winter 2016

the UPDATE

3rd ed.

ALAN FINKEL

Q&A with Australia's Eighth Chief Scientist

FRONTLINE EDUCATION

Encouraging a New Generation of Discovery

KOZWAVES

Understanding the 'Everything' of Wave Theory

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

WINTER OF
DISCON
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DNESS

25 JULY - 5 AUG
THE UNIVERSITY OF NEWCASTLE

INTERNATIONAL
CONFERENCE
IN
K-THEORY

1 - 5 AUGUST
WESTERN SYDNEY UNIVERSITY

GEOMETRY
@ANU

15 - 26 AUGUST
THE AUSTRALIAN NATIONAL UNIVERSITY

NUMBER
THEORY
DOWN
UNDER 4

23-26 SEPTEMBER
THE UNIVERSITY OF NEWCASTLE

TOPOLOGICAL
MATTER
STRINGS
K-THEORY
& RELATED AREAS

26-30 SEPTEMBER
THE UNIVERSITY OF ADELAIDE

AMSI RESEARCH

SCIENTIFIC EVENTS 2016

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MATHEMATICAL
METHODS
FOR APPLICATIONS:

ANZIAM-ZAMA
JOINT MEETING

11 - 14 NOVEMBER
HANGZHOU, ZHEJIANG PROVINCE, CHINA

INTERNATIONAL
CONFERENCE
ON NONLINEAR
PARTIAL
DIFFERENTIAL
EQUATIONS

21 - 25 NOVEMBER
UNIVERSITY OF NEW ENGLAND

AMSI 16
BIOINFO
SUMMER

28 NOV - 2 DEC
THE UNIVERSITY OF ADELAIDE

mathsfest
AUSTRALIA2016

ADVANCES IN
ERGODIC THEORY
HYPERBOLIC DYNAMICS
& STATISTICAL LAWS

28 NOV – 2 DEC
MATHSFEST, CANBERRA

mathsfest
AUSTRALIA2016

60TH ANNUAL MEETING OF THE
AUSTRALIAN
MATHEMATICAL
SOCIETY

5 – 8 DECEMBER
MATHSFEST, CANBERRA

mathsfest
AUSTRALIA2016

NONLINEAR &
GEOMETRIC
PARTIAL DIFFERENTIAL EQUATIONS

9 – 13 DECEMBER
MATHSFEST, CANBERRA

AMSI 17
SUMMER
SCHOOL

9 JAN - 3 FEB
THE UNIVERSITY OF SYDNEY

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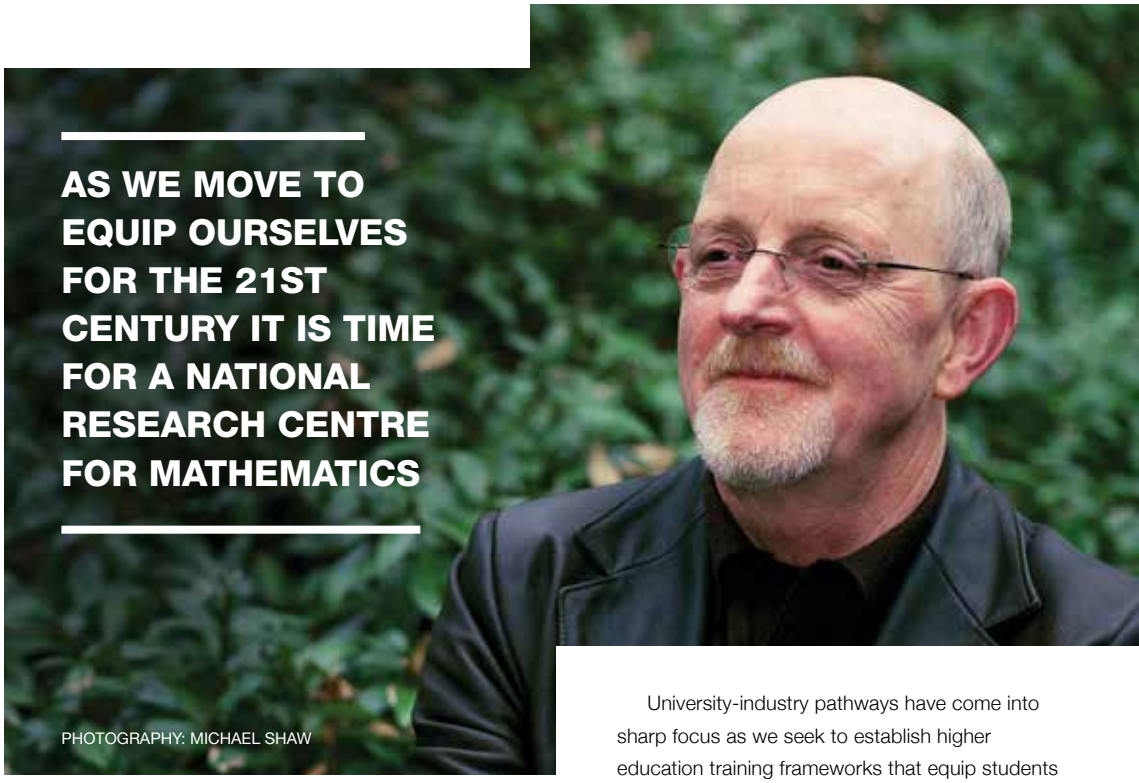


AS WE MOVE TO EQUIP OURSELVES FOR THE 21ST CENTURY IT IS TIME FOR A NATIONAL RESEARCH CENTRE FOR MATHEMATICS

PHOTOGRAPHY: MICHAEL SHAW

NO LONGER A BUZZ PHRASE, THE ELEVATION OF RESEARCH AS A CRITICAL POLICY CHALLENGE FOR THE POST-RESOURCES ECONOMY HAS AUSTRALIA PAYING ATTENTION. AS WE MOVE TO EQUIP OURSELVES FOR THE 21ST CENTURY IT IS TIME FOR A NATIONAL RESEARCH CENTRE FOR MATHEMATICS.

A quick glance at the AMSI website demonstrates the multi-discipline impact of the mathematical sciences, and its role at the heart of innovation and technological development. In this special issue of *the* Update we explore research in the mathematical sciences, in particular how it is supported at major institutes around the world and what our plans are here at home.The recent Decadal Plan for the Mathematical Sciences 2016-2020 identifies the development of a national research centre as a high priority. AMSI has been working with its membership and other partners to realise this vision to further strengthen the discipline, and I write about our progress and immediate plans. This December, Maths Fest Australia, our joint initiative with the Australian Mathematical Society and ANU, will be the launch pad for research centre activities. You can read about Maths Fest activities in this issue of *the* Update.

We also bring you an in-depth interview with Australia's new Chief Scientist, Dr Alan Finkel AO. Alan tells us why mathematics is central to his vision for a STEM nation and gives us some insights into his agenda.

University-industry pathways have come into sharp focus as we seek to establish higher education training frameworks that equip students for research and innovation in the 21st century. Leading the charge is our multi-discipline, cross-sector national postgraduate internship program, AMSI**Intern**. We catch up with AMSI**Intern** student David Price and his mentor Dr Jonathon Tuke, on their experience at SA Pathology, and uncover the impact of this program on both student interns and academic mentors.

With the launch of the CHOOSE**MATHS** Awards, we step into the classroom to explore how mathematics teachers are helping secure Australia's innovation future and the challenges facing girls and women in the discipline.

