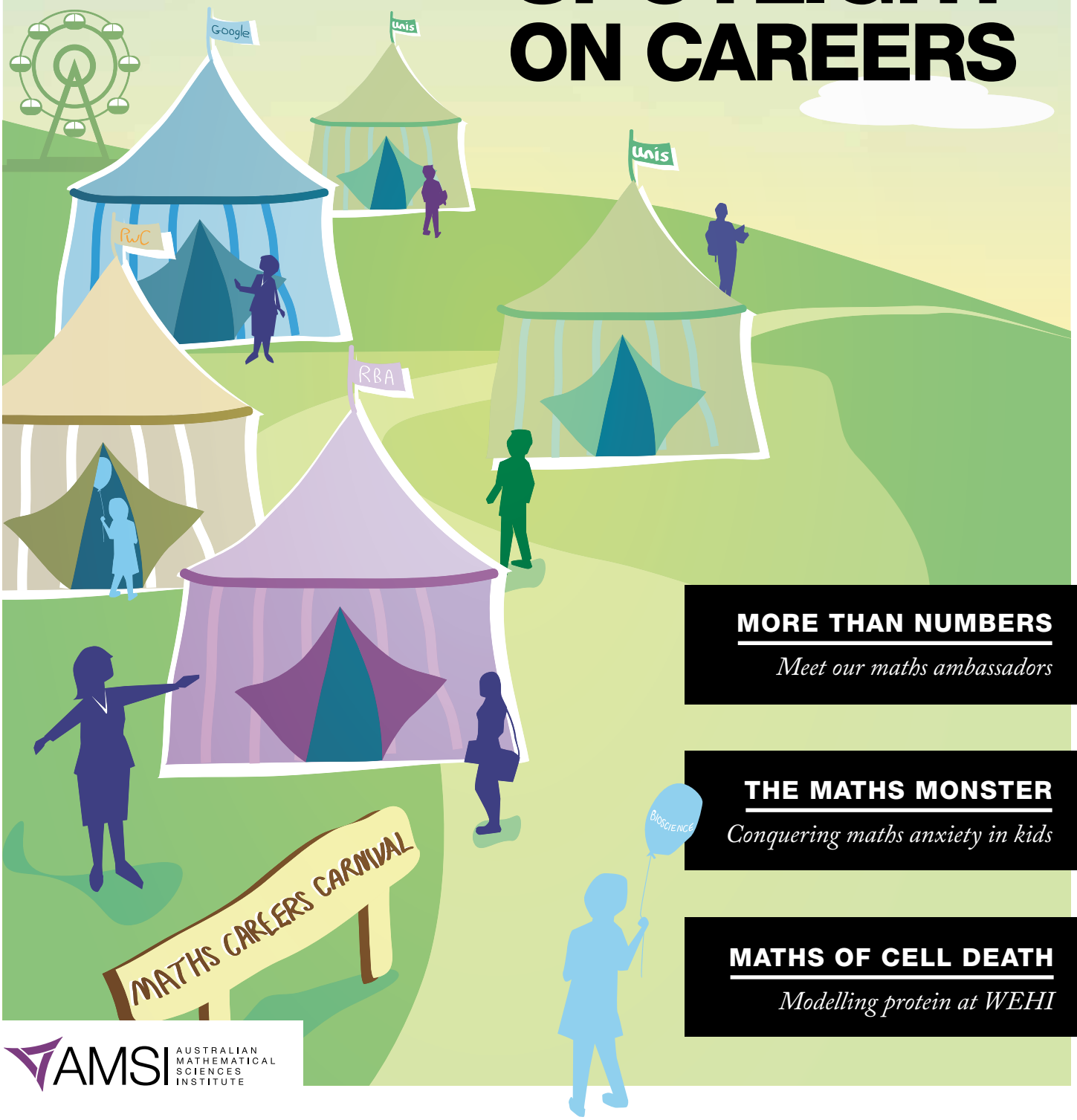
2017 winter

the UPDATE

5th ed.

SPOTLIGHT ON CAREERS



MORE THAN NUMBERS

Meet our maths ambassadors

THE MATHS MONSTER

Conquering maths anxiety in kids

MATHS OF CELL DEATH

Modelling protein at WEHI

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

WORKSHOP ON

FREE BOUNDARIES

PHASE TRANSITIONS

& INTERFACES

18 - 19 SEPTEMBER

MELBOURNE UNI

JONATHAN M. BORWEIN

COMMEMORATIVE CONFERENCE

25 - 29 SEPTEMBER

NEWCASTLE UNI

SINGULARITY THEORY & ITS APPLICATIONS TO **ROBOTIC ALGORITHMS** & COMPLEX SYSTEM

25 - 29 SEPTEMBER

SYDNEY UNI

WORKSHOP ON

MATHEMATICAL **MODELLING OF** RISK

& CONTIGUOUS - TOPICS -

27 NOV - 1 DEC

MATRIX (CRESWICK)

AMSI RESEARCH EVENTS

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

AMSI **VACATION** RESEARCH **SCHOLARSHIPS** 2017/18

1 DEC 17 - 28 FEB 18

AMSI

AMSI 17 BIOINFO SUMMER

A SYMPOSIUM IN BIOINFORMATICS

4 - 8 DECEMBER

MONASH UNI

AUSTMS 2017

12 - 15 DECEMBER

MACQUARIE UNI

AUSTRALIA - CHINA - CONFERENCE

NONCOMMUTATIVE **GEOMETRY**

& RELATED AREAS

18 - 22 DECEMBER

ADELAIDE UNI

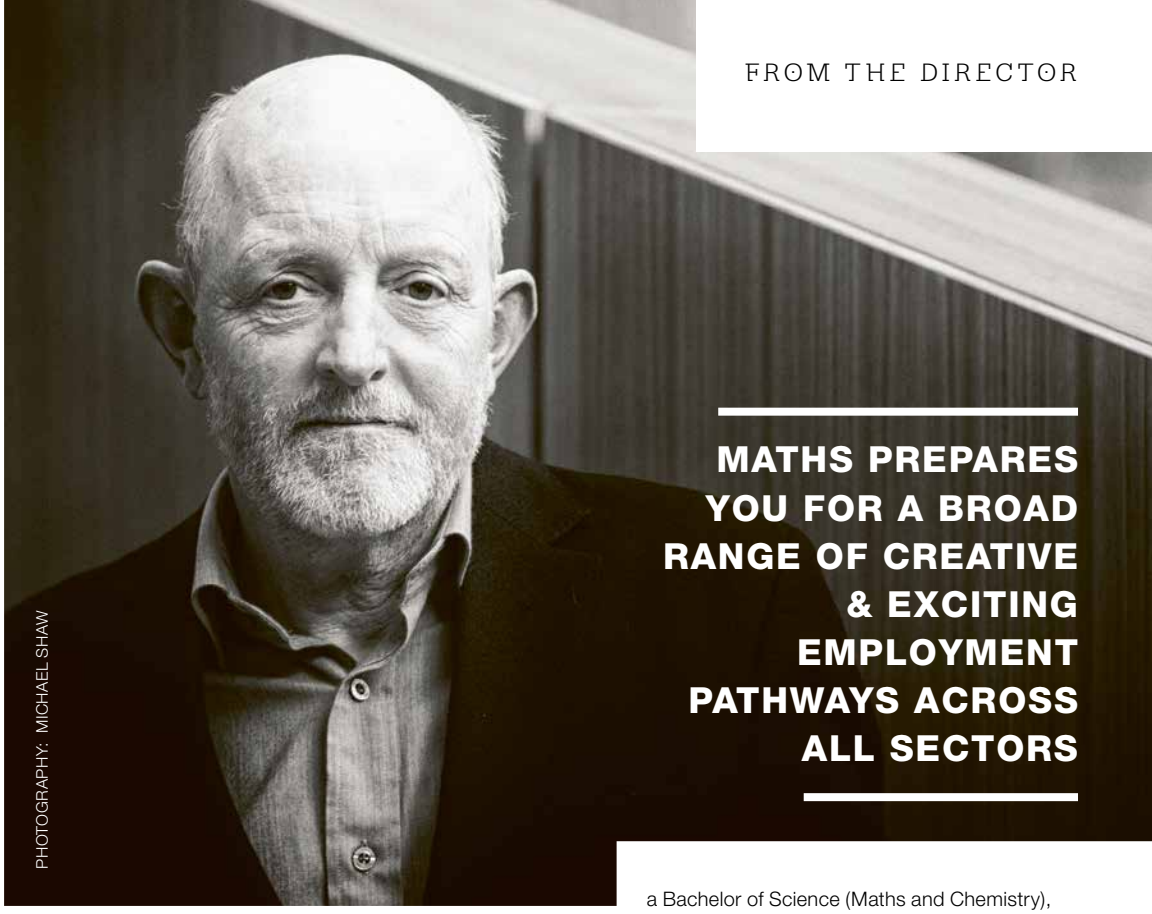
AMSI 18 **SUMMER** SCHOOL

IN THE MATHEMATICAL SCIENCES

8 JAN - 2 FEB

MONASH UNI

AMSI.ORG.AU/SCIENTIFIC



PHOTOGRAPHY: MICHAEL SHAW

MATHS PREPARES YOU FOR A BROAD RANGE OF CREATIVE & EXCITING EMPLOYMENT PATHWAYS ACROSS ALL SECTORS

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TO CELEBRATE THE RECENT NATIONAL LAUNCH OF AMSI SCHOOLS' CHOOSE**MATHS CAREERS AWARENESS CAMPAIGN ACROSS OVER 10,000 SCHOOLS, WE HAVE DEDICATED THIS FIFTH EDITION OF THE UPDATE TO MATHS CAREERS AT ALL STAGES OF THE PIPELINE.**

A component of the ChooseMaths project, this campaign realises a long-standing and critical AMSI policy priority. Turn to page 8 for a taste of the campaign and the stories shared by our 13 inspiring careers ambassadors.

