor Joanne Etheridge


Joanne Etheridge is the Director of the Monash Centre for Electron Microscopy and Professor in the Department of Materials Engineering at Monash University. She obtained her degree in theoretical physics at the University of Melbourne and a PhD in applied physics at RMIT University. She then held appointments at the University of Cambridge in the Department of Materials Science and Metallurgy and Newnham College, including a Rosalind Franklin Research Fellowship and a Royal Society University Research Fellowship. She returned to Melbourne to join Monash University where she established the Monash Centre for Electron Microscopy (MCEM). Her research interests are in the theory of electron scattering in solids and its application to the development of new methods for determining the atomic structure and defect structure of materials. This includes interests in the theory, interpretation and application of electron microscopy and diffraction using electron beams that are smaller than an atom in diameter. She also applies electron microscopy to the study of functional materials, including perovskite, nanoparticle and semiconductor systems.

### Electron—crystallography: Probing the atoms that matter

What if we use electrons, rather than X-rays or neutrons, to probe the atomic structure of matter? Electrons have charge and picometre wavelengths, enabling them to interrogate matter in a very different way. It is just over 80 years since the first electron microscope was demonstrated, and modern instruments can now create images of atoms with unprecedented resolution. Electron waves can be focused to a spot that is much smaller than an atom in diameter, meaning that individual atoms or atomic columns within a crystal can be probed selectively. This is particularly powerful for determining the atomic structure of nanostructured materials, whose properties are often governed by small numbers of special atoms located at critical positions within a larger structure. Professor Etheridge will illustrate this with examples of nanostructures from the natural and engineered world.

## Professor Jenny Martin

Professor Jenny Martin trained as a pharmacist and was the Gold Medallist of her year. Her DPhil in protein crystallography and drug design was awarded from the University of Oxford. After postdoctoral research at Rockefeller University New York, Jenny returned to Australia to establish the first protein crystallography laboratory in Queensland. She has held several nationally competitive fellowships including an ARC Australian Laureate Fellowship at the Institute for Molecular Bioscience in the University of Queensland. From 2008–11, she chaired the National Committee for Crystallography of the Australian Academy of Science, from 2007–09 she was a member of the Australian Synchrotron Scientific Advisory Committee, and she is currently the Vice-President of the Asian Crystallography Association.

### Biological crystallography: Wonder and awe

If DNA is the information of life, then the proteins they encode are the machines of life. But what do DNA and proteins look like? And how do they operate? The secrets of these molecular machines have been revealed through biological crystallography. Important landmarks such as crystal structures of DNA, haemoglobin and insulin showed for the first time the fascinating diversity and complexity of the molecules of life. Fittingly, the world repository of biological crystal structures—the Protein Data Bank open access resource set up in the 1970s—recorded its 100 000th entry in 2014, the UNESCO International Year of Crystallography. Advances in molecular biology, robotics, synchrotron science, computing and crowd-sourcing have revolutionised the field, accelerating crystal structure determinations of key biological molecules. Importantly, these fundamental new discoveries explain how biology works at the molecular level and highlight the wonder and awesomeness of nature.

## Dr Helen Maynard-Casely

Dr Helen Maynard-Casely is a planetary scientist based at the Bragg Institute, ANSTO, where she investigates materials relevant to the surface of the icy moons Europa and Titan. Her journey to exploring these icy moons began with her degree in Planetary Sciences from University College London, and was followed by her PhD in high-pressure physics at the University of Edinburgh. Moving to Australia first to undertake a post-doctoral position at the Australian Synchrotron, she moved to the Bragg Institute in 2013 to work on the High Intensity Powder Diffractometer (known as WOMBAT). When not working on WOMBAT, Helen also promotes science to as wide an audience as possible, with skills in this area honed whilst working as the Christmas Lecturer's researcher for the Royal Institution of Great Britain. She currently writes 'The shores of Titan' column for The Conversation.

### Crystallography that is out of this world!

Although our own Earth is mainly composed of silicate and metals, this is not the case for the majority of the mass of our solar system. Instead, most of the solar system, and indeed many of the extra solar planets we have identified, are composed of small molecules often existing under very extreme conditions. Crystallography has proved an excellent way to explore the properties of these materials in situ. This unrivalled window has allowed us to model and interpret accurately the myriad of phenomena that have been observed.

From the hydrates that govern the cryovolcanoes on the surfaces of the ice moons to the quest for the metallic hydrogen in the centre of Jupiter—the goal of understanding the planets, inside and out, has taken crystallography out of this world, even to the extreme end of installing a powder diffraction instrument on Mars.