Continuing the research theme, find out how the Australasian wave science community is impacting global discovery in our report from KOZWaves 2015. Held in Adelaide, the second of this particularly successful AMSI workshop series again proved an ideal platform for robust discussion and collaboration. We also reveal the exciting location for KOZWaves 2018.

Read on!

Professor Geoff Prince FAustMS

OPENING THE DOOR TO A STATISTICAL FUTURE

Intern & Mentor Build a Lifetime Bond

WHEN AMSIINTERN OFFERED DR JONATHAN TUKE THE OPPORTUNITY TO BE ACADEMIC MENTOR ON AN INDUSTRY RESEARCH PROJECT WITH SA PATHOLOGY, HE IMMEDIATELY THOUGHT OF HIS PHD STUDENT, DR DAVID PRICE. WHAT STARTED AS A CHANCE TO GIVE HIS PROTÉGÉ A DIP IN THE INDUSTRY POOL TURNED INTO AN EXPERIENCE THAT HAS PROFOUNDLY IMPACTED BOTH RESEARCHERS, SHAPING THEIR ENGAGEMENT WITH INDUSTRY AND CEMENTING A LIFELONG FRIENDSHIP.

SO OFTEN IN PRACTICAL APPLICATION, STATISTICAL THEORY AND MODELLING COLLAPSE UNDER THE WINGS OF REALITY. SUDDENLY YOU ARE IN THE REAL WORLD WITH ALL THE VARIABLES AND CHALLENGES THAT BRINGS

THE INTERN

It has been said, "in theory, theory and practice are the same. In practice, they are not."

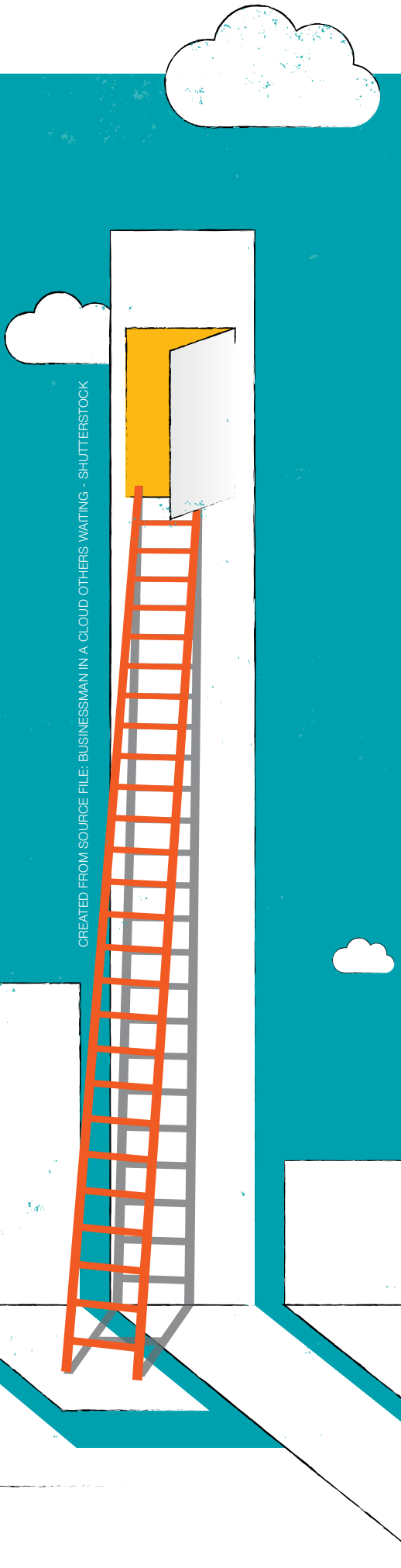
This truth is not lost on Dr David Price, who recently discovered the challenges of industry thanks to an AMSI**Intern** placement with SA Pathology. The then PhD student provided applied statistics expertise to improve outcomes for Chronic Myeloid Leukaemia patients through tailored treatment plans.

"The internship was the first time I had properly worked with non-statistical research scientists on a project. Adding to the challenge it was also an unfamiliar research area, which required close collaboration with experts outside my field," Dr Price explains.

With industry engagement a big part of the job for applied statisticians, David welcomed the chance to gain experience under the guidance of his University of Adelaide supervisor and mentor, Dr Jonathan Tuke. A former veterinarian, Jonathan's biology background and understanding of industry proved invaluable.

"I was excited to take on this challenge with him, as I know he is a fantastic supervisor and mentor. As well as valuable insights from his background and personal experience, he was always there to provide support as needed," he said.

Jonathan also worked closely with David to develop his soft-skills such as time management, planning, data



CREATED FROM SOURCE FILE: BUSINESSMAN IN A CLOUD OTHERS WAITING - SHUTTERSTOCK

storage and cross-discipline communication.

"This experience has given me the skills and confidence to seek cross-discipline consulting opportunities in the future. Jonathon's insights regarding industry, best consulting practices and communication with non-statistical research scientists were invaluable."

After years of focusing on tools and methodology, the internship helped David understand the value of his statistics expertise as he put theory into practice.

"This project showed me how the skills and knowledge I have gained through my studies could be applied to deliver practical outcomes. It was a chance to visit the other side of industry engagement and work on a real-world problem but with a safety net."

As he steps into a postdoctoral role at the University of Cambridge, he will have ample opportunity to make use of the skills he developed through AMSI**Intern**.

"At Cambridge, I will be working closely with biologists. The experience through AMSI**Intern** will mean I am able to communicate effectively and establish their needs and preferences as I progress my project."

As for future endeavours with Jonathan, the door is well and truly open.

"Jonathan has made it clear he is available if I need anything. He is someone I thoroughly enjoy working with and would love to do so again in the future if possible."

THE MENTOR

Summing up the challenge of applying academic theory in the real world, University of Adelaide statistics lecturer and former veterinarian, Dr Jonathan Tuke draws on personal experience, "books don't bite but dogs do."

As a veterinarian science graduate, it was only after months on the job and more than a few bites and scratches that he felt he was a vet. The same can be said for his current field of statistics, says Jonathan, with the divide between theory and practical application just as wide.

"So often in practical application, statistical theory and modelling collapse under the wings of reality. Suddenly you are in the real world with all the variables and challenges that brings."

When he was given the opportunity to act as an Academic Mentor on a project with AMSIIntern industry partner, SA Pathology, Jonathan immediately thought of student and collaborator, David Price. Now nearing the end of his PhD, the internship was the perfect opportunity for David to gain exposure to statistics in the real world.

"We provide PhD students with strong theoretical and academic backgrounding, but not the understanding of the real-life application of their work. AMSIIntern was the ideal platform to address this for David through industry exposure and soft skill development."

Leaving David to drive the project, Jonathan used his mentor role to provide support and guide him on industry best practice, as well as tools of the trade. Thanks to his biology background, he was also able to help facilitate cross-discipline communication.

"Working in statistics, you invariably end up working in someone else's backyard. My role was to equip David with the skills and confidence to work with non-statistical researchers as well as solve problems within industry environments."

Jonathan also hopes the experience will shape David's approach when he trains the next generation of statisticians.

"When he comes to teaching his own students, I hope he will in turn harness opportunities such as AMSI**Intern** to direct them towards consulting."

There were also benefits for Jonathan. A closer relationship with SA Pathology has opened doors for future consultation and opportunities for other students.

