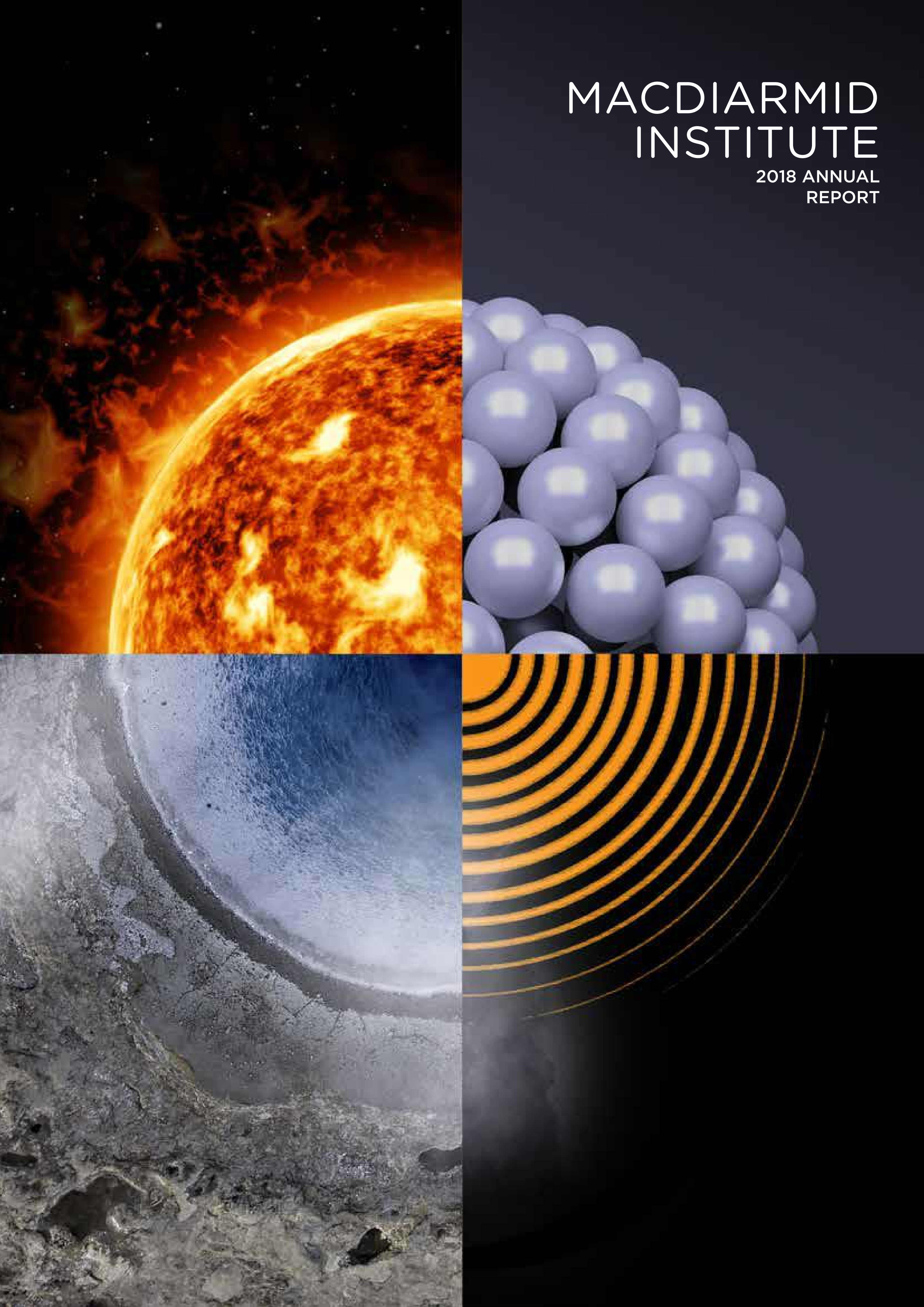
MACDIARMID INSTITUTE

2018 ANNUAL REPORT



Our focus is materials science research and technologies, especially the unexplored territory where chemistry, physics, biology and engineering meet.

We collaborate to create new knowledge addressing the big problems of our time, and bring innovations to the marketplace and contribute to the New Zealand Economy. Our ultimate aim is to create technologies that can improve our lives and our environment.

From 2002 - 2018

656 PhD graduates

852 research alumni

3500+ AMN conference attendees

64 inventions patented

15 spinout companies created

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CO-DIRECTORS' REPORT

Nicola Gaston and Justin Hodgkiss
Co-Directors

THE CORE PURPOSE OF THE INSTITUTE IS THE WORK WE DO TRAINING NEW ZEALAND'S BEST STUDENTS TO BE THE SCIENTIFIC EXPERTS THE WORLD WILL NEED IN THE FUTURE.

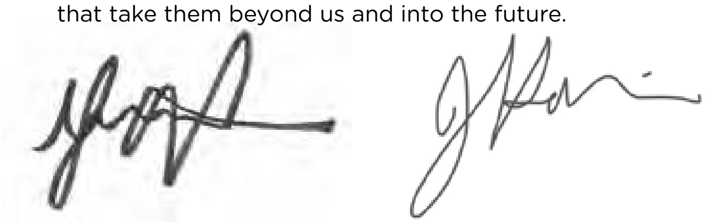
Reflecting on 2018 – our first year as co-directors of the MacDiarmid Institute, it has been a year of new people, new partnerships, and new directions.

We celebrate the eight new Principal Investigators who joined us this year. This cohort includes early career researchers who are injecting new capability and energy – and New Zealand's leading proponents of materials science in the context of mātauranga Māori. Along with the nine new Associate Investigators joining us this year, this new talent will expand the horizons for materials science in New Zealand in years to come.

We forged a partnership with Whakarewarewa thermal village. Our journey together sees us exploring the material world of the thermal village through the dual lenses of modern materials science and Māori knowledge passed through generations. This science partnership engages educators, children, and visitors to the small community where it is embedded.

We hosted a major forum – Materialise: A Sustainable Future – exploring the science for an environmentally and economically sustainable Aotearoa. International experts illuminated the basic research needs for new battery technologies, sustainable computing, water purification, and sustainable phosphorous use in fertiliser. The forum went beyond science; inspiring kids to become scientists and engineers to better the world; celebrating Māori knowledge forged throughout centuries of sustainability, building the business case for sustainability, and empowering the public. The work of the MacDiarmid Institute is at the heart of New Zealand's burgeoning environmental innovation movement, where confronting climate change can be our opportunity.

Alongside all this, we never forget that the core purpose of the Institute is the work we do training New Zealand's best students to be the scientific experts the world will need in the future. Many of our students' stories appear throughout this report — stories of vital research, and of careers that take them beyond us and into the future.



CHAIR'S REPORT

Paul Atkins
Chair

MATERIALS SCIENCE IS CRUCIAL TO MANY OF THE TECHNOLOGIES WE NEED FOR SUSTAINABILITY; NEW BATTERIES, SOLAR PHOTOVOLTAICS AND ENERGY EFFICIENT COMPUTING

The 2018 IPCC report leaves us all in no doubt that we need to act now and we need to act fast if we are to have any chance of mitigating changes to our climate. It is certainly clear to me we need materials science more than ever before.