Industry remains clear in its demand for a STEM (Science, Technology, Engineering and Mathematical sciences) skilled workforce. Maths prepares you for a broad range of creative and exciting employment pathways across all sectors. A quick look through the print and online versions of AMSI's maths careers guide, **MATHS**ADDS, confirms that maths and statistics truly opens doors for graduates.

We share a responsibility to mathematically equip Australia's future business, research, innovation, and thought leaders, for our future prosperity. Teacher and mother of four, Sally Saviane, challenges parents to foster maths learning in the home in a powerful call to arms, which charts her journey from maths anxiety to teacher.

We also hear from 2016 top ChooseMaths Award Winner, Peter Chandler, who updates us on the positive impact of his prize on his school's mathematics program, in particular the funding of the Penrhos College Maths Mentor Scholarship. Having announced the winner, Peter introduces us to recipient, Hannah Mast. With a Bachelor of Science (Maths and Chemistry), Hannah represents the type of talent we are seeking to attract to education to address out-of-field teaching in mathematics.

Further along the pipeline, we explore research careers beyond academia and the benefits of research-industry linkages. Fresh from his recent Vacation Research Scholarship, Asem Wardak talks about getting a taste for research projects and the value of attending AMSI Connect. **AMSI**Intern mentor, Associate Professor Yakov Zinder takes on the role of program champion having mentored more AMSI Intern students than any other academic partner. He shares his thoughts on AMSI Intern as a platform for fostering industry-research engagement and preparing students to drive commercial innovation.

From the research frontline, Dr Ruth Kluck and her team at Walter and Eliza Hall Research Institute talk about using mathematics and statistics to provide new insights into apoptosis or cell death and open new avenues to tackle cancer and neurological diseases. □

Professor Geoff Prince FAustMS

IF WE WANT TO FUTURE PROOF OUR KIDS, WE NEED TO BE A LITERATE ADULT POPULATION OF OPTIMISTIC NUMERICAL LEARNERS, MODELLING BY EXAMPLE FOR OUR CHILDREN

PHOTOGRAPHY: MICHAEL SHAW | ILLUSTRATION: CAT TAN

FUTURE PROOFING OUR KIDS

Why parents are important in conquering maths anxiety

THE RAPID PACE OF TECHNOLOGICAL ADVANCEMENT AND EVOLVING WORKFORCE MEANS MANY OF TODAY'S PRIMARY SCHOOL STUDENTS WILL END UP IN CAREERS NOT YET INVENTED. GOING BY CURRENT FIGURES, 75 PER CENT OF AUSTRALIA'S GROWTH EMPLOYMENT AREAS REQUIRE STEM (SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS), THIS MEANS A STRONG FOUNDATION IN MATHEMATICS. MOTHER AND PRIMARY SCHOOL TEACHER, SALLY SAVIANE, TALKS OVERCOMING MATHS ANXIETY AND THE ESSENTIAL ROLE OF PARENTS IN FUTURE PROOFING THE NEXT GENERATION.

I am just like you. I give and do my best as I try to be all things to all people – mum, sister, daughter, and wife. Juggling deadlines, aspiring to excellence and above all trying to equip my children as citizens of the world. This means giving them the skills to thrive and the tools to actively participate in a constantly changing world and multiple careers.

I have some experience with career change having transitioned through various roles - HR consultant, IT consultant and a variety of overseas contract roles. Having finally found what I want to do when I grow up, I recently completed a Master's in Teaching and now teach across all primary school curriculum areas and have relished relearning with my students.

As a primary school teacher I am responsible for equipping students with the foundations for a lifetime of learning. As a parent my role is broader, as I foster my children's maths learning across both primary and secondary curriculum areas.

Initially some people questioned my ability to actually teach mathematics. I did have to study quite intently, unlike other areas of learning, to consciously know the subject matter. Spearheaded by a lecturer, I have also reflected on experiences and addressed my maths anxiety. For a long time I thought I was bad at it, a belief compounded by a lack of support in the classroom and at home. In hindsight I realise, I just had my own methods and approaches to learning – a way that worked for me. Wearing my teacher's hat, I understand I just needed time to connect my own dots in a tangible way.

Now I see it as a language used to unravel and explain our world's intricate detail. While seeing the world mathematically doesn't come naturally, I do so much more now. Even looking at buildings for their aesthetic symmetry is mathematically beautiful to me and inspires the pleasure I experience in hobbies such as photography.

Unfortunately, experimenting and exploring mathematical concepts was not encouraged and by Year 4 I had developed maths anxiety. I have two defining memories of freezing in the face of maths. The first was while reciting times tables at school. I made a mistake on 7 x 8. I started trying to count it in my head — adding eights, then thinking about what 7 x 4 was to double it. The next time was at work when I was 14. I was serving a customer using an old cash register that didn't calculate anything and couldn't work out the correct change to give him from $5. We stood staring at each other until he told me to count to the next 5 which would be 75 cents, then take 2 cents from the till and count to 80 cents, then 5 cents from the till to $1 and so on until I reached $5. That maths lesson was the best of my life and I now teach kids to count back change and also think about how they might apply what they learn in their day-to-day lives.

⇨

If we want to future proof our kids, we need to be a literate adult population of optimistic numerical learners, modelling by example for our children. We also need to contextualise maths within our children's experience of the world and environment. For example if students express a love of cars, we learn place value by studying odometer readings on digital displays. While a simple example, it places conceptual understanding of our base 10 system into purposeful real-life context. Toys like Lego give us visual tools to play with maths concepts, allowing kids to learn by doing.

As a parent, I don't describe my experiences as negative or really discuss it at all. I try to keep my child's experience their own, without clouding their vision with my own. I think it's important to make truthful observations about their strengths, opportunities for improvement and achievements. We try to have fun with maths in our family, such as the '*If maths were an animal...*' poem. I think the saying 'maths is boring' is a cliché used by the uninspired. As a parent, whenever my child claims boredom, they are given a job to do and I tell them that boredom is a luxurious indulgence. They have to cost the job, determine its value (to both them and me) and negotiate a fair price. This involves estimating the cost, time needed and making some assumptions about expectations.

I need to help my children become more aware of maths around them in every field of endeavour and help them make those connections. This becomes more challenging as they get older and move beyond counting apples at the supermarket. To engage my 14-year old son, I have provided opportunities to earn more money. If he works, we match his pay. If he doesn't spend the money in 12 months time he will earn 15 per cent compounding interest, which he must calculate monthly.

Perhaps our biggest challenge is navigating a 21st century educational system with new strategies, new contexts and jobs within an unpredictable landscape. You need to make use of resources such as those available through AMSI. I have used these online resources to teach my own kids and my niece most of the Year 5 and 6 curriculum with ease and confidence. The activities online are practical and *MathsAdds* gives my son who is in Year 9 a real sense of possibility about his future as a working person. It would be amazing to see these resources present in more schools.

As a mother of two daughters, I do wonder about how they perceive their world, how I might color it through unintended linguistic filters or choice of occupation. I ask myself how am I modelling or not modelling positive associations to maths, science and use of technology. I am also aware of the jokes made, the references to 'it's just a joke - come on!' Being a bit older now, I don't mind saying when a joke is just not a joke, calling out generalised statements about gender or plainly incorrect grandiose assumptions about a person's ability.

I like the saying 'the journey itself is the destination'. I don't recall the author of this, however I'll never forget it. When we view life this way, our approach to the journey becomes the focus and how we apply ourselves. We are measured by our incremental choices and how these decisions contribute to daily learning.

Every child will feel uncertain sometimes. As parents we need to be present even when it is inconvenient for us, teaching them when we are tired and refocusing them when they lose their way. If we are serious about the future success of our children, then we must recognise the shifting sands of their evolving environment. A world responding to emerging challenges requiring conceptual scientific and applied mathematical thinking. This sort of unorthodox inventive thinking is founded in collaborative conceptual learning that traverses traditional core curriculum subject areas. □

After completing a Masters of Education at La Trobe University in 2016, Sally Saviane teaches primary years and consults with schools on their digital literacy programs.

If Maths were an Animal...

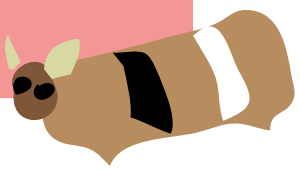
If it were an animal, my daughter says maths would be a #orse because it #as one #ead and four Legs.