"This project has been a great stepping stone for further conversation with SA Pathology and involvement in their research. They now have a better idea of what I can do and how statistics can benefit their work."

As for whether he has played any role in David's success – he has recently taken up a postdoctoral position with the University of Cambridge – Jonathan gives his student all the credit.

"David is not only a skilled statistician but a great communicator. I have just been lucky enough to steer him in the right direction." □

INNOVATING AUSTRALIA'S FUTURE

Renaissance Man to Chief Scientist, Dr Alan Finkel AO

A RESPECTED NEUROSCIENTIST, ENGINEER, ENTREPRENEUR AND EDUCATOR, AUSTRALIA'S EIGHTH CHIEF SCIENTIST, DR ALAN FINKEL, SHARES HIS VISION FOR THE NATION'S TOP SCIENCE JOB AND THE FUTURE DIRECTION OF AUSTRALIAN RESEARCH, INNOVATION AND THE MATHEMATICAL SCIENCES.

WHAT ARE YOUR KEY PRIORITIES DURING YOUR FIRST YEAR AS CHIEF SCIENTIST?

Year one is already well spoken for with three major advisory roles: leading the research infrastructure roadmap, co-chairing the R&D tax incentive review and sharing the development of a draft national strategic plan for science, research and innovation with Bill Ferris and others on the Board of Innovation and Science Australia.

The first is probably the least discussed, but for the mathematics community it really should be front of mind. We are talking about the nationally accessible supercomputers and research facilities that will underpin Australian research for more than a decade to come. It will be critical to sustaining excellence in our fields of strength and building new capability in areas of strategic potential. Our supercomputers, for example, will support mathematicians in the huge variety of modelling and analysis tasks we need, ranging from materials analysis to climate projections. I'm delighted to be leading a highly consultative process across a broad range of capability requirements.

I'll also be busy telling the success stories of Australian and global science, and pointing to the ways that science, technology and mathematics continue to contribute to all aspects of our national wellbeing.

WHY IS THERE SUCH A DISCONNECT BETWEEN HOW WE VALUE MATHEMATICAL LITERACY AND OUR UNDERSTANDING OF ITS CRITICAL ROLE IN OUR TECHNICAL WORLD?

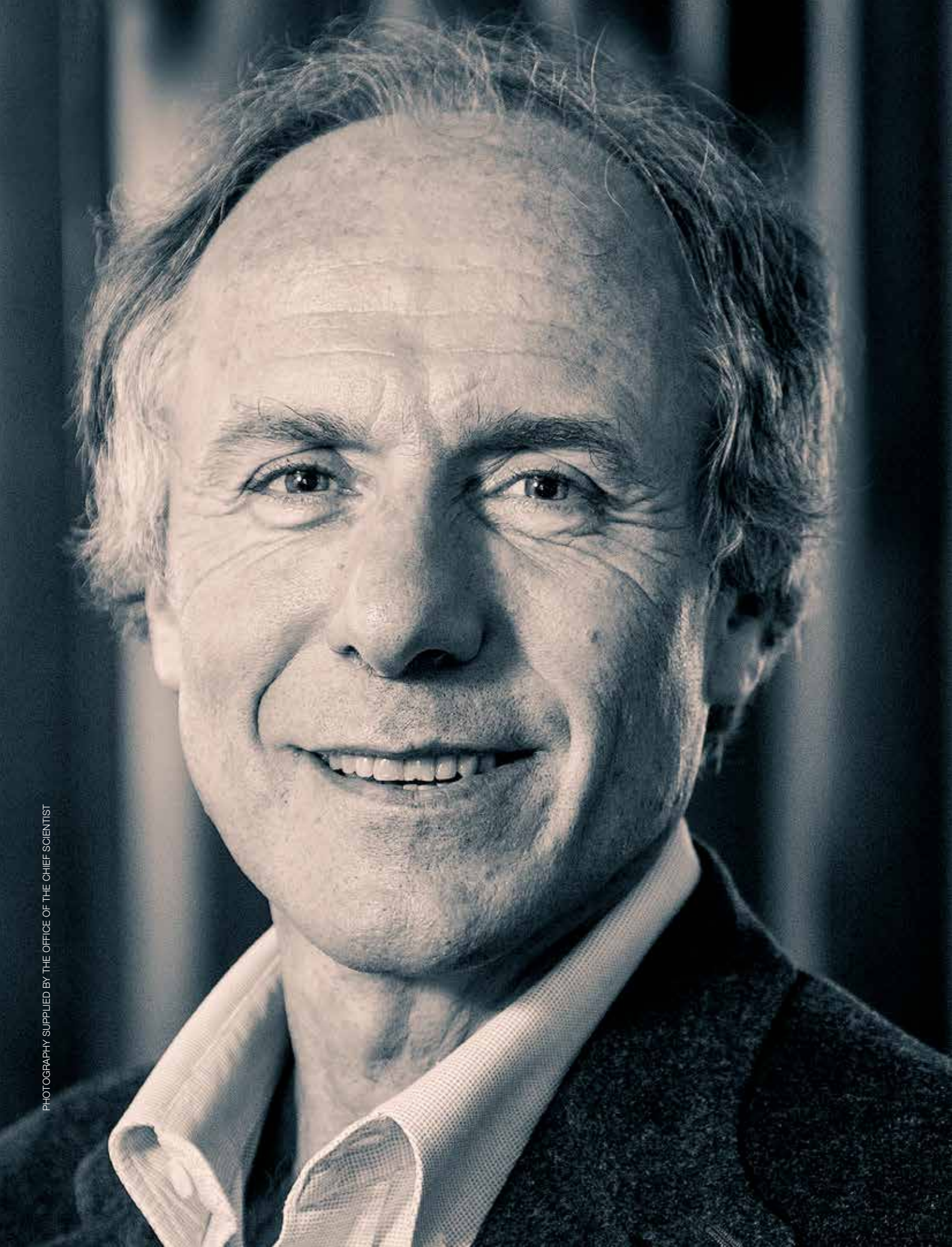
It's part of a broader problem at least as old as the desktop calculator. We see that machines can do a particular task, and we assume that we've got an easy substitute for human beings with deep knowledge and skills. So we lessen our expectations of mathematics education. That is a deeply mistaken viewpoint. To be a technologically sophisticated economy, of course we need to be numerically literate people! Software engineers, for example, cannot write algorithms without using mathematics, and they cannot write creative algorithms if they have to consult websites all the time. Human brains process information in parallel, but they cannot do that unless the information is already pre-loaded. Sequentially accessing information one website at a time is the antithesis of parallel processing and the dampener on creative design.

It's not just high-technology workers and industries where mathematical literacy counts. It's the foundation of all commercial exchange. Just as the quality of social discourse is diminished if your dinner companions are too busy digging up answers and facts on their smartphones to respond to your witticisms, so too is the quality of business interactions diminished if the participants don't have useful knowledge at their fingertips and the ability to process information themselves. It annoys me when investors cannot work out the rough area of a block of land from the length and the breadth. Or when my dinner companions take up half the meal trying to do the sums on splitting the bill. But my personal annoyance aside, the problem is that the progress of the transaction is slowed down while they whip out their smartphones, find the calculator app and deal with their typing errors.

Scale that up across an economy trying to transform itself for the Data Age, and you don't have to be a mathematician to see the imperative for mathematics education.