## Dr Adrian (Adi) Paterson

Dr Adi Paterson commenced as Chief Executive Officer of the Australian Nuclear Science and Technology Organisation (ANSTO) in 2009. In this role, he has oversight and responsibility for ANSTO's multi-facetted portfolio of activities.

Since his arrival at ANSTO, Dr Paterson has driven a program of positive change and growth. These transformation processes have focused on the interrelation between public spending and practical innovation. This has seen ANSTO become the operator of the Australian Synchrotron in 2013, enabling leveraging of neutron scattering at Lucas Heights and X-ray scattering in Melbourne for an extensive user community in Australia, New Zealand and overseas.

A number of major engineering projects have been initiated and are being progressed: the world-class Centre for Accelerator Science, a new suite of neutron beam instruments, the first commercial synroc waste processing plant and a global scale nuclear medicine facility. This new manufacturing facility will enable ANSTO to supply internationally and alleviate a world shortfall in supply of molybdenum-99.

Dr Paterson was elected a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) in 2009. In 2012 he was elected a Fellow of Engineers Australia and recognised by the Sydney Division as their 2012 Professional Engineer of the Year. He holds a BSc in Chemistry and a PhD in Engineering from the University of Cape Town.

### Crystallography in Australia: The role of ANSTO's landmark facilities

The development of high performance synchrotron and neutron beam facilities in the last three decades has resulted in a revolution in the technology and impact of crystallography worldwide. Smaller crystals and larger and more complex molecules are now being studied than would have been dreamed of just 20 years ago, with applications from understanding the molecular basis of life to developing materials which can withstand the extreme conditions in next generation reactors.

ANSTO has been in the forefront of Australian crystallography via provision of advanced neutron scattering facilities at HIFAR and recently the OPAL reactors. State-of-the-art synchrotron radiation facilities were provided overseas via the Australian Synchrotron Research Program, and now at the Australian Synchrotron, which ANSTO has operated since January 2013. These facilities underpin much of the distinctive research presented by peers at today's symposium. Future plans for OPAL and the Australian Synchrotron will be outlined emphasising maintaining Australian research leadership at the forefront of crystallography.

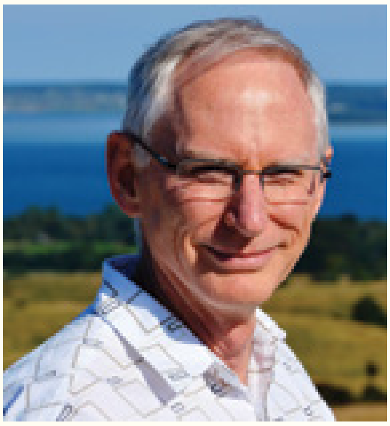
## Professor Allan Pring

Professor Allan Pring studied Chemistry and Geology at Monash university, before taking a PhD in solid state chemistry at the University of Cambridge in 1983. He joined the South Australian Museum as curator of minerals in 1984 and built a large research group studying the crystal chemistry of sulfide minerals and the chemistry and physics of ore deposit formation. The group specialises in experimental studies of hydrothermal ore-forming processes using in situ diffraction techniques. In 1993 he was an Alexander von Humboldt Fellow at the University of Hamburg and in 1999 a visiting fellow at Trinity College, Cambridge. He was also awarded a ScD by the University of Cambridge for his contributions to mineralogy in 2006. In 2014 he was appointed Distinguished Research Professor in Chemical Mineralogy in the School of Chemical and Physical Sciences, Flinders University.

### Mineralogy and X-ray crystallography: A symbiotic growth

For over a century before the discovery of X-ray diffraction and structure determination, the sciences of crystallography and mineralogy had grown together. By the turn of the 20th century, the threshold of structure determination of close-packed structures had been reached. It was only natural that the first crystals studied by the new X-ray diffraction techniques were minerals: sphalerite, halite, sylvanite and diamond. Over the next 30 years many of the major developments in techniques came through the study of mineral structures. At the same time the determination of crystal structures brought about a major revolution in our understanding of the relationships between minerals and the discovery of new minerals. The number of recognised minerals species increased from around 800 in 1910 to nearly 5000 now. Today X-ray diffraction techniques are widely used in the mining industry and the study of minerals has led to breakthroughs in technological minerals.