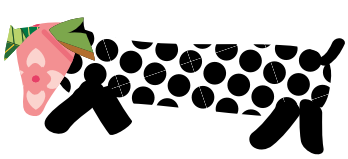
#er sister says a tiger because it #as four Legs, You can count #ow many centimeters and You can measure its Long fluffy tail, or a dog because some can be small and big.

My #usband suggests an owl, because t#ey are clever and smart and my son a guinea pig because t#ey are annoying

#is brot#er disagrees, says it is definitely a bird t#at flies in one ear and out t#e ot#er.

Once a t#reatening animal, for me it is now like t#e elusive flas# of ligt of t#e firefly. Quick and not always easy to capture, wit# patience and perseverance it lig#ts up t#e darkness for us all.





CHOOSE
MATHS
MENTORING

AN **AMSI** SCHOOLS PROJECT

DELIVERED BY AMSI Australian Mathematical Sciences Institute

SUPPORTED BY bhpbilliton Foundation

WHO WILL YOU INSPIRE ?

AMSI is looking for enthusiastic individuals to join us in changing perceptions of mathematics among high school girls. If you are studying or working in a job that involves maths and enjoy telling others about it, contact us today and help someone CHOOSE**MATHS**.

CHOOSE**MATHS**.ORG.AU/MENTORING

PAYING IT FORWARD

Award winner expands mentoring program

WE RECENTLY CAUGHT UP WITH AMSI'S CHOOSE MATHS AWARD WINNER, PETER CHANDLER TO TALK MATHS AT PENRHOS COLLEGE AND WHY HE HAS USED HIS BHP BILLITON FOUNDATION FUNDED PRIZE TO ESTABLISH THE PENRHOS COLLEGE MATHS MENTOR SCHOLARSHIP.

WHAT DID YOUR AWARD MEAN TO YOU AND YOUR STUDENTS?

The girls' response really captured everything that motivates me to keep mentoring maths - they were excited and enthusiastic and encouraging. The first thing they said was 'we need to share the prize'. They wanted to let other schools know what we are doing and share in the achievement.

I was very humbled, and very proud of our program and being recognised as I was against other fantastic teachers from other states. I'm also very privileged that I get to work with some incredible students.

I became a maths teacher because I was inspired by the teachers I had and I think part of the reason we are successful is we also have inspiring girls and teachers. I think you have to be enthusiastic and passionate about what you do and it spreads to everyone around you.

WHAT IMPACT HAS IT HAD AT YOUR SCHOOL?

This prize has created extra buzz and excitement around maths at Penrhos with the girls' coming up with some creative and positive ideas on how we can best use it. We haven't reached any conclusions, but we are hoping to use it to benefit a wider community to continue to inspire our students and hopefully others.

$5000 of the prize for my personal development has gone to the Penrhos College Maths Mentor Scholarship which was awarded to Curtin University student Hannah Mast (pictured). The purpose of this scholarship is to inspire and support a student who is studying to become a Mathematics teacher, and encourage a passion for Mathematics in his/her students.

I should share the credit for this with my students. The 2016 Maths Captains said we should be sharing this award [Peter's ChooseMaths Award for Mentoring Girls] and that's where the idea was born.

In addition to the $5000 payment, Ms Mast will be invited to participate in the life of a Maths Mentor and complete practical placements at Penrhos College.

WHY IS THIS SCHOLARSHIP SO IMPORTANT?

I hope that providing practical placements to a future maths teacher will inspire them. There's also the added opportunity to show them what the Maths Mentor Program is all about allowing them to be a Maths Mentor themselves. I like that I can share our experience and give them ideas, but I'm also hoping that I am also able to learn and grow from their knowledge and experiences.

PHOTOGRAPHY: COLIN MURTY/NEWSPIX

WHAT ARE YOU UP TO AT THE MOMENT?

At Penrhos we try and make maths fun and social, we even provide Milo and raisin bread to encourage girls to build friendships with each other at after school maths sessions.

Programs such as Maths Mentor are ongoing because they have been successful and the girls enjoy participating in them. PenrhosProfs@Perkins has especially been popular because it provides inspirational opportunities for the girls to engage in medical research. As more girls join our program each year we are seeing a cultural shift. Maths is now considered 'cool' and carries some prestige. We are excited to offer STEM co-curricular options next term, and a new STEM coordinator was appointed at the beginning of the year.

This year, we've had more girls than ever doing Specialist Maths in Year 11, there's also been an increase in the number of girls doing STEM courses at university and we've introduced Maths Captains, which is unique. The Maths Captains relish the opportunity to mentor younger students and work with other, more experienced mentors.

As well as our inspirational teachers, we have Maths Mentors outside the College, including university students – they are absolutely amazing and great role models. We also have a visiting Mathematician Program where an experienced mathematician comes and offers master classes to our students. On top of this, we offer Engineers in Schools run by Curtin University as well as provide the girls opportunities to participate in USA Space Camp and STEM Tour which is a fantastic opportunity to see and experience how wide STEM careers are.

DOES REAL WORLD CONTEXT ENHANCE LEARNING?

Students will choose maths if they see there's a reason for it in the real world. During the years, the girls have contact with many people from different careers so if the girls can see maths in action they can get a real look into their future and what they want to work towards. We have an annual MathsNight@Penrhos celebration, which acknowledges what our girls have been doing in our STEM and Maths Mentor programs. Two inspirational speakers come along to this event and show how they use maths in their career. This provides students with an insight into real and valued pathways for girls in STEM.

HOW IMPORTANT IS CAREERS AWARENESS?

We realised the importance of this very early in our Maths Mentor Program which was launched in 2009. During this time, we have built up contacts with universities, work places and our Alumni, who provide experience and knowledge showing and teaching our girls firsthand where maths can lead and is used every day in the work place. We really support what AMSI's ChooseMaths is preparing because we know it works and is of great benefit.

I've personally been amazed at how many careers require a good maths background. We know that more than 70 per cent of the jobs yet to be created will be in the STEM field, and we want to prepare our girls for these jobs of the future.

HOW CAN WE BETTER ENGAGE GIRLS WITH MATHS?

It is important all students are made aware of the opportunities maths offers. Girls at Penrhos don't see any restrictions on their future careers or any gender stereotypes attached to certain career pathways. However, it's so important that ChooseMaths breaks down any stigma that may or may not exist to allow everyone, girls and boys included, to see where their future could lead, and to be inspired to reach their full potential.

I encourage workplaces, universities and Alumni to get on board and help offer opportunities for girls and boys alike - to play an important part in continuing to mentor and inspire students to consider a future they may not have considered, to open their eyes to all options and provide them with the opportunities and resources to reach their full potential. I also encourage parents to support their children to consider a STEM pathway if they are interested. □

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*Peter Chandler was one of two teachers who received the inaugural CHOOSE**MATHS** Mentoring Girls in Mathematics Awards in 2016. A national collaboration between AMSI and the BHP Billiton Foundation, CHOOSE**MATHS** is empowering Australian students to pursue mathematics. Working across the pipeline from the classroom to university and industry, this initiative aims to strengthen capability, improve public perceptions and increase engagement of women and girls. Visit – CHOOSE**MATHS**.ORG.AU*

MORE THAN NUMBERS

AMSI's newest career ambassadors talk maths

MATHS OPENS PATHWAYS TO JOBS ACROSS A WIDE RANGE OF SECTORS FROM ANIMATION, ENGINEERING AND FINANCE TO HEALTH, MEDICAL RESEARCH AND ALL AREAS OF SCIENCE. THE CHOOSEMATHS** CAREERS AWARENESS CAMPAIGN FEATURES 12 MATHEMATICALLY CAPABLE PROFESSIONALS WHOSE MATHS STUDIES HAVE OPENED DOORS TO EXCITING CAREER OPPORTUNITIES.**

Meet Ben Waterhouse and Saskia Freytag, two ChooseMaths careers ambassadors who are interested in the world around them, passionate about finding solutions and creating a better world.

BEN WATERHOUSE

I was originally going to study a Bachelor of Commerce, but fate had other ideas by way of some unexpected advice. During maths our teacher asked each of us what we were planning to do next. On hearing my plan, she roared back that commerce was a terrible idea and I should study maths. A few months later, I started my maths degree! She was clearly very persuasive!

My first job after graduating from university was with a consulting company. I learnt an enormous amount from this experience, in particular how little I knew. Eventually I returned to uni to complete a maths PhD. Not something I had ever really planned, it turned out to be the best few years of my life.

Following my PhD, I started Model Solutions. My company uses data every day to answer questions about pharmaceutical drug use. We work with clinicians, pharmaceutical companies and government agencies on a range of complex questions and problems within that sphere. Our work varies from helping launch a new treatment or ensuring a drug is being used in line with its approvals to writing an academic paper about how treatment of a particular disease is changing.

Business success requires a toolbox of different skills. As well as getting along with people, you need to be able to prioritise and execute different tasks and make decisions. Increasingly you also need the ability to both understand and critically interpret large volumes of data.