I would also like to commend AMSI for its recommendations to establish a mathematical sciences committee that will advise my office on key policy measures. I look forward to more dynamic interaction with the Institute. ⇨

IT'S NOT JUST HIGH-TECHNOLOGY WORKERS & INDUSTRIES WHERE MATHEMATICAL LITERACY COUNTS. IT IS THE FOUNDATION OF ALL COMMERCIAL EXCHANGE



PHOTOGRAPHY SUPPLIED BY THE OFFICE OF THE CHIEF SCIENTIST

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WHERE CAN AMSIIntern TAKE YOU?

DRIVING **INDUSTRY & UNIVERSITY** COLLABORATIONS

HOW DO YOU RATE THE HEALTH OF AUSTRALIAN MATHEMATICS EDUCATION IN SCHOOLS? WHAT ARE THE BIGGEST CHALLENGES?

From the declining number of Year 12 students choosing advanced or intermediate mathematics, the health of Australian school mathematics would clearly benefit from some strong medicine. That's not to suggest the cure is painful! On the contrary, mathematics can and should be a subject students enjoy, and choose because it equips them well for life. If that message has been lost, we need to intervene to reinforce it.

I would start by restoring mathematics prerequisites for university courses. Apart from a few brave Vice-Chancellors and Deans, most universities have sacrificed their prerequisites to make it easier to enrol students. It has nothing to with the goals of education, and everything to do with the incentives built into the funding and school-leaver assessment systems. If we corrected that market failure, schools would respond by improving their mathematics teaching all the way back to early primary years.

The merits-based case for mathematics prerequisites is, of course, very strong. When asked, "why mathematics", I answer indirectly that there should be prerequisites for two subjects. English (in Australia) because our language is how we engage in discussions ranging from philosophy to economics. Mathematics, because it is the language of science, engineering and non-science disciplines such as commerce. With a firm basis in english and mathematics our students can aspire to any university course and career that takes their fancy.

YOU ARE AN ENTREPRENEUR, ENGINEER, NEUROSCIENTIST AND EDUCATOR, WHAT DO YOU SEE AS YOUR BIGGEST ACHIEVEMENT TO DATE?

While I am proud of most things that I have done in my various careers, I would have to point to the development of a series of products at Axon Instruments as collectively my biggest achievement. We made the best in the world scientific instruments for measuring the electrical activity of brain cells, for fluorescent imaging to monitor the response of living cells to medicinal compounds, and for scanning DNA microarrays to measure gene expression. I'm proud of what we achieved, as well as the progress we enabled other scientists and clinicians to make.

HOW CRITICAL ARE PROGRAMS SUCH AS AMSIINTERN, AS WE BUILD INDUSTRY RESEARCH EXPERIENCE INTO THE AUSTRALIAN STEM PHD TRAINING?

We owe it to our STEM PhD graduates to prepare them for industry careers, not just because the opportunities in academia are limited but because the paths in industry can be extremely rewarding. Here I am interpreting the term 'industry' very broadly, to include all non-academic activities. We know from the recently released *STEM Workforce Report* from the Office of Australia's Chief Scientist, as well as surveys by associations such as the American Institute of Physics, that PhD graduates are employed very successfully in a wide range of non-academic roles. Portfolio management, financial planning, urban planning, wine making, company management – these and many more are attractive industry paths to which a PhD can bring valuable transferrable skills.

In addition to the AMSI program, there is the IMNIS mentoring program run by ATSE. Both of these are national programs, delivered on the initiative of non-university organisations. These are critically important. Some of our best universities are modernising their PhD programs to add training for a variety of work-relevant attributes, and these efforts are complemented by the industry training provided by AMSI and ATSE's programs.

AN AMSI PRIORITY, HOW WILL YOU AND YOUR OFFICE IMPROVE GENDER EQUITY IN STEM?

Our *STEM Workforce Report* indicates about a 60:40 male to female split in the cohort of working age Australians with bachelor qualifications and above in mathematics. At the doctorate level, the gap widens to 80:20. There is also the question of pay. In the 30 to 59 year age bracket, for example, the percentage of men with bachelor qualifications reaching the highest income bracket is more than double that of women qualified at the same level. Mathematics is significantly better than other disciplines, such as ICT and physics to name two, but it's still got a way to go.

WE OWE IT TO STEM PHD GRADUATES TO PREPARE THEM FOR INDUSTRY...PATHS TO WHICH A PHD CAN BRING VALUABLE TRANSFERABLE SKILLS

Highlighting these issues is just a first step. Through my previous role as President of ATSE and through my current role as Chief Scientist I am a strong supporter of the Athena Swan program introduced by AAS and ATSE. It is built on a proven UK model that accredits universities and other research institutions taking action to improve gender equity. The universities themselves are enthusiastic and a large number of them have volunteered to sign up for the pilot program.

WHAT ADVICE WOULD YOU GIVE SOMEONE CONSIDERING A MATHEMATICS OR SCIENCE CAREER?

I speak to students often and always encourage them to choose a science, engineering or mathematics degree if they enjoy these disciplines. Career opportunities are evolving at a rapid rate. Analytical thinking, problem solving and deep discipline knowledge are applicable to all jobs, even if the disciplines are not necessarily the ones in which the students train.

Good fortune comes to the prepared mind. Students considering a career in science or mathematics should prepare themselves well. The better they can think without reaching for their smartphones, the more good fortune they will enjoy – and the more dinner invitations they are likely to get!

Professor Ian Chubb elevated Australia's innovation capacity to a critical policy issue. As he builds on this legacy, AMSI welcomes Dr Finkel's vocal support for initiatives to grow Australia's mathematical sciences at all stages of the pipeline, from the classroom to higher education, research and industry. □

CHARLES GRAY

From Music to Maths, Discovering a New World with AMSI

STATISTICAL GENOMICS MIGHT SEEM A MILLION MILES FROM LIFE AS A GIGGING MUSICIAN BUT, ACCORDING TO PHD STUDENT AND AMSI BIOINFOSUMMER (BIS) 2015 PARTICIPANT, CHARLES GRAY, THEY HAVE MUCH IN COMMON.

"It isn't strange or far fetched for a musician to become a mathematician. In retrospect, it was music's mathematical axioms I liked the most," she explains.

Anything but traditional, Charles' maths journey started with a desire for greater stability. After a decade in music, and with a musicology degree and Bachelor of Arts majoring in cinema studies and literature, she decided to study Pure Mathematics. Following her honours she was drawn to the practicality of biostatistics and decided to complete a PhD in Statistical Genomics. A smooth transition she credits in part to AMSI.

"I always wanted to do maths but didn't have the courage until my thirties. I love pure maths but it is increasingly competitive and I was drawn to biostatistics as it plays to my creative strengths and has wider career options. I also love its cross-disciplinary nature and the daily variety," Charles explains.

Her recent experience at AMSI's one-week bioinformatics and mathematical and computational biology research training event, BioInfoSummer has left her in no doubt she's made the right decision. Hoping for a better understanding of key statistical models and DNA methylation analysis tools, Charles left a step ahead and with her expectations well and truly exceeded.

"BIS provided a great foundation for my PhD. I can't think of anywhere else you can access a week of bioinformatics talks and workshops perfectly pitched to someone with my level of mathematics and biology," she says.

In particular, the University of Newcastle's Dr Garth Tarr's workshop has profoundly impacted her transition to bioinformatics and PhD studies.

"I was so inspired by Dr Garth Tarr's data visualisation workshop, I spent the rest of summer learning as much as possible about new R packages. Impressed with my knowledge, my supervisor asked me to give a guest lecture on data visualisation."