Materials science is crucial to many of the technologies we need for sustainability; new batteries, solar photovoltaics, energy efficient computing, and the clever materials to soak up CO_2. The MacDiarmid Institute is uniquely placed to be able to make a significant contribution to answering some of the major questions posed by the IPCC and the Living Planet reports, and providing real technological solutions to the challenges we face.

It has been a real privilege to be part of the Institute this year. I wish to firstly extend my thanks to Thomas Nann who led the Institute through to March this year. He has taken a new and exciting role in Newcastle Australia. I acknowledge the contribution Thomas made to the Institute, and wish him all at the best in his new role.

And my thanks go to Nicola Gaston and Justin Hodgkiss, who took over as Co-Directors. The pace at which you have stepped into these positions is truly impressive.

I also wish to pay tribute to Ray Thomson, my predecessor as Board Chair, who passed away suddenly and unexpectedly this year. In his three years as Chair, Ray boosted the commercialisation capability and mindset within the Institute to unprecedented levels.

I invite you to read in this report the work of MacDiarmid Institute researchers and I am sure you will be as inspired and encouraged as I am by these stories. Clever structures that could reduce the energy computers need (pp); smart materials for more sustainable batteries (pp); examining the nano-environment between cancer cells (pp) and more, as well as the ever expansion of our engagement, this year encompassing exciting new partnerships with Whakarewarewa Village, Te Papa and MOTAT.

Printable solar panels, bioplastics, aluminium batteries, handheld gene testers and novel super-conductors.

1. Out of the lab.

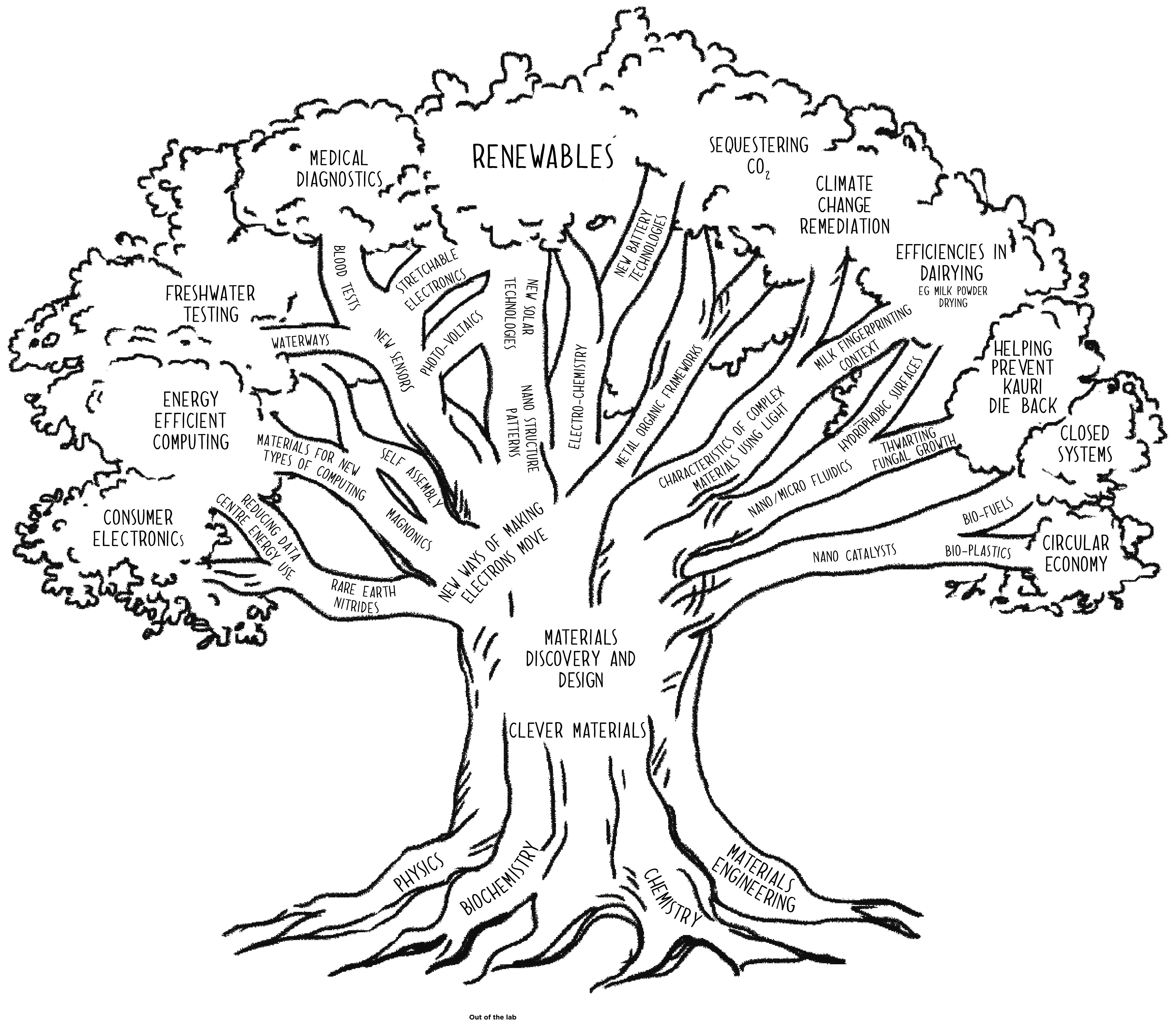
We tackle basic materials science and nanotechnology questions in the laboratory, to ultimately create something that will meet a need in the real world. We are especially focused on applications that will help our transition to a more sustainable way of life.