Study not only equips you with a body of knowledge but also exercises your intellectual muscle. Bodies of knowledge come and go, some are forgotten about over time, but a strong intellectual drive and love of learning will serve you well for many years to come. I think that mathematics is some of the heaviest intellectual weight going around.

Dr Ben Waterhouse is the owner of Model Solutions. As well as a combined bachelor of Science and Arts majoring in Maths and German, he also has a PhD in Mathematics.

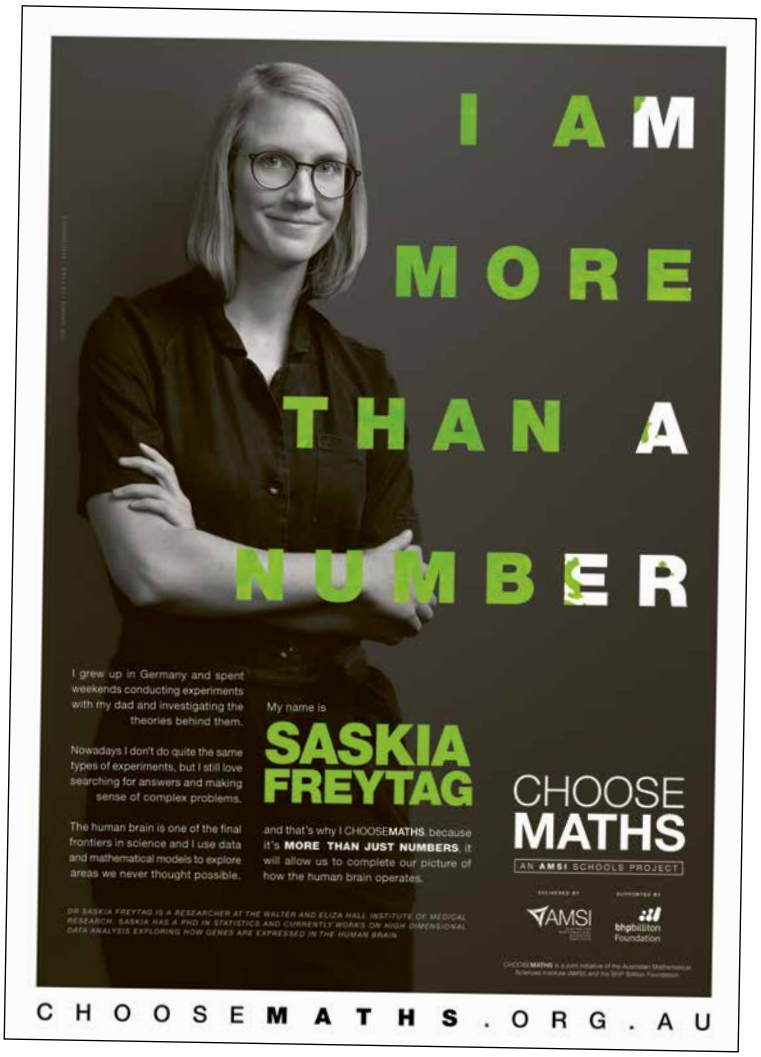
SASKIA FREYTAG

Growing up in Germany I spent many weekends conducting experiments with my dad who is a physicist. My brother and I would look on as he demonstrated home creations such as self-made rockets powered by pressure and pendulums attached to the kitchen ceiling. We would then investigate the theories. I guess it was because of these experiences that I always enjoyed maths at school.

Weirdly it was through a conference in the Netherlands that I found my way to Australia. I gave my first scientific presentation in front of an international audience and afterwards Professor Terry Speed, a leading Australian statistician based at the Walter and Eliza Hall Institute (WEHI), approached me with a job offer. Which is how I ended up where I am today.

My work at WEHI explores how genes are expressed in the human brain throughout development – from foetus to old age. The brain is an organ that undergoes a tremendous amount of change throughout a person's lifetime and using gene expression we can start to understand why and how these changes happen. This is important because many diseases originating in the brain, such as mental illnesses and neurological disorders, manifest because of misregulation of genes during brain development.

The human brain is one of the final scientific frontiers and is incredibly complex and hard to study. I use data, mathematical models and new technologies to explore areas we never thought possible. These advances are transforming the future of medical research, which is really exciting. Ten years ago, some of the things that we are able to do today would have seemed impossible; the next decade will be so exciting and data science, mathematics and statistics will be at the heart of it all.



Dr Saskia Freytag is a researcher at the Walter and Eliza Hall Institute of Medical Research. Saskia has a PhD in statistics and currently works on high dimensional data analysis, exploring how genes are expressed in the human brain.

CHOOSEMATHS CAREERS AWARENESS CAMPAIGN

AMSI launched their ChooseMaths Careers Awareness Campaign in June 2017, with careers packs distributed to almost 7500 schools, including posters, a booklet and other collateral.

The campaign profiles inspirational people, from a broad range of industry sectors, who use maths in their careers. Some work in medical research, coding or engineering, while others stem from indigenous astronomy or mineral and resources. ChooseMaths Director and AMSI Schools Program Manager, Janine McIntosh, says the campaign is an important step in beginning this critical national discussion.

"The stories shared by these inspiring women highlight perfectly the core message of this campaign. That maths is available to everyone and opens pathways you never imagined," says Ms McIntosh.

Despite increased industry demand for maths skills, Year 11 and 12 advanced maths enrolments remain in decline. In 2015 only 6.8 per cent of Year 12 girls enrolled in the subject compared to 13.4 per cent of boys.

"Students aren't getting the message about the opportunities in maths. This campaign provides critical real-world context to challenge community perception and gender bias," says AMSI Director, Professor Geoff Prince.

The ChooseMaths Careers Awareness Campaign was previewed at a series of screenings of the recent film Hidden Figures in March and April, which attracted close to 1700 female high school students at events held in Sydney, Brisbane, Melbourne and Adelaide. Several of the ambassadors attended the screenings, taking part in a panel discussion and answering questions from the students.

AMSI and the BHP Billiton Foundation are empowering Australian students to pursue mathematics through their five-year national program, ChooseMaths. The program aims to turn around public perception of mathematics and will contribute to the health of the mathematics pipeline in Australia from school through university and out to industry and the workplace. □

*For more information about the CHOOSE**MATHS** Careers Awareness Campaign and to see profiles of all 12 career ambassadors, go to: CHOOSE**MATHS**.ORG.AU*

PHOTOGRAPHY: MARK LOBO

OPENING UP MATHS CAREERS

Addressing every stage in the maths careers pipeline

AMSI DIRECTOR, PROFESSOR GEOFF PRINCE TAKES US ON A GUIDED TOUR OF AMSI'S CAREERS RESOURCES INCLUDING, THE RECENTLY LAUNCHED CHOOSEMATHS** CAREERS AWARENESS CAMPAIGN AND **MATHS**ADDS CAREERS GUIDE. HE REVEALS THE THREE C'S FOR INDUSTRY READINESS, WHY RESEARCH-INDUSTRY COLLABORATION IS THE MISSING LINK AND UPDATES US ON AMSI'S NATIONAL ALL-SECTOR, ALL-DISCIPLINE POSTGRADUATE INTERNSHIP PROGRAM **AMSI**INTERN.**

NOT SO HIDDEN FUTURES

Centred on the achievements of three female mathematicians at NASA, Theodore Melfi's movie, *Hidden Figures* challenges gender bias and highlights mathematics as an innovation driver. We need narratives like this as we seek to engage women and girls and rebrand maths as an exciting pathway to emerging career opportunities. The movie has been well received globally, including by those who attended the recent AMSI ChooseMaths screenings.

Mathematics and statistics research underpins innovation capacity across nearly every discipline. If we are to succeed as a STEM driven economy, Australia needs to change how maths is valued across the community. This remains a core focus across AMSI's policy agenda, *Securing Australia's Mathematical Workforce*. In addition to addressing university maths prerequisites, out-of-field teaching and industry engagement, measures to tackle careers awareness are critical to protect mathematical skill supply. The need for such action is supported by recommendations delivered by the AMSI Industry/Mathematical Sciences Engagement Taskforce to address industry engagement and future workforce challenges.

The mathematical sciences' impact on innovation is no secret to industry and government who have been quick to recognise the economic benefits of a strong mathematical workforce. Further down the pipeline, however, the message that maths opens powerful career pathways is not getting through to teachers, students and parents. If we want to equip children to succeed we need to give them skills that provide the resilience and agility to navigate an increasingly dynamic world. In her call to arms on page 2, Sally Saviane, parent and primary teacher, sets out a powerful case to parents supporting the value of mathematics as a flexible and essential pathway to future prosperity.