As well as opening career pathways, bioinformatics has given Charles a sense of belonging

BIOINFOSUMMER PROVIDED A GREAT FOUNDATION FOR MY PHD. I CAN'T THINK OF ANYWHERE ELSE YOU CAN ACCESS A WEEK OF BIOINFORMATICS TALKS & WORKSHOPS PERFECTLY PITCHED TO SOMEONE WITH MY LEVEL OF MATHEMATICS & BIOLOGY

as part of Australia's fraternity of medical discovery, particularly the support she has received within the maths community.

"After surviving from gig to gig as a musician, the support I've received has been incredible. AMSI has been an ever present entity in my world opening up opportunities such as a Victorian Research Scholarship at Walter and Eliza Hall Institute and its world class training events," she says.

She continues to draw on her BIS experience as she catches up on biology and progresses her PhD research to minimise effects in measurement of DNA mythelation, a mechanism that activates cells that is of particular interest in epigenetics and cancer research.

"Not only has it provided a great foundation for my PhD, but I continue to benefit from the great connections I made within the field. Just recently I was having a bad day and was able to ring a BioInfoSummer friend for a virtual coffee. It makes such a difference to not only be able to share knowledge and skills but draw on much needed support as part of a community." □

PHOTOGRAPHY: CHARLES GREY

TAKING RESEARCH TO THE NEXT LEVEL

The National Research Centre:
A Vision for Australian Mathematical Sciences

THE DECADAL PLAN

The Australian Academy of Sciences launched *The Mathematical Sciences in Australia: A vision for 2025* in March this year. A headline recommendation of this decadal plan concerned the formation of a national research centre:

"Australian universities should collaborate with the discipline to source seed funding for a new national research centre in the mathematical sciences, with the objective of enhancing connectivity with industry and strengthening the international collaboration and visibility of Australian research in mathematics and statistics."

The decadal plan subcommittee charged with examining this issue was unequivocal about the structure an Australian centre would have:

"The panel members were unanimously of the view that the relatively vast distances within major centres in Australia, combined with the relatively sparse population density, makes a distributed model the best of the options for initiating a research centre.

The distances between major population centres in Australia are not dissimilar to those on the west coast of Canada, and we note that the best known distributed research centre in the mathematical sciences, PIMS, is centred in this region."

A NATIONAL RESEARCH CENTER IN THE MATHEMATICAL SCIENCES REMAINS AT THE VERY TOP OF AMSI'S AGENDA & IS A KEY RECOMMENDATION OF THE NEW DECADAL PLAN FOR THE MATHEMATICAL SCIENCES

AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

DIRECTOR: **PROFESSOR GEOFF PRINCE**

AUSTRALIA'S NATIONAL RESEARCH CENTRE

AMSI's programs in school education, public outreach and research training are highly regarded at home and abroad. In turn, we envy the well-funded research programs of our sister institutes elsewhere. While we have sponsored more than 250 workshops, bringing around 60 international colleagues to Australia each year and put many eminent mathematical scientists on tour, we have not seen the sort of funding necessary to engage in the long term, collaborative projects which are the hallmark of famous institutes such as Oberwolfach (Germany), the Isaac Newton Institute (UK), the Pacific Institute for Mathematical Sciences (Canada & USA) and the Institute for Mathematical Sciences (Singapore). You can read about their programs in the following pages.

A COMPELLING CASE

The Australian mathematical sciences community wants a well-resourced national research centre which will:

- **Deliver significant growth of high quality research outputs;**
- **Build a stronger discipline in all of Australia's universities & research agencies;**
- **Establish Australia as an international research destination;**
- **Network existing centres of excellence;**
- **Be a platform for attracting funding, philanthropic, public & private;**
- **Be a hothouse for mathematical sciences start-up companies;**
- **Build sustaining & strategic research-industry collaborations;**
- **Build the future mathematical sciences workforce, public & private;**
- **Increase public awareness of the role of the mathematical sciences in 21st century science, technology, innovation, the social sciences & commerce.**

THE MODEL

A national research centre in the mathematical sciences remains at the very top of AMSI's agenda and is a key recommendation of the new decadal plan for the mathematical sciences. Planning for this centre is currently underway as a partnership comprising AMSI's membership, learned societies, agencies, centres of excellence and existing networks which currently run research and research training programs in the mathematical sciences.

During an initial three-year period the partners will co-badge their programs, including AMSI's own significant research and higher education initiatives, as national research centre programs. They will also co-operate on national programs like the successful Maths of Planet Earth led by AMSI in 2013. The new AMSI Trust will support the formation of the centre and a high profile group of champions will pursue philanthropic, public and private sector funding.

The new centre will build on AMSI's existing model of distributed delivery, wiring up the various hotspots in the mathematical sciences scene, simultaneously strengthening our ability to raise national funding and also strengthening the position of the partners. These programs will be designed to deliver on our aspirations, informed by international best practice and addressing the gaps in current research funding. For example, a small grant scheme for individual mathematicians to fund collaborations, a network scheme to fund long term, themed national collaborations on a smaller scale than the current Centres of Excellence, and themed industry collaboration programs.

As Australia seeks to implement a national research centre to strengthen its mathematical sciences leadership, we talk to leaders of some of the world's most successful mathematics institutes about their programs, the benefits of national leadership, and how they are influencing research policy and funding, as well as their impact on innovation, industry and research collaboration. ⇨

TOGETHER WITH THE OTHER MATHEMATICS INSTITUTES IN CANADA WE HAVE RECENTLY BEGUN AN INNOVATION PROGRAM. THIS INITIATIVE AIMS TO DEVELOP CONTACTS BETWEEN RESEARCHERS IN THE MATHEMATICAL SCIENCES & INDUSTRY

Pacific Institute *for the* Mathematical Sciences

ONE OF THREE CANADIAN DISTRIBUTED INSTITUTES, THE PACIFIC INSTITUTE FOR THE MATHEMATICAL SCIENCES (PIMS) is working to promote mathematical sciences generated across Western Canada and Western USA. Based at the University of British Columbia, the institute's membership includes all major Western Canadian universities, as well as the University of Washington. Working at all stages of the mathematics pipeline, the institute supports initiatives through its high school education, industrial innovation and fundamental research programs.

INTERIM DIRECTOR: **PROFESSOR MARTIN BARLOW**

COUNTRY: **CANADA**

COLLABORATION

Collaboration is a strong focus for PIMS. Our flagship program is our Collaborative Research Groups (CRGs). These support a group of researchers across PIMS sites to run a three to four-year themed research program. As well as providing support to postdocs, workshops and graduate summer schools, CRGs are frequently the basis for ongoing research collaboration between different PIMS sites.

INNOVATION & INDUSTRY

Together with the other mathematics institutes in Canada, we have recently begun an Innovation Program. This initiative aims to develop contacts between researchers in the mathematical sciences and industry.

INFLUENCING PUBLIC POLICY

Primarily PIMS funding comes from the Natural Sciences and Engineering Research Council of Canada (NSERC). This funds postdocs, workshops, graduate summer schools and collaborative research groups. While contacts between scientists and government are not as extensive or as broadly based in Canada as other countries, this is something we would like to improve and that the leaders of the institutes are well places to address.

Currently Canada has several research institutes in the Mathematical Sciences – the Fields Institute (Toronto), the Centre Recherché Mathematique (Montreal) and three distributed institutes: PIMS, AARMS (Eastern Canada) and the Canadian Statistical Sciences Institute. As a collective, these institutes provide a powerful voice for the mathematical sciences in Canada, promoting mathematics and securing additional funding from the Provincial Governments.