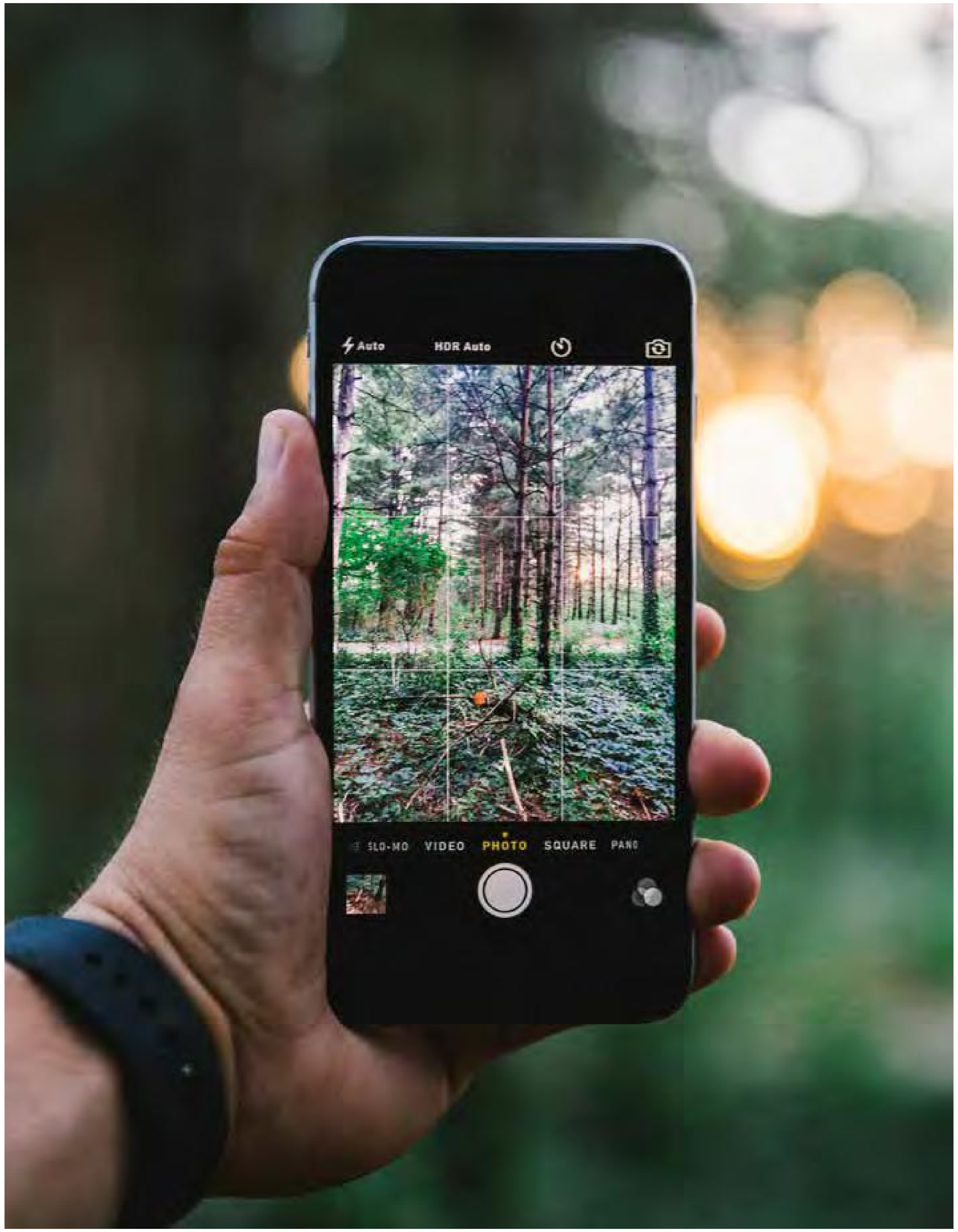
Developments underway include printable solar panels, bioplastics, aluminium batteries, handheld gene testers and novel superconductors. And this is just the start. Our aim is that the research we undertake today will continue to help people, and the planet, for decades to come.

We want to help transform society for good.

“The whakataukī that best captures our purpose is: ‘Ahakoa he iti, he pounamu’. We invest in the development of fundamental knowledge, and so enable ourselves and others to be smart about what resources we use to make the materials needed for technology development. It’s about minimising the material impact we make on the world.”

MACDIARMID INSTITUTE CO-DIRECTOR ASSOCIATE PROFESSOR NICOLA GASTON


RENEWABLES
MEDICAL DIAGNOSTICS
SEQUESTERING CO_2
CLIMATE CHANGE REMEDIATION
EFFICIENCIES IN DAIRYING
EG MILK POWDER DRYING
FRESHWATER TESTING
BLOOD TESTS
STRETCHABLE ELECTRONICS
NEW SOLAR TECHNOLOGIES
NEW BATTERY TECHNOLOGIES
WATERWAYS
NEW SENSORS
PHOTO-VOLTAICS
NANO STRUCTURE PATTERNS
ELECTRO-CHEMISTRY
METAL ORGANIC FRAMEWORKS
MILK FINGERPRINTING CONTEXT
HELPING PREVENT KAURI DIE BACK
ENERGY EFFICIENT COMPUTING
MATERIALS FOR NEW TYPES OF COMPUTING
SELF ASSEMBLY
MAGNONICS
CHARACTERISTICS OF COMPLEX MATERIALS USING LIGHT
HYDROPHOBIC SURFACES
THWARTING FUNGAL GROWTH
CLOSED SYSTEMS
NANO/MICRO FLUIDICS
CONSUMER ELECTRONICS
REDUCING DATA CENTRE ENERGY USE
RARE EARTH NITRIDES
NEW WAYS OF MAKING ELECTRONS MOVE
BIO-FUELS
BIO-PLASTICS
NANO CATALYSTS
CIRCULAR ECONOMY
MATERIALS DISCOVERY AND DESIGN
CLEVER MATERIALS
PHYSICS
BIOCHEMISTRY
CHEMISTRY
MATERIALS ENGINEERING



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BEYOND LITHIUM

NEW BATTERIES: THREE APPROACHES

TO BUILD MORE SUSTAINABLE BATTERIES, SHOULD WE LOOK TO DIFFERENT MATERIALS?

In today's tech-hungry world, lithium batteries are ubiquitous. Everything from your mobile phone to the neighbour's electric car rely on the metal, and it's easy to see why. Lithium-ion (Li-ion) batteries pack a punch, storing more energy than any other battery of equivalent size, and delivering power to where it's needed, quickly and efficiently.

But they're far from perfect. For a start, lithium batteries come with a significant environmental footprint – extracting a tonne of lithium requires more than two thousand tonnes of water – and at the end of its life, a Li-ion battery is usually dumped in a landfill or incinerator, thanks to a lack of practical recycling routes. In operation, lithium batteries can overheat, and as news headlines have reported since 2013, they can combust, or even explode, when damaged. And finally, the materials that go into making Li-ion batteries – namely lithium and cobalt – are not Earth-abundant. Eventually, we will run out of them.

With demand for reliable batteries growing exponentially, what can we do? According to MacDiarmid Institute Principal Investigator, Professor Thomas Nann from Victoria University of Wellington, the answer is to look elsewhere on the Periodic Table of Elements. Specifically, at a very familiar metal – aluminium. "We found that aluminium's potential energy density (a measure of how much energy a material can store) comes very, very close to lithium's, but it has the added bonus of being the third most abundant element in the Earth's crust," he says. Professor Nann and his team took that as a starting point, and set out to design a new aluminium-ion battery.

They wanted to stick with a proven battery architecture – namely, two electrodes separated by an electrolyte – but the chemistry needed a shakeup.

> Lithium batteries come with a significant environmental footprint.

Their first target was the electrolyte material itself, which, because ions move through it, is vital to the battery's operation. It is usually made from an expensive cocktail of compounds, so in search of a cheaper alternative, Professor Nann and MacDiarmid Institute-funded PhD student, Nicolò Canever, looked to the mining industry. "There's a compound called acetemide that's already used to extract aluminium ions from solution, so we decided it would be the basis for our electrolyte," Professor Naan explains, "It can also be produced by bacteria, so is incredibly inexpensive." Their final compound worked well, and even allowed for ultrafast charging.

While that work was recently published in a Royal Society of Chemistry journal, the team's design of a new electrode material has taken a different route. "It is so transformative and so surprising that we knew we had to patent it," Professor Nann says. He credits his PhD student Shalini Divya with taking up the challenge of starting from scratch, rather than simply improving on what had gone before, "She found a material that outperforms everything that's been published to date".