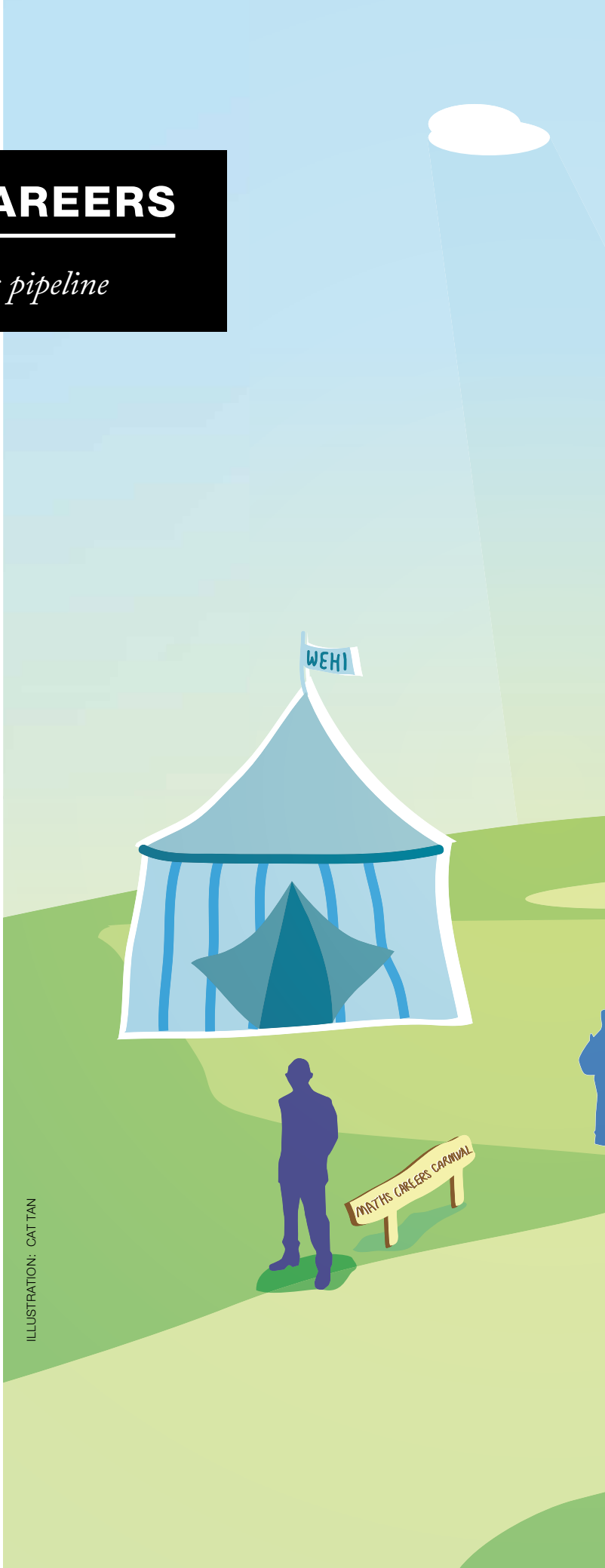


ILLUSTRATION: CAT TAN

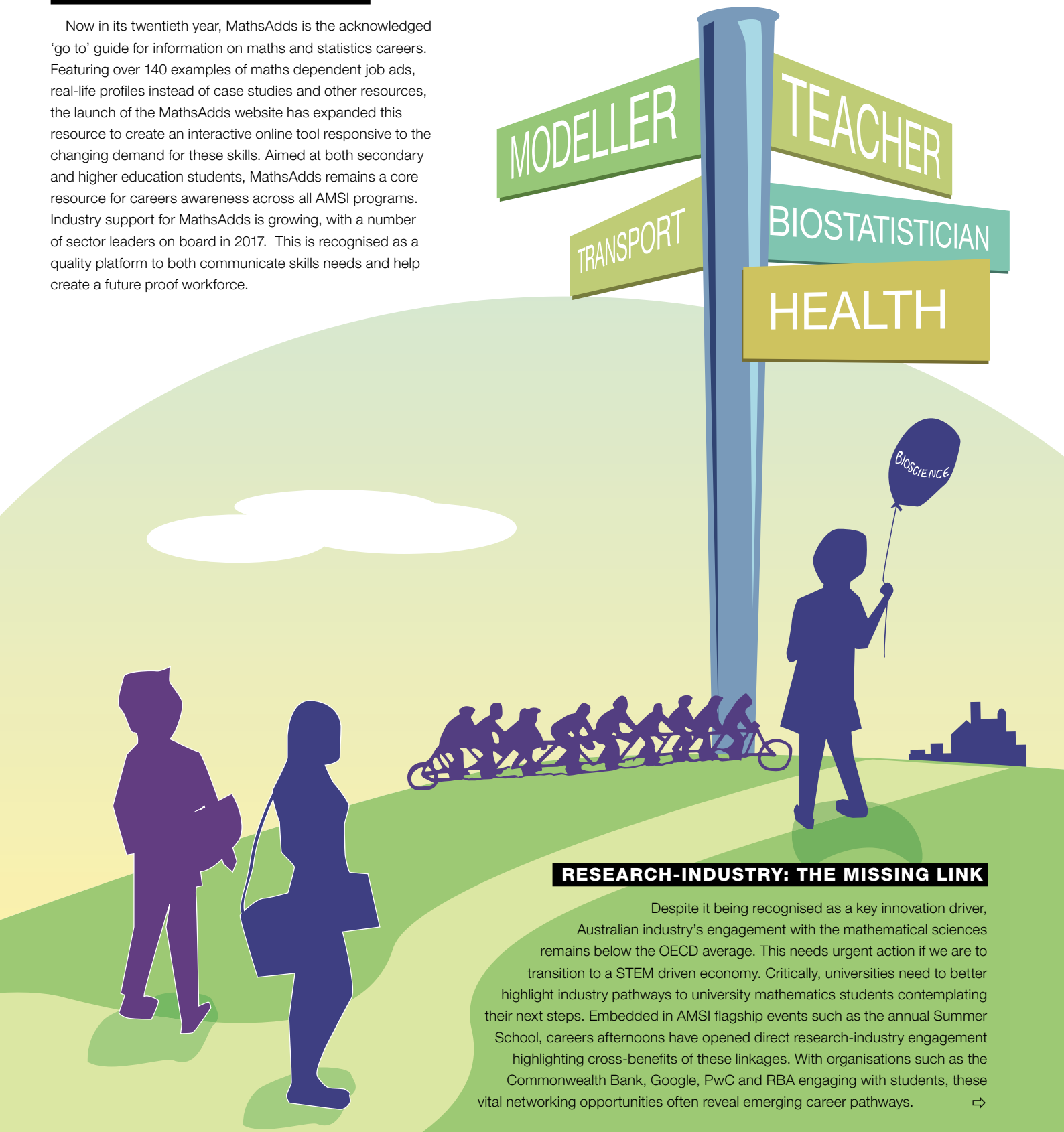
CAREERS AWARENESS

The recently launched ChooseMaths Careers Awareness campaign represents a significant milestone in tackling this challenge. Almost 10,000 schools across the country have received launch careers awareness packs, including a poster series featuring inspiring women in maths. *More than a number*, these mentors are accessibly representative of the wide-ranging industry impact of mathematics. The campaign will expand on our existing ChooseMaths outreach events, as well as drawing on topical resources including our successful video series already viewed by over 40,000 people. As the current mathematical workforce ages, resupply is dependent on strong participation of women in mathematics.

The mathematical sciences has a long-standing entrenched gender divide, in 2015 only 6.9 per cent of Year 12 girls undertook advanced maths compared to 12.6 per cent of boys with women accounting for only one third of Australian undergraduate maths students. The Women in Maths Network will bolster engagement of women and girls, essential to securing future skill supply across the pipeline, through establishment of a network of female mentors. This community of passionate and inspiring STEM professionals will support, motivate and advise young women pursuing mathematical careers. ⇨