NUS National University of Singapore | IMS Institute for Mathematical Sciences

ESTABLISHED IN 2000, THE INSTITUTE FOR MATHEMATICS IS A UNIVERSITY-LEVEL RESEARCH INSTITUTE BASED AT THE NATIONAL UNIVERSITY OF SINGAPORE (NUS). With the aim of fostering both fundamental and multidisciplinary mathematical research, the Institute provides funding and facilities to the global mathematical sciences community for research and collaboration. It aims to nurture mathematical research expertise, train new research talent and provide a platform for research interaction between the Singapore and global science communities. Over the past 15 years it has held more than 90 programs and perhaps an equal number of workshops.

DIRECTOR: **PROFESSOR CHI TAT CHONG**

COUNTRY: **SINGAPORE**

THE PROGRAMS & ACTIVITIES ORGANISED AT THE IMS ARE ALL ABOUT INNOVATION & A LARGE NUMBER OF THEM CONCERN APPLICATIONS OF MATHEMATICS TO TECHNOLOGY

COLLABORATION

Many research collaborations and discoveries have arisen from work done at IMS. The Institute cooperates with many departments and institutes in the country to organise programs in multiple areas within the mathematical sciences, from pure to interdisciplinary, serving both the Singapore and international scientific communities.

We host a range of thematic one to three-month programs and specialised one-week workshops. With the aim of nurturing young women and men interested in mathematical science careers, the institute organises summer and winter schools on advanced topics for graduate students, and provides opportunities for mathematical scientists beginning their research careers for short-term attachments at the institute. The IMS periodically organises public lectures to fulfil its other mission of raising the interest and awareness of the public in the role of mathematics in modern society. Finally IMS also works closely with other mathematical institutes to organise joint scientific activities.

INNOVATION & INDUSTRY

In many respects, the programs and activities organised at the IMS are all about innovation and a large number of them concern applications of mathematics to technology (e.g. computer security, high performance computing and materials science, finance and drug delivery).

INFLUENCING PUBLIC POLICY & FUNDING

As Director of the IMS, I serve on various committees outside the university, including those at the Ministry of Education and other statutory boards. Mathematics and its applications are often on the agenda. ⇨

Mathematisches Forschungsinstitut Oberwolfach

Member of the Leibniz Association

LOCATED IN THE GERMAN BLACK FOREST, the Mathematisches Forschungsinstitut Oberwolfach (MFO) attracts over 3000 researchers annually. Covering the full spectrum of mathematics research and its applications within science and technology, the institute's programs provide ideal conditions for researchers to drive discovery and influence and stimulate field development.

DIRECTOR: **PROFESSOR GERHARD HUISKEN**

COUNTRY: **GERMANY**

SEVERAL SENIOR GERMAN INDUSTRY LEADERS OFFER ADVICE ON RELEVANT MATHEMATICAL DEVELOPMENTS & HIGHLIGHT THE IMPORTANCE OF MATHEMATICAL RESEARCH WITHIN THEIR INDUSTRIES TO POLITICIANS

COLLABORATION

The MFO's research program includes weekly and mini one-week workshops, as well as six annual Oberwolfach seminars where PhD students engage with field leaders to explore hot research topics. The Oberwolfach Arbeitsgemeinschaft lecturers provide a 'learn by doing' experience through presentation of recent results and research activities. Individual engagement through initiatives such as Research in Pairs and Simons Visiting Professors also supports discovery advancement. The high degree of abstraction and specialisation in mathematics makes distraction-free direct communication between mathematicians critical to inspire new ideas and technology development. MFO plays a crucial role at the beginning of concrete projects (inspiration, discussion of new resolution methods) and with the presentation of new results at the end, leading to new inspirations and applications to other problems.

INNOVATION & INDUSTRY

Several senior German industry leaders support the MFO as board members of the Oberwolfach-Foundation. They both offer advice on industry relevant mathematical developments and help highlight the importance of mathematical research within their industries to politicians and public office holders. While industry leaders provide financial and political support to the MFO in driving and applying basic mathematics research, they do not influence its excellence based scientific selection process.

INFLUENCING PUBLIC POLICY & FUNDING

A member of the Leibniz Association, the MFO receives German federal and state government funding. Represented on the administrative council, government funding agencies and external foundations also assist to legally oversee the institute.

Despite having no direct capacity to influence national policy, the institute's directors, MFO scientific committee members and program organisers and participants serve on relevant committees of many important German science institutions. Oberwolfach meetings and discussions also play an important role in policy debate and consensus building amongst German mathematicians.

THE ROLE OF RESEARCH INSTITUTES IS TO NURTURE COLLABORATIVE RESEARCH ON A SCALE, BREADTH & DEPTH THAT COULD NOT REALISTICALLY BE ACHIEVED BY ANY SINGLE DEPARTMENT

INI Isaac Newton Institute for Mathematical Sciences

BASED IN CAMBRIDGE, UK, The Isaac Newton Institute (INI) is a national and international visitor research institute. Attracting leading UK and international mathematicians, the institute runs science programs with applications across a wide range of science and technology. INI has a vital role, building on the existing strengths of UK universities to generate a new vitality through stimulating and nurturing research throughout the country.

DIRECTOR: **PROFESSOR JOHN TOLAND**

COUNTRY: **UNITED KINGDOM**

COLLABORATION

Collaboration can have a transformational effect not only on the field itself but also on individuals, especially early-career individuals who are involved. The role of research institutes is to nurture collaborative research on a scale, breadth and depth that could not realistically be achieved by any single department. Inviting internationally leading experts nurtures and supports research in areas where your country may not yet have a significant presence. During each INI scientific program new collaborations are made and ideas and expertise are exchanged and catalysed through lectures, seminars and information interaction, which the INI building has been designed specifically to encourage.

INNOVATION & INDUSTRY

Established in 2013, the Turing Gateway to Mathematics (TGM) (turing-gateway.cam.ac.uk) acts a channel for knowledge flow and ideas between the mathematical sciences and mathematics users. It does this by facilitating interactions and activities such as programmes of work, events, projects, and education and training in areas where maths skills are needed. Acting as a gateway between academic mathematics, industry and government and other disciplines, it helps widen the access to mathematics generally and shorten pathways to impacts.