A key step in the patenting process is to prove that their lab-produced batteries could be manufactured in a commercial facility, so Professor Nann and Ms Divya recently travelled to Germany's Fraunhofer Institute to do just that. The trip, funded by the MacDiarmid Instiute, was a huge success. They arrived back to New Zealand with twenty of their novel aluminium batteries, which Professor Nann says are "... approaching the performance of lithium ion batteries currently on the market." Best of all, they could be produced with only very minor changes to existing processes, "...which is a key consideration for potential investors or manufacturers."

Professor Nann and his team are continuing to develop their patent and their battery at a time when the need for sustainable energy storage has never been more urgent. "As we transform into an energy landscape dominated by renewables, the problem is not getting hold of energy – after all, if we covered 250 by 250 square kilometres of the Australian outback in commercial solar panels, we'd generate all the energy our entire planet needs," he explains. "This isn't as much area as it initially seems – rows of solar panels alongside

existing highways could make a big impact.”
Professor Nann is driven by adding value through his science.

“The most pressing issue is matching supply and demand, and that’s where our work comes in. I want to make a difference; to have a real impact on energy storage in New Zealand and around the world.”

CAN WE SKIP THE SOLAR CELL ALTOGETHER?

Another battery project connects Professor Nann with his MacDiarmid Institute collaborators and University of Canterbury researchers, materials engineer Professor Maan Alkaisi, chemist Associate Professor Vladimir Golovko, and chemical engineer Associate Professor Aaron Marshall.

Associate Professor Marshall says the project is funded under MBIE Smart Ideas, and involves looking at new smart materials that can convert sunlight directly into stored battery energy, without making electricity in the process (i.e. skipping the whole solar cell creation of electricity step).

“Currently the challenge is to find a material which absorbs the sunlight and catalyses the charging reaction directly inside the battery”

SHRINKING MONSTER-SIZED FLOW BATTERIES.

Associate Professor Marshall and his MacDiarmid Institute collaborator University of Canterbury chemist Professor Alison Downard are also working to speed up (and shrink) redox flow batteries. In a redox flow battery, the ‘energy’ is stored in chemicals which sit in (usually big) tanks separate to the battery itself. When energy is needed, the chemicals are pumped through the battery and through the porous electrodes.

“The concept it a bit like filling your car’s fuel tank with petrol – you could then leave the car for a year and it would still have a full tank of gas and be ready to drive when you needed it.”

> “The project is funded under MBIE Smart Ideas and looks at new smart materials that can convert sunlight directly into stored battery energy.”
> ASSOCIATE PROFESSOR AARON MARSHALL

And he says the chemicals (usually a dissolved metal species like iron, vanadium or bromine) are relatively abundant and therefore relatively cheap over the lifetime of the battery. But the batteries are currently slow.

“Slow reactions means the battery requires big electrodes. And if the electrodes are large, the rest of the battery has to be large as well, and the whole thing ends up being expensive.”

So the MacDiarmid Institute team at the University of Canterbury is looking at ways to coat the electrodes with new materials to speed up the reaction - so they can reduce the size of the electrodes. They’re using the vanadium electrolyte system to test changes against; vanadium is well studied in redox flow batteries and therefore a useful standard system with which to trial improvements. If they can improve the reaction rates by two to three times without losing efficiency, these new electrodes would make flow batteries very competitive.

Associate Professor Marshall says he and Professor Downard share supervision of a PhD student Leatham Landon-Lane who is working full-time on this project.

“MacDiarmid funds supported the student to travel to Australia this year to study the surface chemistry of their electrodes at La Trobe University’s Centre for Materials and Surface Science.”

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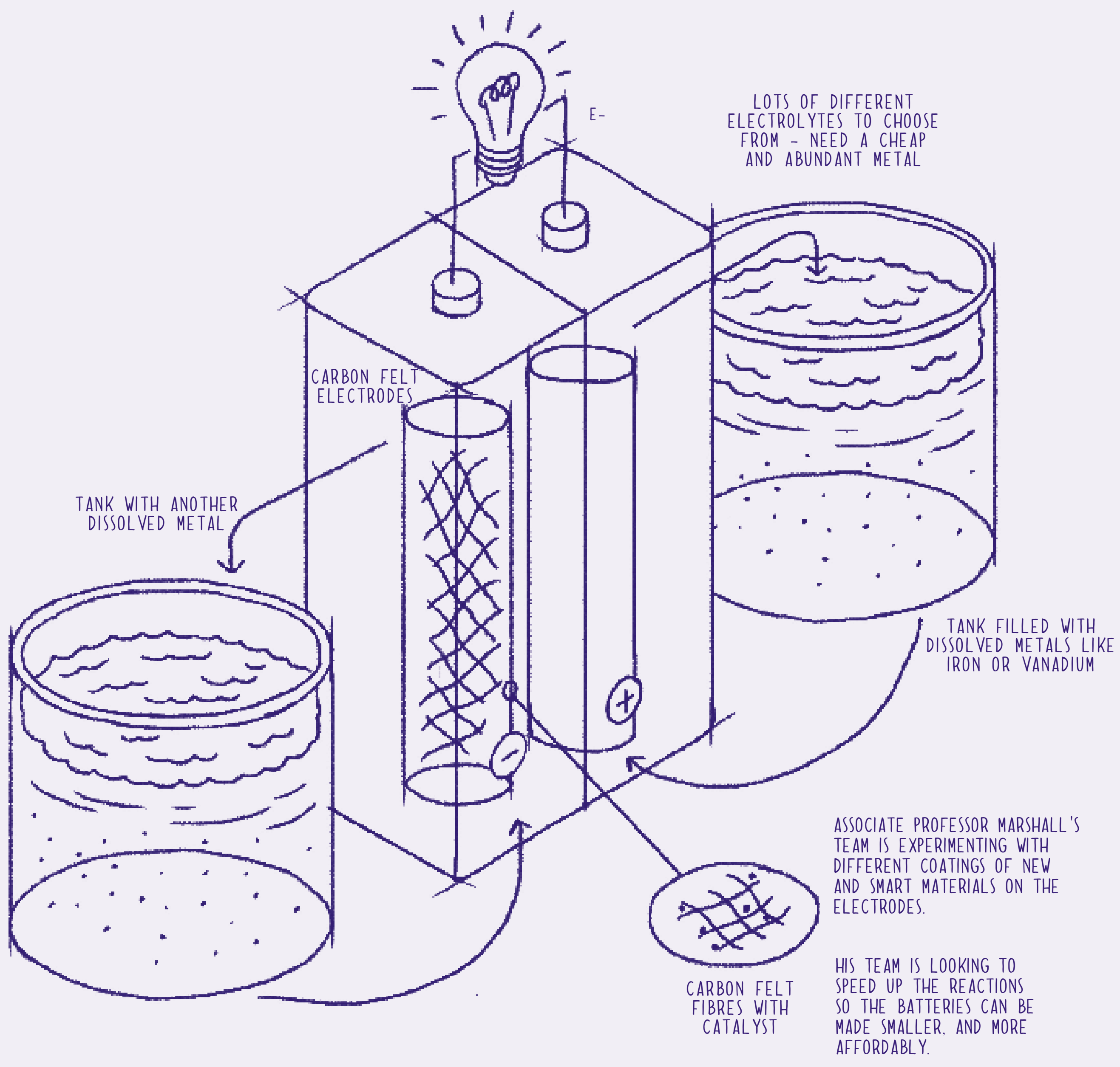
The MacDiarmid Institute team is coating electrodes with new experimental materials to speed up the reactions, in order to be able to reduce the size and cost of batteries.