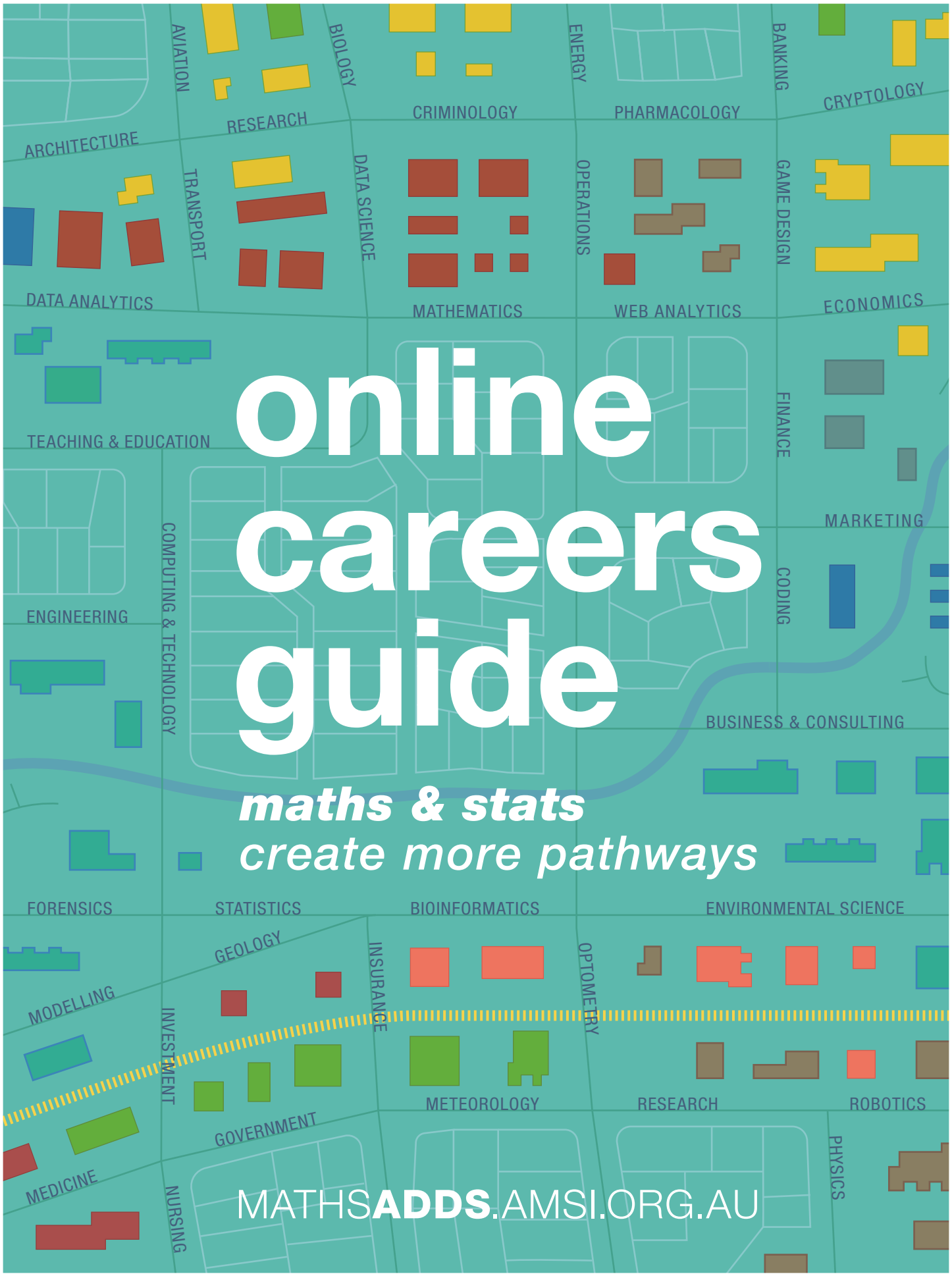
MATHSADDS: CAREERS GUIDE

Now in its twentieth year, MathsAdds is the acknowledged 'go to' guide for information on maths and statistics careers. Featuring over 140 examples of maths dependent job ads, real-life profiles instead of case studies and other resources, the launch of the MathsAdds website has expanded this resource to create an interactive online tool responsive to the changing demand for these skills. Aimed at both secondary and higher education students, MathsAdds remains a core resource for careers awareness across all AMSI programs. Industry support for MathsAdds is growing, with a number of sector leaders on board in 2017. This is recognised as a quality platform to both communicate skills needs and help create a future proof workforce.



RESEARCH-INDUSTRY: THE MISSING LINK

Despite it being recognised as a key innovation driver, Australian industry's engagement with the mathematical sciences remains below the OECD average. This needs urgent action if we are to transition to a STEM driven economy. Critically, universities need to better highlight industry pathways to university mathematics students contemplating their next steps. Embedded in AMSI flagship events such as the annual Summer School, careers afternoons have opened direct research-industry engagement highlighting cross-benefits of these linkages. With organisations such as the Commonwealth Bank, Google, PwC and RBA engaging with students, these vital networking opportunities often reveal emerging career pathways. ⇨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THE THREE C'S FOR INDUSTRY READINESS

As we seek to foster research-industry engagement, it is essential to provide a supply of work ready mathematics graduates. A workforce equipped not only with the required specialist knowledge but also the soft skills needed to navigate and thrive in commercial environments. As part of its engagement with industry, AMSI's Industry Advisory Committee asked senior company executives to identify the skills in most demand. As expected the ability to communicate and collaborate were at the top of this list, as was the almost universal demand for maths graduates with the ability to code. This gives weight to the benefits of inclusion of coding in the school syllabus, and keeping these skills front of mind for maths and stats postgraduates as they compete for the new generation of roles in the innovation system.

AMSI's Vacation Research Scholarship program plays an important role in transition from classroom to career, teaming undergraduate students such as Asem Wardek featured in this *Update* issue, with established researchers for short-focused projects with real outcomes. You can read about Asem Wardek's experience and the benefit of the program on page 17.

Integrated learning opportunities (WIL) expose university students to industry and opening essential industry-research pathways. Industry focused postgraduate internships are a proven model to equip the emerging research workforce to engage with industry and open new avenues for future collaboration.

Launching in June 2017, AMSI Optimise seeks to strengthen mathematical-industry ties and build essential commercial optimisation capacity. Featuring a mix of presentations and practical challenges, AMSI Optimise will create strategic pathways for researchers to collaborate with the public and private sector in areas such as transport and supply chain logistics, energy pricing and communication networks.

NATIONAL INTERNSHIP PROGRAM

Australia's only national, university-owned PhD internship program, AMSI Intern has already made a considerable impact on the innovation landscape, placing over 200 interns across all disciplines and industry sectors into four to six-month industry research projects. This has served to not only increase industry led university-research collaboration but has led to growth in the employment of specialist research staff across both SMEs and big business. We are now preparing to bring the program to national scale, with the government announcing a $28.2 million funding package to place 1400 interns over four years.

One of the strengths of AMSI's internship model is the participation of academic mentors to support postgraduate researchers. This has proven effective in building research-industry partnerships well beyond the internship. For industry, the opportunity to see first-hand the benefits of accessing specialised research skills establishes new need for collaboration and, in some cases, leads to employment of interns to enhance internal research capabilities.

MAKING MATHS THE FUTURE

The rapid pace of technological development continues to open new opportunities and exciting career pathways not yet found in MathsAdds or any other career resource. Careers awareness is about more than jobs, it is about futures. And in our shared and individual futures mathematics continues to be both a fundamental foundation and at the very frontier of what we know. By choosing maths and encouraging our children to choose maths we equip ourselves to evolve with the world and be part of the extraordinary.

Much like Astronaut John Glenn in Hidden Figures, industry innovators know you 'can't get anywhere without the numbers.' □

MONASH UNI

4 - 8 DECEMBER

AMSI BIOINFO SUMMER 17

A SYMPOSIUM IN BIOINFORMATICS

AMSI VACATION RESEARCH SCHOLARSHIPS 17 18

AUSTRALIA WIDE

1 DEC 17 - 28 FEB 18

MONASH UNI

8 JAN - 2 FEB

AMSI SUMMER SCHOOL 18

IN THE MATHEMATICAL SCIENCES

CONNECTING THE DOTS

Industry insights a light bulb moment

ASEM WARDAK'S RECENT VACATION RESEARCH SCHOLARSHIP (VRS) PLACEMENT WAS SOMETHING OF A LIGHT BULB MOMENT. THE PROGRAM, INCLUDING PRESENTING AT AMSI CONNECT, WAS THE FIRST TIME THE UNIVERSITY OF SYDNEY MATHS AND PHYSICS STUDENT HAD ENCOUNTERED INDUSTRY RESEARCH.

"Linking industry and maths research allowed me to develop a clearer picture of the multi-discipline opportunities available within mathematics."

Now completing Honours in Physics, Asem spent six weeks from December to February exploring negatively curved structures in dimensions three and four via discrete geometry. These higher-dimensional versions of making a saddle out of triangles have angle sums greater than 360 degrees around a point, meaning they are negatively curved.

"Negatively curved structures are extremely important in natural sciences such as general relativity and molecular structure in chemistry," Asem says.

As well as general relativity – a branch of physics focused on understanding the nature of gravity in the universe – these structures are also used in knot theory. Inspired by knots in everyday life such as in a rope or a shoelace, this field of research enables prediction of molecule properties.

Having completed a Bachelor's degree in Pure Mathematics and Physics, the VRS project was a chance to bring together two subjects of passion.

"This project looked at metric spaces and differential geometry. This type of research greatly interests me and I hope to pursue it in the future," Asem says.

During 2017, however, Asem will focus on his Honours in Physics and a project at the bridge of neuroscience and artificial intelligence. He hopes to apply some of the skills developed during VRS to these studies.

"I realised how vital communication is to the production of research. With effective communication, existing ideas may be improved in subtle ways, which end up making significant contributions."

For Asem the biggest drawcard for completing the intense six-week VRS program was the opportunity to tackle real-world research challenges alongside field leaders. The program's beauty being the opportunity to see your work have impact and propel yourself forward as a researcher.

"My main aim, which I achieved, was to participate in current research in pure mathematics and produce real scientific outcomes," he says.

A program highlight, AMSI Connect, acts as a punctuation mark for the experience giving VRS participants a platform to both to both present their work and hear from industry and research experts. The two-day conference allows students to connect the dots between research and commercial application and the many opportunities beyond their studies.

"The various events expounding this connection between industry and research were enormously valuable. It allowed me to develop a clearer picture of the opportunities available in a range of disciplines within mathematics," says Asem.