INFLUENCING PUBLIC POLICY & FUNDING

INI has made several written submissions to parliamentary enquiries on the science/industry/business interface. From time to time it attends lobbying meetings, for example at the House of Commons earlier this year and it answers questionnaires. □

AMSI SUMMER SCHOOL 17

IN THE MATHEMATICAL SCIENCES

9 JAN – 3 FEB 2017

THE UNIVERSITY OF SYDNEY

CATEGORY THEORY & COMPUTER SCIENCE
Richard Garner & Dominic Verity, Macquarie University

COMPUTATIONAL BAYESIAN STATISTICS
Scott Sisson, The University of New South Wales

COMPUTATIONAL MATHEMATICS
Markus Hegland, The Australian National University

GEOMETRIC GROUP THEORY
Lawrence Reeves, The University of Melbourne
& Anne Thomas, The University of Sydney

HARMONIC ANALYSIS
Pierre Portal, The Australian National University

MATHEMATICAL BIOLOGY
Mary Myerscough, The University of Sydney

MATHS & STATS OF BIG DATA
Kerrie Mengersen, Queensland University of Technology

OPTIMISATION
Michelle Dunbar, The University of Sydney

REGISTER:
AMSI.ORG.AU/SS

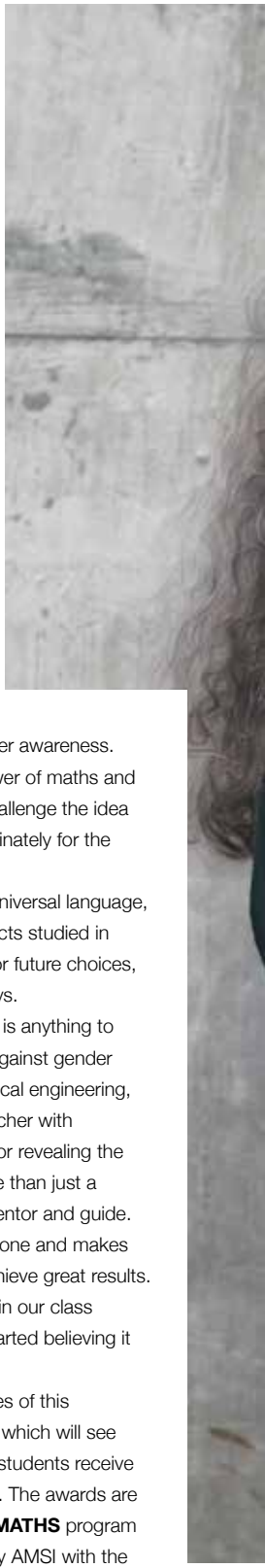
AMSI RESEARCH

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE
THE UNIVERSITY OF SYDNEY
Australian Government Department of Education and Training
Aust MS Australian Mathematical Society
ANZIAM
bhpbilliton Foundation

EDUCATION FRONTLINE

Teaching Our Way Out of Australia's STEM Crisis

HOW AUSTRALIA'S BEST EDUCATORS ARE ENCOURAGING A NEW GENERATION OF DISCOVERY. THE INNOVATION PIPELINE STARTS IN THE CLASSROOM WHERE THE NATION'S TEACHERS ARE WORKING AT THE FRONTLINE OF STEM, FOSTERING CURIOSITY AND A LOVE OF LEARNING, AND ENCOURAGING STUDENTS TO CHOOSE MATHS. WE MEET THE FACES OF THE 2016 CHOOSE**MATHS** AWARDS, AS AMSI PARTNERS WITH THE BHP BILLITON FOUNDATION TO STRENGTHEN THE EDUCATION PIPELINE AND SUPPORT AUSTRALIA'S INNOVATION AND SCIENCE CAPACITY. ⇨



Engagement with maths and science, according to high-school teacher Jacinta Deylen, starts with being interested in the world.

We all enter the classroom inquisitive and thirsty to learn. The art of teaching is fostering this natural curiosity and shaping it into deeper understanding and a love of learning. It is this powerful combination that drives discovery and ultimately innovation.

This puts teachers, such as Santa Maria College, Northcote's Jacinta Deylen, at the frontline of the education pipeline as we build Australia's innovation and science capacity for the future. They are charged with the task of not only fostering and mentoring emerging maths talent, but also re-engaging those who have opted out, particularly in the later years of high-school. With only 10 per cent of Year 12 students studying advanced maths and 19 per cent intermediate, this is critical to secure Australia's research and innovation future.

With over 30 years teaching experience, Jacinta believes the key to rewriting Australia's maths education narrative is career awareness. Greater understanding of the power of maths and its possibilities is critical as we challenge the idea that higher-level maths is predominately for the intellectual elite and men.

MATHS IS EVERYWHERE! IT IS A UNIVERSAL LANGUAGE, HAVING MATHS AS ONE OF THE SUBJECTS STUDIED IN YEAR 11 & 12 WILL OPEN DOORS FOR FUTURE CHOICES, COURSES & CAREERS

"Maths is everywhere! It is a universal language, having maths as one of the subjects studied in Year 11 and 12 will open doors for future choices, courses and careers," Jacinta says.

If ex-student Laura McMahon is anything to go by, Jacinta is clearly winning against gender stereotypes. Now studying chemical engineering, Laura credits her high-school teacher with helping realise her potential and for revealing the possibilities of mathematics. More than just a teacher, she sees Jacinta as a mentor and guide.

"Ms Deylen encourages everyone and makes her students feel like they can achieve great results. She kept believing that everyone in our class was capable at maths until we started believing it ourselves," she explains.

Jacinta and Laura are the faces of this year's CHOOSE**MATHS** Awards, which will see outstanding maths teachers and students receive a share of $83,000 on 26 August. The awards are one component of the CHOOSE**MATHS** program national project being delivered by AMSI with the support of the BHP Billiton Foundation.

Two top prizes of $10,000 and eight prizes of $1,000 will be awarded to teachers across

Australia for demonstrated excellence in mathematics teaching and the fostering participation of girls in the discipline. Each winner's school will also receive a grant equal to their prize to further initiatives within their mathematics programs. The student awards, Maths. Camera. Action, will take maths out of the classroom with students encouraged to use their maths talent to create short films. Ten awards in total are on offer, five junior (Years 5-8) and senior (Years 9-11) with best junior and senior video receiving $2,000 with second place receiving $1,500 and third $1,000.

In addition to the awards, AMSI will work with schools over the next five years to turn around public perception of mathematics through teacher training, student empowerment, career awareness and support for women and girls in maths.

CHOOSE**MATHS** Program Director, Janine McIntosh, says the awards "recognise the capacity of skilled educators such as Jacinta to foster talent and to shape lives beyond the classroom."

Also an ex-student of Jacinta's, Laura's sister Elise is now studying physiotherapy. She applauds her former maths teacher's efforts to rewrite traditional gender narratives surrounding maths and science.

"Ms Deylen has always defied the stereotype that girls struggle with maths, a concept that has always annoyed me. She encouraged me to persevere despite the social acceptance of females not undertaking mathematics and science studies," she says.

A passionate teacher can make a lifetime of difference beyond the classroom and by fostering the skills and confidence of emerging talent, the health of our mathematical pipeline. Something, now more than ever, Australia is banking on as we seek to achieve our innovation potential. □

PHOTOGRAPHY: LILLI WATERS

MS DEYLEN ENCOURAGED ME TO PERSEVERE DESPITE THE SOCIAL ACCEPTANCE OF FEMALES NOT UNDERTAKING MATHEMATICS & SCIENCE STUDIES

FOR MORE INFORMATION, VISIT - **CHOOSEMATHS.**ORG.AU

KOZWAVES 2015

Australasia Making Waves in Global Science

WAVES ARE FUNDAMENTAL TO OUR UNDERSTANDING OF SCIENCE AND NATURE. THEY SURROUND US ON WATER AND LAND, IN SOUND AND LIGHT AND IN MODERN TECHNOLOGY, SUCH AS FIBRE OPTIC CABLES AND MEDICAL IMAGING. WE SURF WATER WAVES, PROTECT OUR TOWNS AND CITIES FROM EARTHQUAKES AND TSUNAMIS, AND USE ELECTROMAGNETIC WAVES IN TECHNOLOGIES THAT SAVE LIVES AND KEEP US GLOBALLY CONNECTED.