WHEN PHYSICS MEETS BIOCHEMISTRY

COULD BIO-INSPIRED SELF-ASSEMBLED MAGNETIC STRUCTURES MAKE COMPUTERS MORE EFFICIENT?

Anyone who has ever picked up a phone while it's charging, or worked with their laptop on their knee, can tell you that electronic devices produce heat. It's all down to the way electrons push through the device's components, continuously giving up small amounts of heat energy. But those interactions add up, and for the server farms that the internet relies on, this 'waste' consumes vast amounts of electricity, and costs billions of dollars to manage. Some organisations are trialling systems to recycle this heat, but wouldn't it be better if our electronics didn't waste so much energy in the first place?

That's the view of newly-promoted MacDiarmid Institute Principal Investigators Dr Jenny Malmström (University of Auckland) and Dr Simon Granville (Victoria University of Wellington). They're collaborating on an ambitious project to build a new generation of devices from the bottom up, with self-assembled magnetic nanoparticles.

It's based on the idea that, rather than using an electric current to send information, computers could be driven by spin waves – tiny oscillations in the magnetic properties of certain materials. This field of research, called magnonics, only emerged in the last decade, but ambitions are already running high. "The potential gains are enormous," says Dr Granville. "Magnonic devices could theoretically use less power, and waste less energy, than conventional electronics, while also operating at speeds way beyond anything we have today."

They could do this largely because magnonic devices don't rely on a flow of electrons to operate. The 'current' is actually more like a wobble in the magnetic field that propagates through a material, and because it occurs without any particle motion, it doesn't generate heat. Magnonics could also help make individual components much faster, by shrinking them to unimaginably small sizes. "The ability of chip manufacturers to continuously improve computing power by shrinking transistors is finally being hampered by the laws of physics," says Dr Granville. "Once they drop below seven nanometres, transistors start becoming really unpredictable". Magnonic devices, however, would only be limited by the gaps between atoms, so if they could be made small enough, it would be possible to push them harder and faster than traditional transistors.

The wasted heat from computing consumes vast amounts of electricity and costs billions of dollars to manage.

And that 'if' is where Dr Malmström comes in. "Even today's very best fabrication facilities can't pattern magnetic materials into the sorts of patterns we'd need to make magnonic devices practical," she says. So Dr Malmström and her team have been applying lessons from both biology and chemistry to the problem. "We wanted to focus on different self-assembly approaches because it could give us a low-cost way to produce very small patterns over large areas," Dr Malmström explains.

They started by adding iron salts into materials called block copolymers, which, because of their chemical structure, naturally assemble into nanopatterns. They're also now collaborating with MacDiarmid Institute Principal Investigator and University of Auckland's Professor Penny Brothers and her postdoc, Dr Seong Nam, to put polyoxometalates – molecular clusters with a magnetic core – into their self-assembled materials.

In addition, Dr Malmström recently published a paper with a group of colleagues that included Auckland-based Associate Investigator, Dr Laura Domigan, and PhD student Sesha Manuguri. In it, they report on the use of proteins as a way to organise nanoparticles into specific patterns. By trapping particles in the centre of donut-shaped protein structures, and using self-assembly to stack them, they've shown that they may be able to create nanoscale wires. "This seems unbearably cool to me," says Dr Granville. "As a physicist, I'm used to looking at things from the top down, but here, we're building these structures from the bottom-up!"

Dr Granville and Dr Malmström's cross-discipline approach to

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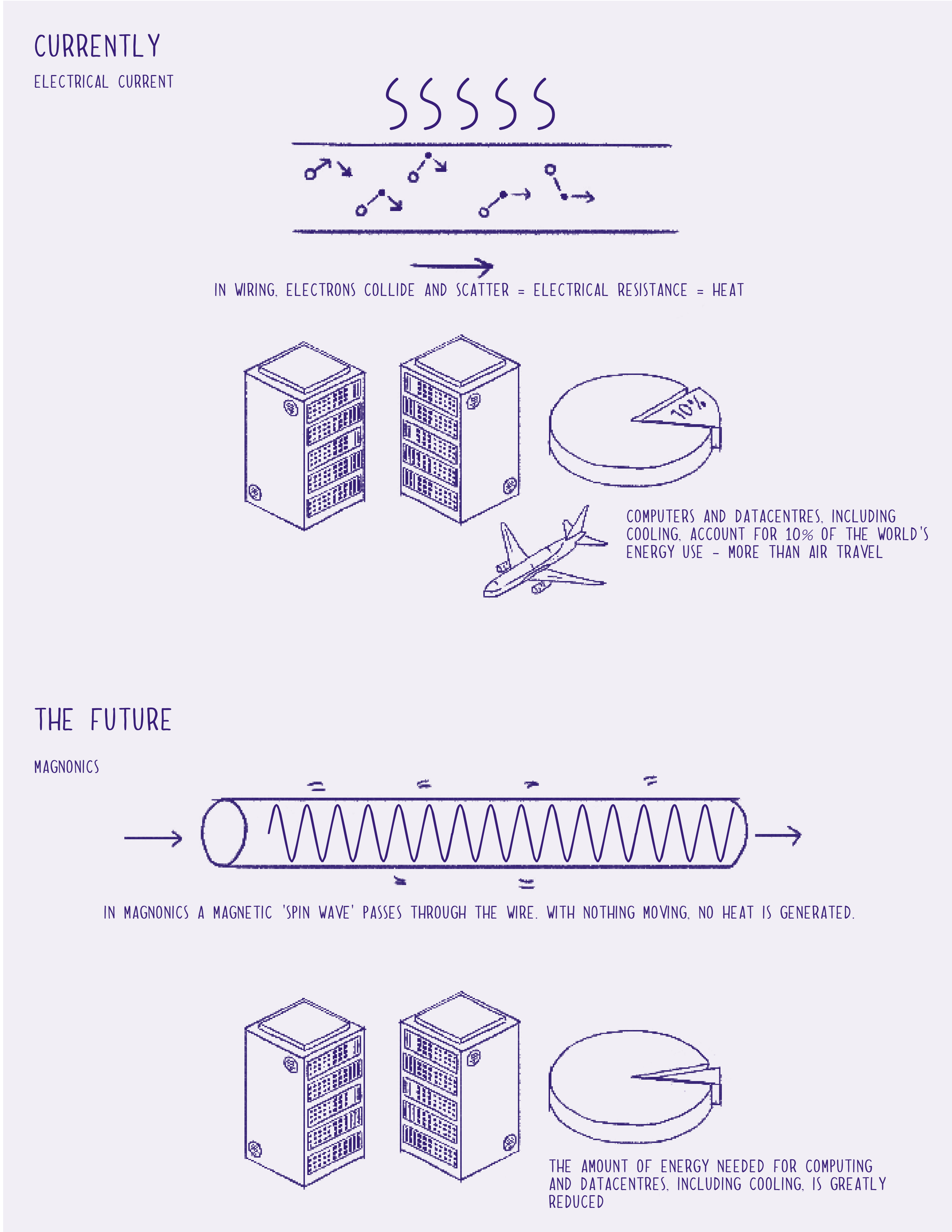
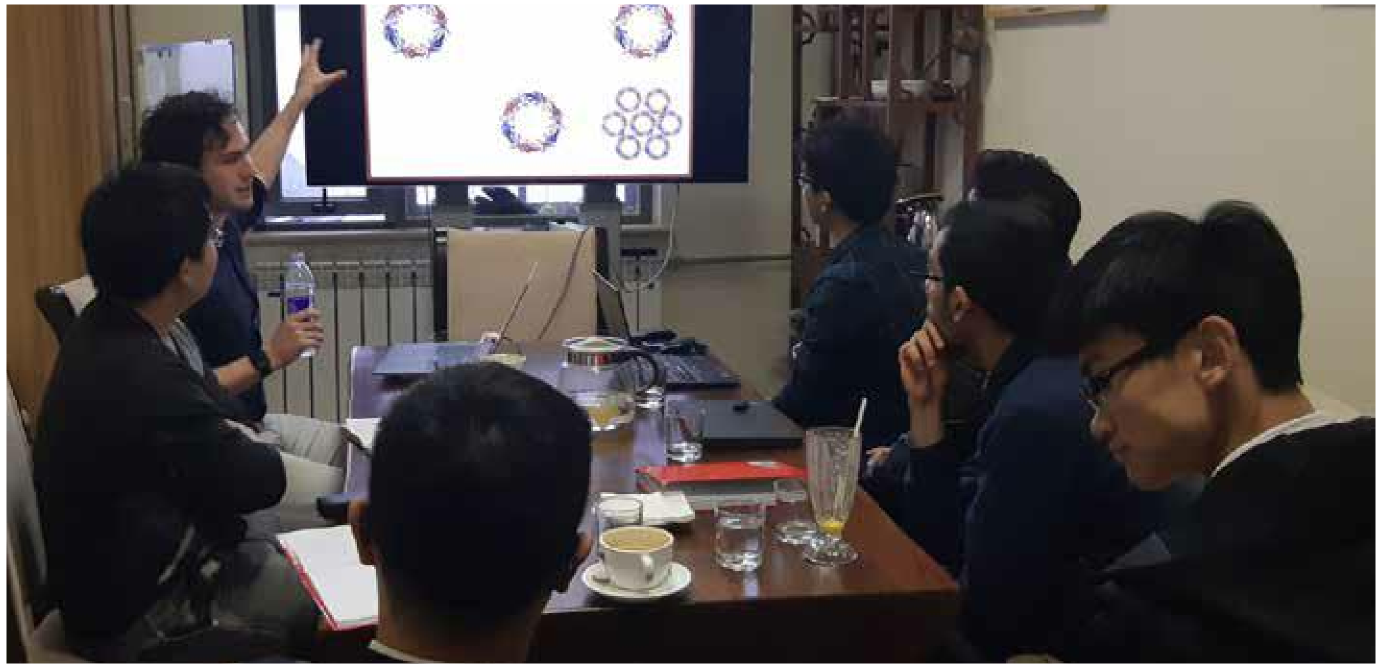