With PhD and postgraduate research on the horizon, as Asem discovered at VRS, anything is possible. □

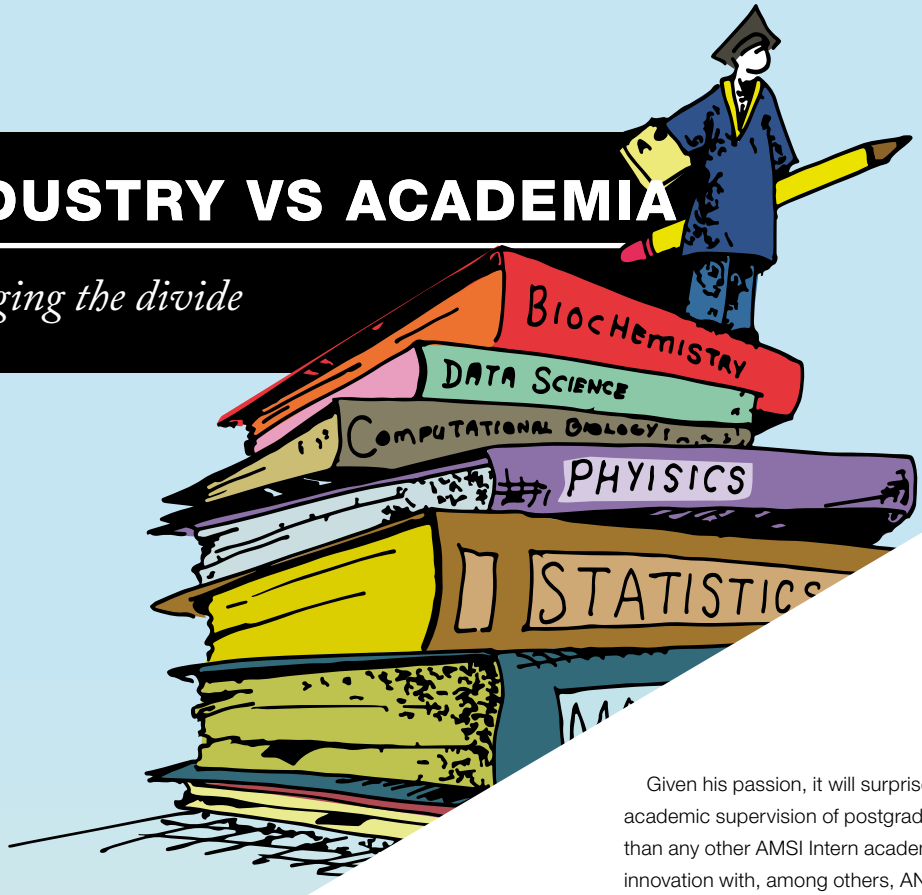
LINKING INDUSTRY & MATHS RESEARCH ALLOWED ME TO DEVELOP A CLEARER PICTURE OF THE MULTI-DISCIPLINE OPPORTUNITIES AVAILABLE WITHIN MATHEMATICS

PHOTOGRAPHY: MICHAEL SHAW

Asem Wardak was a recipient of an AMSI Vacation Research Scholarship in 2016-17. AMSI Vacation Scholars undertake a 6-week research project, presenting their results to peers and supervisors at AMSI's student conference (AMSIConnect) at the end of the summer.

INDUSTRY VS ACADEMIA

Bridging the divide



PERHAPS ONE OF THE BIGGEST QUESTIONS FACING POSTGRADUATE RESEARCH STUDENTS – INDUSTRY OR ACADEMIA?

As Australia seeks to strengthen industry led university research engagement, researchers such as University of Technology Sydney's (UTS) Associate Professor Yakov Zinder are helping students see they can have a career that includes both.

Having led research in quantitative management science and operations research, Yakov is drawn to real-world industry research challenges.

"For applied mathematicians, industry poses some of the most interesting questions. Engagement with industry is essential in my field," he says.

He has used mentor roles, with both **AMSI**Intern and the Australian Technology Network Industry Doctoral Training Centre to champion the benefits of industry engagement to his students.

Given his passion, it will surprise few to learn he has set the bar for academic supervision of postgraduate interns, working on more projects than any other AMSI Intern academic mentor. Research that has helped drive innovation with, among others, ANC, Fleet Flyers, CSIRO, Energy Australia, and Intelligent Energy Systems Pty Ltd.

Yakov's success and impact as a mentor for both programs recently saw him jointly honoured with a UTS Vice-Chancellor's Award for Research Excellence in the category Research Development (including Supervision) with colleague Professor Alex Novikov.

With Australia trailing the OECD in university-industry collaboration, he believes national scale programs, such as AMSI Intern, are critical in building such linkages.

"To support future research and development capability and secure Australia's innovation capacity, it is critical we equip the future research workforce to effectively apply their knowledge and expertise in industry settings," he says.

The fostering of new talent remains the biggest driver in his passion for mentoring students into industry. His involvement in programs such as AMSI Intern, he believes, allows him to elevate his student's learning experience.

"Industry collaboration enriches my teaching and research by deepening my understanding of specific industry

needs, while also helping my students develop critical soft skills such as cross-discipline communication," he says.

The intense research challenges posed by AMSI Intern industry partners are, he admits, hard work, with the projects designed to deliver fast tracked industry-specific solutions within tight deadlines. Involved at all stages of the project, his role is to guide postgraduate interns through what is usually their first taste of industry innovation.

"The workload is high with constant student contact and engagement with the industry partners, it can be intense. However, it is rewarding to be able to watch your students mature and develop during these collaborations," he explains.

Personally, Yakov has benefited as much as his student with access to industry opening opportunity to build long-term collaborations.

With a national scale expansion of AMSI Intern announced as part of the Australian Government's recent election package, academic research access to industry is likely to grow.

Rather than choosing between academic and industry pathways, we need postgraduate research students to follow Yakov's lead in doing both. This not only adds up to a more interesting and satisfying career, but a stronger innovation future for Australia. □

***AMSI**Intern matches the advanced skill sets of PhD students with private and public sector partners to work on focused research projects for four to five months. For more information on **AMSI**Intern and becoming a mentor, visit **AMSI**INTERN.ORG.AU*

TO SUPPORT FUTURE RESEARCH & DEVELOPMENT CAPABILITY & SECURE AUSTRALIA'S INNOVATION CAPACITY, IT IS CRITICAL WE EQUIP THE FUTURE RESEARCH WORKFORCE TO EFFECTIVELY APPLY THEIR KNOWLEDGE & EXPERTISE IN INDUSTRY SETTINGS

ILLUSTRATION: CAT TAN

THE MATHEMATICS OF CELL DEATH

Modelling protein arrangements at the Walter & Eliza Hall Institute

MATHEMATICS HAS HELPED A TEAM OF RESEARCHERS AT MELBOURNE'S WALTER AND ELIZA HALL INSTITUTE OF MEDICAL RESEARCH (WEHI) UNCOVER POSSIBLE THERAPEUTIC TARGETS FOR CANCER AND NEUROLOGICAL DISEASE.

Drs Ruth Kluck and Rachel Uren from WEHI's Molecular Genetics of Cancer Division teamed up with the Bioinformatics Division's Martin O'Hely, now at Deakin University, to take a world-first view of proteins Bak and Bax in action during a type of cell death called apoptosis.

The biostatistician used his mathematical modelling skills to simulate how these killer proteins cluster to puncture the surface of the central energy source within cells, the mitochondria. Dr Kluck has been studying apoptosis for 20 years, and likens these killer proteins to the Transformers in the famous movies.

"Like Transformers these proteins take on new shapes that allow them to work together to cause cells to die through the penetration of the mitochondrial membrane. These findings show these proteins talk to the mitochondrial membrane in a way never before proposed," she explains.

The fact that Bak and Bax play a key role in cell death by pairing up and joining together in large numbers to puncture the mitochondria is not new. However, the team's recently published findings go some way to answering the important question of how.

"The challenge was to confirm the arrangement of the protein groups, whether they were in a clumpy or ring formation. I was able to complete the puzzle by modelling the proteins as interacting particle systems to simulate the clustering process," explains Martin.

Dr O'Hely's statistical capability, says Dr Rachel Uren, provided opportunity to study proteins embedded in biological membranes in a way not possible using traditional biochemical or imaging techniques.

"The mathematical modelling in this project was critical as a complementary approach to our biochemical studies that allowed us to explore biology in more detail than would otherwise have been possible," she said.

While still a considerable way off, the possibility of eventual clinical application is particularly exciting, particularly for patients with cancer, neurodegenerative disease and autoimmune conditions.

"While still very early-stage, these findings may allow manipulation of apoptosis in diseases where this process has been disrupted," says Dr Uren.

First however, the team will need to now understand how the mitochondrial membrane, which is made up of fatty molecules called lipids, talks to Bak and Bax proteins. Biostatistics and bioinformatics will play a vital role as they tune into this conversation and analyse data patterns.

"This is just one of several aspects of apoptosis and its role in cancer research that will require biostatistics and bioinformatics, with demand for this expertise only set to grow at WEHI," says Dr Kluck.