## Professor Mark Spackman



Professor Mark Spackman received his BSc in chemical physics and PhD in theoretical chemistry from the University of Western Australia. After postdoctoral studies in the United States he joined the University of New England in 1987. With the award of an ARC Professorial Fellowship in 2003 he returned to the University of Western Australia, where he currently heads the School of Chemistry and Biochemistry. Professor Spackman has served terms as President of the Society of Crystallographers in Australia and New Zealand and Chair of the IUCr Commission on Charge, Spin and Momentum Densities, and was a member of the Australian Academy of Science's National Committee for Crystallography for over a decade. In 2013 Professor Spackman was jointly awarded the Gregori Aminoff Prize for Crystallography by the Royal Swedish Academy of Sciences 'for developing experimental and theoretical methods to study electron density in crystals, and using them to determine molecular and crystalline properties'. He is the first Australian crystallographer to be awarded this prize.

### X-ray crystallography: Built on a foundation of theory and experiment in physics

It is remarkable to look back and realise that X-rays were discovered as recently as 1895, and X-ray diffraction itself in 1912. The early development of X-ray crystallography relied heavily on fundamental advances in theoretical and experimental physics, and the first X-ray crystal structure analyses were reported by the father and son physicists, William and Lawrence Bragg in 1913—a time when little was even known about the actual nature of the atom itself. In the decades immediately following those discoveries, pioneering X-ray crystallographic studies were performed on relatively simple ionic solids and minerals, and they rapidly improved our understanding of bonding in those materials. The focus soon shifted to crystalline materials of increasing complexity—simple organic molecules and biomolecules—and these accumulated results underpinned Linus Pauling's influential 1939 book describing the subtle nature of the chemical bond in all its detail.

# Event information

## Colour coding

- New Fellows
- Fellows
- EMCRs/Lindau participants
- Awardees
- Symposium speakers

## Photo sessions

Please meet in the foyer where you will be directed.

### Tuesday

*Morning tea*

EMCRs group photo
EMCR awardee and Lindau participants group photos

*Lunch*

New Fellows group and individual photos

*Afternoon tea*

New Fellows individual photos continued

### Wednesday

*Morning tea*

Honorific Awardees (early morning session) individual photos

*Lunch*

Awardee group and individual photos

### Thursday

*Lunch*

Symposium speakers group photo

## Registration desk

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

## Luggage

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

## Replacement silk ties and scarves

Replacement silk ties and scarves with the Academy logo are available for purchase by Fellows by emailing **fellowship@science.org.au**

## Twitter

Follow us on twitter
**@Science_Academy #shinedome15**

## Wi-fi

Wireless internet access is available throughout the Shine Dome. The network is **SHINEDOME**, password is **5hinedome**. Please disable personal mobile hotspots as this can slow down the network for all delegates.

## Taxi

Canberra Elite **13 22 27**

The Shine Dome
15 Gordon Street
Canberra ACT 2601

Please use the phone located in the foyer.

## Bus routes

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

## Parking

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

## Disabled access

Two disabled parking spaces are available within the Academy car park. The Shine Dome is also equipped with wheelchair access and disabled facilities.

## Quiet spaces/hearing loop

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

The Ian Wark Theatre is equipped with a hearing loop. Please look for seats in the lower area of the theatre with a gold plaque indicating a hearing loop is available.

An IR hearing loop is available for the first floor. Please see event staff to obtain a device.

## Coach timetable

### Wednesday annual dinner

**6.30 pm** Shuttle bus runs every 10 minutes from University House to QT Hotel Canberra
Last shuttle 7.20 pm

**10.15 pm** Shuttle bus runs every 10 minutes from QT Hotel Canberra to University House
Last shuttle 11.15 pm

### Thursday airport shuttle

**4.00 pm** From the Shine Dome to the airport

## Contacts

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

### General enquiries

| | |
|---|---|
| Mitchell Piercey | 0466 271 430 |
| Ray Kellett | 0411 156 801 |

### Lindau delegates

| | |
|---|---|
| Meaghan O'Brien | 0438 458 637 |

### Early- and mid-career researchers

| | |
|---|---|
| Sandra Gardam | 0406 754 600 |

### New Fellows

| | |
|---|---|
| Karen Holt | 02 6201 9406 |

### Awardees

| | |
|---|---|
| Dominic Burton | 02 6201 9407 |

### Media inquiries

| | |
|---|---|
| Bella Counihan | 0419 212 219 |
| Kylie Walker | 0405 229 152 |

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Monash University will be sponsoring the following symposium speakers:

- Professor Stuart Batten
- Professor Joanne Etheridge

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