PhD student Kyle Webster with collaborators at Beihang University in China

this challenge is what makes it unique, and they've used it to build a large team that spans the MacDiarmid Institute. "Emeritus Investigator Professor David Williams was the first person to join the dots," says Dr Malmström. "He's a fantastic 'big ideas' man, and understands the value of collaboration. Former MacDiarmid Institute Principal Investigator, Juliet Gerrard – now the Prime Minister's Chief Science Advisor – has also been central to this work." Other Principal Investigators involved include Auckland's Associate Professor Duncan McGillivray, Professor Alison Downard from the University of Canterbury, and and former MacDiarmid Institute Director Professor Thomas Nann.

An important addition to the team came last year, when Sesha Manuguri joined the University of Auckland as a postdoc, supported by the MacDiarmid Institute. "Sesha's work sits perfectly between what we're doing in functional nanostructures, and what Simon is doing in thin-film magnetic materials, so she's been a fantastic addition" says Dr Malmström. Dr van der Heijden recently joined Dr Granville on a research trip to China, where they were joined by Manuguri and another PhD student, Kyle Webster. There, they met and worked with a team of researchers at Beihang University. "I've known Professor Haiming Yu since he was a PhD student in Switzerland," says Dr Granville. "He now runs a unique facility that can be used to measure the performance of exactly the type of magnetic materials we're trying to make."

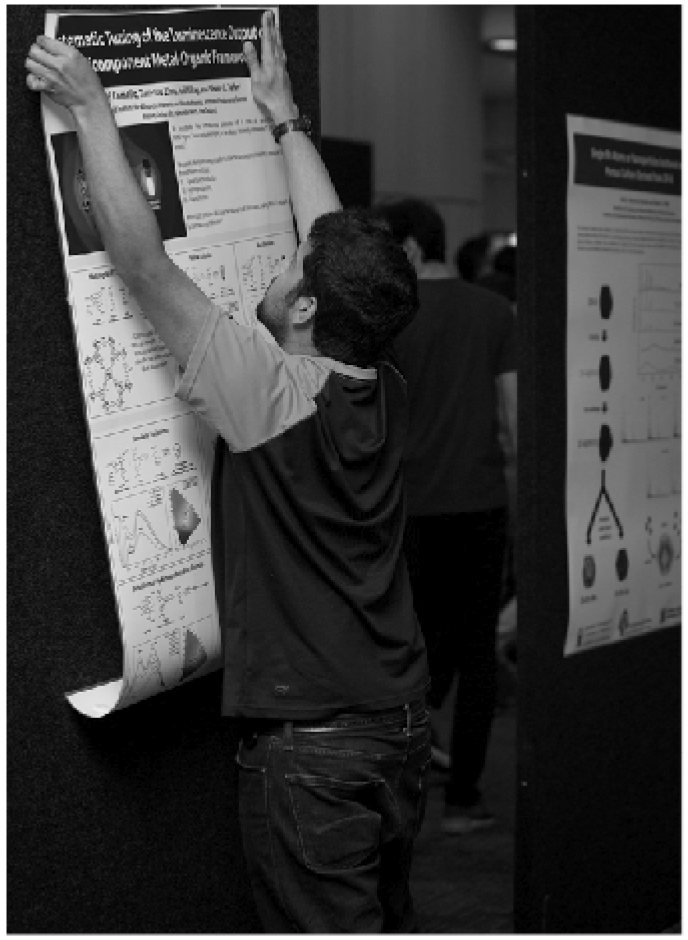
The visit itself was very positive, giving the team the first round of results on their samples, some of which were described as "unexplained but exciting", by Manuguri. It's a sentiment echoed by Dr Granville, too. "With the first spin wave measurements, we knew not to expect a 'smoking gun', but there were definitely lots of positive things to look at," he says. "The visit also gave us the opportunity to sit down with Haiming and plan the next steps."