At a time when analysis is playing catch up to biochemistry, past AMSI BioInfoSummer attendee, Dr O'Hely is up for this exciting challenge. □

FIGURE 1: *The Walter and Eliza Hall Institute*

This donut shows a single simulation of the aggregation and induced linkage of Bak dimer molecules on the mitochondrial outer membrane. For the simulation, each subunit representing a Bak dimer was evenly distributed on a geometric grid imposed on a flat surface, with dimers able to link with up to two neighbours. To avoid edge effects, this surface was then wrapped onto a donut shape (or torus). In the output, each coloured "snake" represents distinct contiguous chains of linked Bak dimers.

MEET THE TEAM

Dr Ruth Kluck

Dr Ruth Kluck is a cell biologist who has studied apoptotic cell death since her PhD at the Queensland Institute for Medical Research. As laboratory head at the Walter and Eliza Hall Institute of Medical Research, her focus has been on defining the mechanism of apoptotic cell death, and how it can be regulated for therapeutic benefit in cancer and other diseases. Her group has defined several steps in mitochondrial pore formation, a key event leading to cell death. She has had a total of 52 biomedical papers that have attracted over 9,000 citations.

Dr Rachel Uren

Dr Rachel Uren is a post-doctoral researcher at the Walter and Eliza Hall Institute of Medical Research. She completed her Bachelor of Science degree with honours and her PhD at the University of Melbourne. Rachel uses biochemistry to study proteins inside cells that control the tightly regulated process of apoptotic cell death. She hopes that a better understanding of these molecules will aid the design of better therapies for diseases such as cancer and neurodegeneration.

Dr Martin O'Hely

Dr O'Hely is a mathematician who works on problems from the biological sciences. He studied maths as an undergraduate at Monash University and as a PhD student at the University of Minnesota. He has worked in ecology, evolution, maths/stats and bioinformatics groups around the world and is currently responsible for microbiome bioinformatics in the Barwon Infant Study, a joint project of Deakin University, the Murdoch Children's Research Institute and Barwon Health.

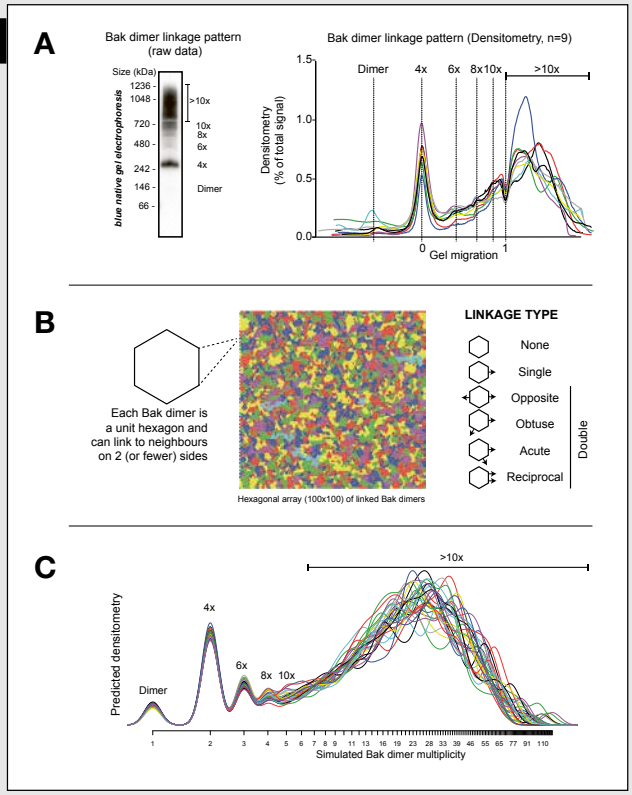


FIGURE 2: *The Walter and Eliza Hall Institute*

A Apoptotic mitochondria were tested for induced linkage between Bak dimers, and the size of these linked complexes assessed by blue native gel electrophoresis (left) and quantification (right, nine experiments).

B We simulated the aggregation and linkage of Bak dimers with a hexagonal 100 X 100 grid. Each hexagon represented a Bak dimer (left), with the capacity to link to at most two neighbours. Neighbouring subsets (clusters) of linked Bak dimers are highlighted by different colours (centre). The direction of linkage from each hexagon was randomised and linkage possibilities are shown (right).

C The linkage simulations were output as a predicted densitometry plot (30 simulations are shown in overlay). These simulation results closely parallel the experimental results (see A), highlighting that the observed experimental linkage pattern could arise from random contact between proteins. These data reveal that Bak dimers form disordered, dynamic clusters to create the apoptotic pore.

Uren, R. T., O'Hely, M., Iyer, S., Bartolo, R., Shi, M. X., Brouwer, J. M., Alsop, A.E., Dewson, G. and Kluck, R. M. (2017). Disordered clusters of Bak dimers rupture mitochondria during apoptosis. eLife, 6, e19944. http://doi.org/10.7554/eLife.19944

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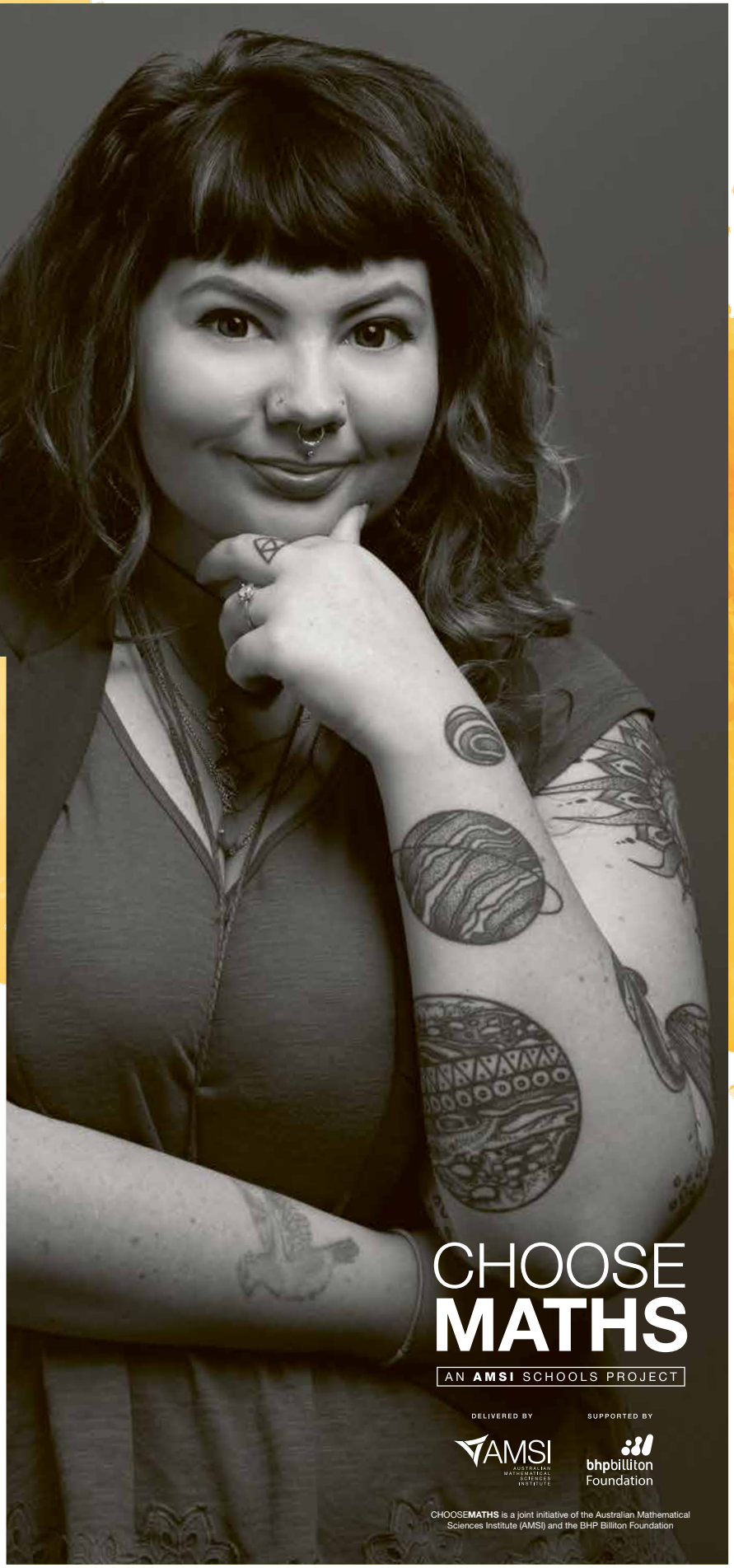

Choose the path which you find the most interesting -- if you love it and have a passion for it, everything else will follow. When you CHOOSE**MATHS** a world of possibilities opens up.

My name is

KARLIE NOON

Karlie Noon completed a double degree in Maths and Physics at The University of Newcastle. Currently she is researching for a Masters in the field of Astrophysics. ***Read her story at***

CHOOSEMATHS.ORG.AU