Bringing these phenomena together is a unifying framework known as wave theory, an area of strength within the local scientific community. Australasian scientists are currently leading projects in many areas of wave science, including design of ocean wave energy devices, development of cloaking devices and metamaterials, and modelling ocean waves in extreme environments, such as during hurricanes and in the sea-ice-covered oceans.

With an Australasian wave science community essential to encourage collaboration and advance discovery, local researchers launched the KOZWaves conference series in 2014. Now running biennially, this event provides both a platform for discussion and a launching pad to strengthen the region's global impact. Quickly growing as it catches international attention, the event attracts leading mathematicians, physicists, material scientists, engineers and geophysicists.

There is no doubt KOZWaves is already having a positive impact both locally and internationally. On the back of the second conference, held at the University of Adelaide in December 2015, organiser Dr Luke Bennetts will undertake a project with members of the DST Group to design ultrathin soundproof coatings. He has also been invited for a research trip to the Waves in Complex Media Group at KAUST, Saudi Arabia.

Closer to home, Australian researchers are rapidly discovering new applications of wave theory. Research teams at Swinburne University (led by Associate Professor Richard Manasseh) and the University of Adelaide (led by Professor Ben Cazzolato) are helping develop efficient devices to extract vast sources of renewable energy available in ocean waves. This will significantly impact current projects to deploy wave energy devices off the Australian coastline. An Australian-New Zealand collaboration, involving researchers at the University of New South Wales, is also underway to investigate sonic crystals. These structures are designed to act as shields from noise pollution such as near highways and railways.

The Aussie-Kiwi collaborations are set to continue with teams working to shed light on the destructive effects of ocean waves on sea ice in the Arctic and Antarctic. These findings have the potential to significantly improve climate studies and safety forecasts for shipping and other human activity in and around ice-covered oceans.

As the community thrives, KOZWaves is predicted to become one of the premier events in an increasingly important area of scientific discovery. In February 2018, KOZWaves will move to New Zealand with the third event to take place in Auckland. □

KOZWAVES 2015: GLOBAL LEADERS TO WATCH

Professor Mathias Fink

Based at France's Ecole Superieure de Physique et de Chimie Inustrielles (ESPCI) in Paris, Professor Fink is unquestionably one of the world's leading wave scientists with 55 patents and over 350 papers to his name. He founded and directed the world-leading centre for wave science and a French 'laboratory of excellence', the Lagevin Institute at ESPCI. A member of the French Academies of Science and Engineering and Chair of Technological Innovation at the College de France, he is best known for pioneering time reversal mirrors. Used to focus waves, this work has been applied in medical imaging and electromagnetic communications.

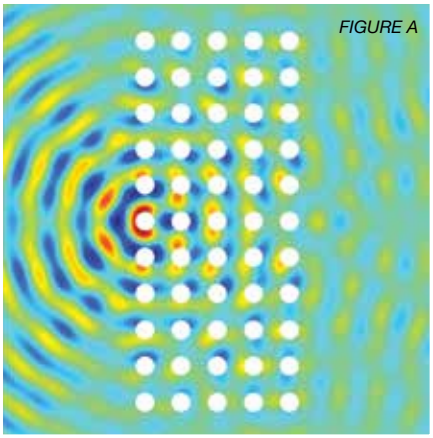
Professor William Perrie

A Chief Marine Scientist at Bedford Institute of Technology, Canada's largest centre for ocean research, Professor Perrie is a leading authority on ocean wave modelling. Furthering understanding of these models, he has used numerical models, field experimental data and remote sensing methods to explore their role in the global climate system. He has led research investigations into extreme "hurricane" waves: wave interactions with currents and waves in the Arctic Ocean. Highly published he has written over 180 journal articles and two books, and is currently Editor-In-Chief of leading international journal Ocean Modelling.

IMAGES SUPPLIED BY LUKE BENNETTS

The presentations at KOZWaves covered a range of governing equations, including Helmholtz equation (e.g. acoustic waves), potential-flow equations (e.g. surface water waves) and thin-plate equations. These are illustrated by the figures below.

FIGURE A



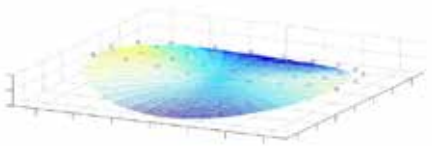
Acoustic waves travelling through a lattice of circular sound-hard inclusions (Fabien Montiel, Uni Otago, NZ).

Figure A shows acoustic waves travelling through a lattice of sound-hard inclusions, which is governed by the Helmholtz equation

$$\Delta\phi + k^2\phi = 0$$

in the region surrounding the inclusions, where $\Delta = (d/dx, d/dy)^2$ and ϕ is the acoustic potential, and $\phi_n = 0$ on the boundaries of the inclusions.

FIGURE B



A thin floating elastic disk bending under water wave forcing (Fabien Montiel, Uni Otago, NZ).

Figure B shows a thin floating elastic disk bending under water wave forcing. The motion of the plate is governed by the Kirchhoff-Love thin-plate equation

$$(1-\sigma M)w + F\Delta^2 w = \phi$$

where w is the vertical displacement of the plate, σ is a frequency parameter, M and F are scaled versions of the mass and flexural rigidity of the plate, and ϕ in this case is the velocity potential of the water at the lower surface of the plate. □

mathsfest AUSTRALIA 2016

THE AUSTRALIAN NATIONAL UNIVERSITY

CANBERRA 2016

ADVANCES IN ERGODIC THEORY, HYPERBOLIC DYNAMICS & STATISTICAL LAWS

28 NOV – 2 DEC 2016

Beniamin Goldys, Sydney
Andrew Hassell, ANU
Carlangelo Liverani, Rome Tor Vergata
Maria José Pacifico, UFRJ
Mark Pollicott, Warwick
Kavita Ramanan, Brown (TBC)
Jana Rodriguez Hertz, IMERL
Françoise Pêne, Brest
Eric Vanden-Eijnden, Courant (TBC)
Amie Wilkinson, Chicago

3 EVENTS IN 1

60TH ANNUAL MEETING OF THE AUSTRALIAN MATHEMATICAL SOCIETY

5 DEC – 8 DEC 2016

Tomoyuki Arakawa, Kyoto
Miranda Cheng, Amsterdam
Adelle Coster, UNSW
Alessio Figalli, ETH Zurich
Georg Gottwald, Sydney
Simon Levin, Princeton
André Arroja Neves, Imperial College
Kavita Ramanan, Brown
Kari Vilonen, Northwestern
Lesley Ward, UniSA
Nicholas Wormald, Monash

28 NOV – 13 DEC

NONLINEAR & GEOMETRIC PARTIAL DIFFERENTIAL EQUATIONS

9 DEC – 13 DEC 2016

Binglong Chen, Sun Yat-sen
Jaigyoung Choe, KIAS
Alessio Figalli, ETH Zurich
Ailana Fraser, British Columbia
Nicola Fusco, Naples Federico II
Gerhard Huisken, Tübingen/Oberwolfach
Fernando Coda Marques, Princeton
André Arroja Neves, Imperial College
Duong Phong, Columbia
Yoshihiro Tonegawa, Tokyo Tech
Mu-Tao Wang, Columbia
Guofang Wei, UCSB

Australian Government Australian Research Council
AMSI Australian Mathematical Sciences Institute
Australian Mathematical Society
Australian National University
MONASH University
UNSW Australia
The University Of Queensland Australia
The University of Sydney
The University of Western Australia
University of Wollongong

Register: mathsfest.amsi.org.au

AMSI RESEARCH