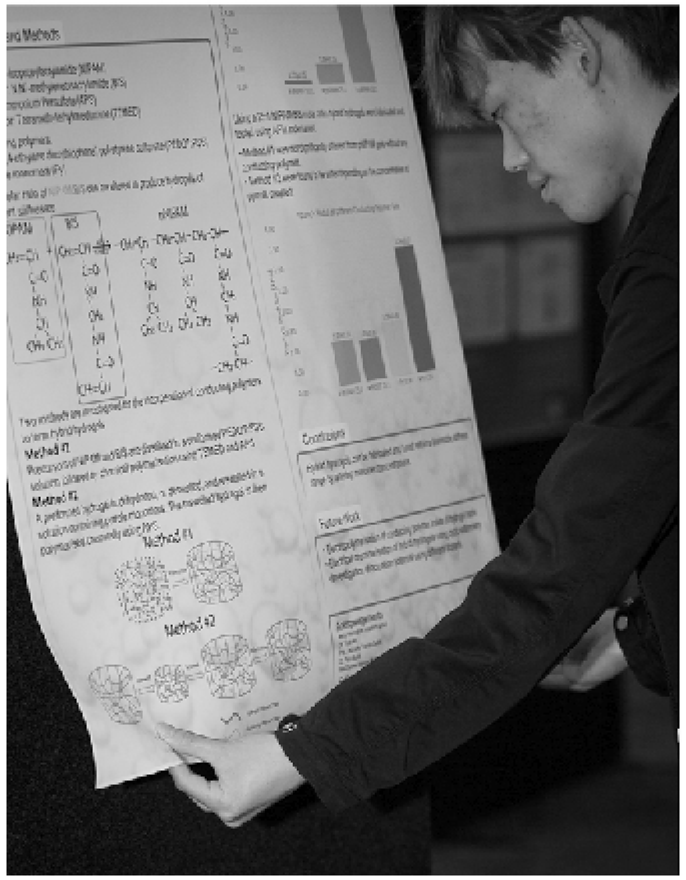
And they have their eyes on a very big prize – getting closer to building working magnonic transistors, and testing their performance. "Simon, David and I have talked about making real devices," says Dr Malmström. "No-one else has managed to build even the simplest logic gate, so yes, it's ambitious. But I think we have the right team to tackle it, so why not try?" With the world searching for an alternative to today's computers, it's a timely goal to aim for.

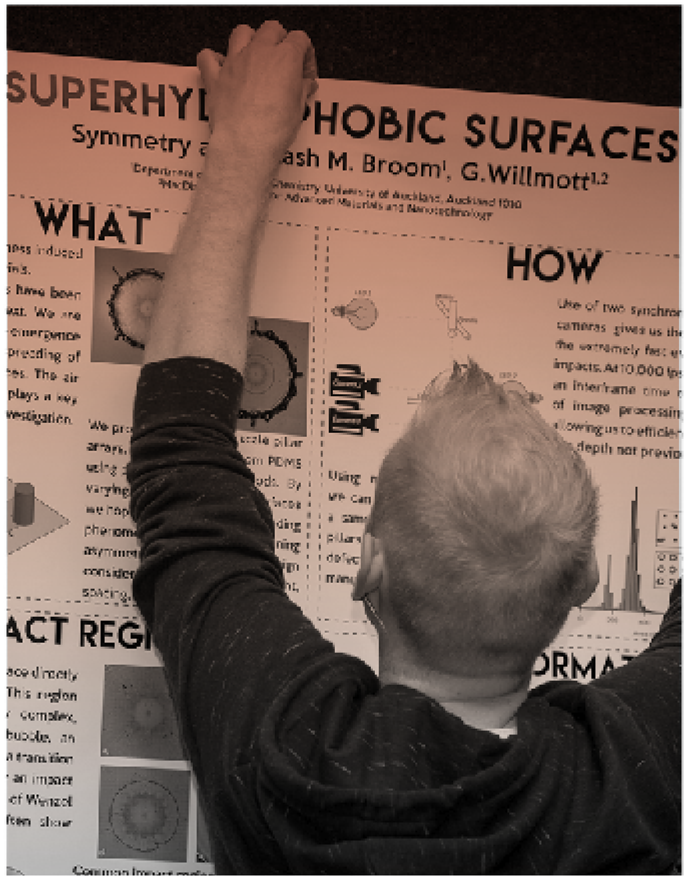
> "No-one else has managed to build even the simplest logic gate, so yes, it's ambitious. But I think we have the right team to tackle it, so why not try?"
>
> DR JENNY MALMSTRÖM

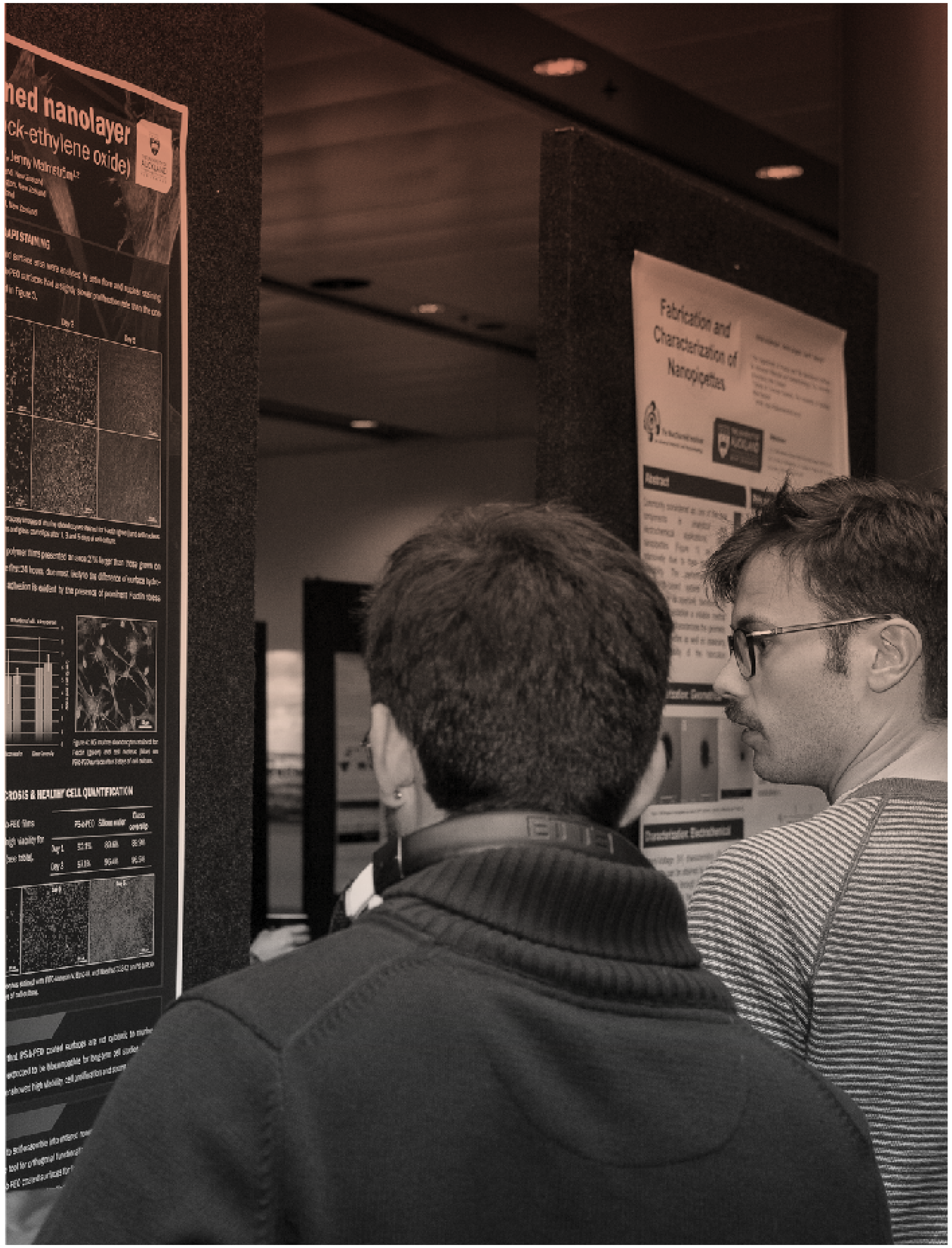
> "As a physicist, I'm used to looking at things from the top down, but here, we're building these structures from the bottom up!"
>
> DR SIMON GRANVILLE

ANNUAL SYMPOSIUM POSTER SERIES









FEELING THE FORCE OF FUNGI TO STOP IT KILLING OUR FORESTS

IN 2018 THE GOVERNMENT ANNOUNCED A $13.75 MILLION FUNDING BOOST FOR RESEARCH TO COMBAT THE SPREAD OF KAURI DIEBACK AND MYRTLE RUST. COULD MICROFLUIDICS BE THE SOLUTIONS WE ARE LOOKING FOR?

Here in New Zealand, our native trees are currently under threat from two pathogens – an oomycete (water mould) called *P. agathidicida*, which causes Kauri dieback, and *A. psidii*, the fungus behind myrtle rust. Organisms like these are found in almost every ecological niche, but what sets these two apart is how they grow and spread.

The complex process is known as tip growth. Rather than extending from the root, like human hair does, in fungi and water moulds, cells in their tips extend and form strong, thread-like structures called hyphae. In some cases, hyphae can grow invasively, penetrating deep into the roots and leaves of other plants, on their search for food. This is why they've caused some of the most devastating extinctions of both flora and fauna throughout history.

Understanding how these hyphae generate force gives us an insight into the mechanics of pathogen growth, and is a key step towards eradicating them. This is the focus of research by MacDiarmid Institute Principal Investigator, Dr Volker Nock.

Working with his colleagues at the University of Canterbury, Dr Nock has developed a novel lab-on-a-chip platform that can measure the protrusive forces that fungi hyphae exert as they grow. The device consists of a series of measurement channels – just tens of microns wide – which each contain a single, flexible micropillar, thinner than a human hair. As the hyphae of a specific fungus or oomycete grow out from the seeding area, the channels guide them towards the force-sensing pillars. Once a hypha tries to grow past the pillar, the bendy material flexes and deflects in a predictable way.

> "Could microfluidics offer a solution for Kauri dieback and myrtle rust?"
> DR VOLKER NOCK

By monitoring the whole process with a standard optical or fluorescence microscope, Dr Volker and his team can collect images of the pillar deflection as it happens. And feeding it into their modelling software lets them convert those deflections into force values.

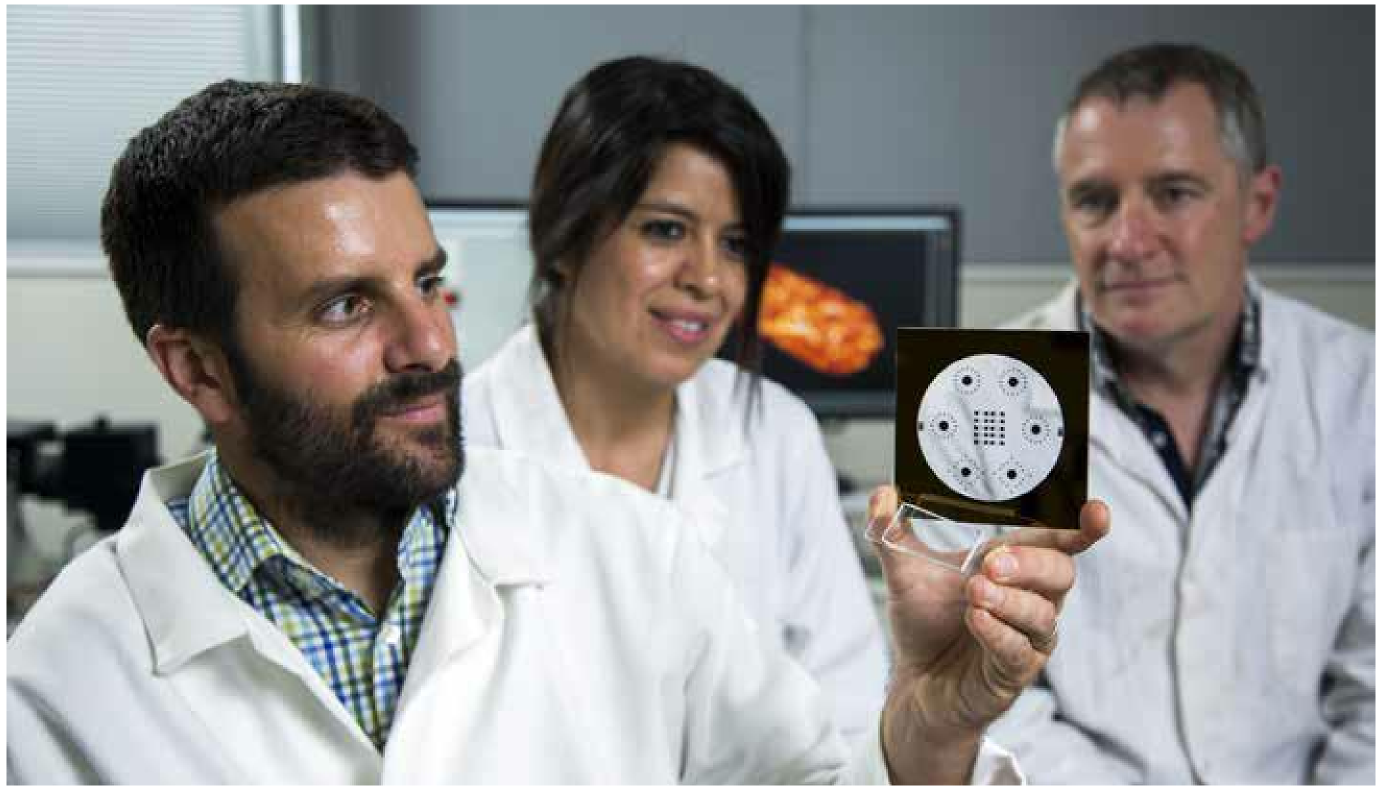
"Ashley Garrill from the School of Biological Science here at Canterbury saw me present work we'd done with nematode worms, and wondered if we could apply it to fungi", he says. That led to a Marsden FastStart grant in 2015, launching not only their collaboration, but also a new area of research with real-world applications.

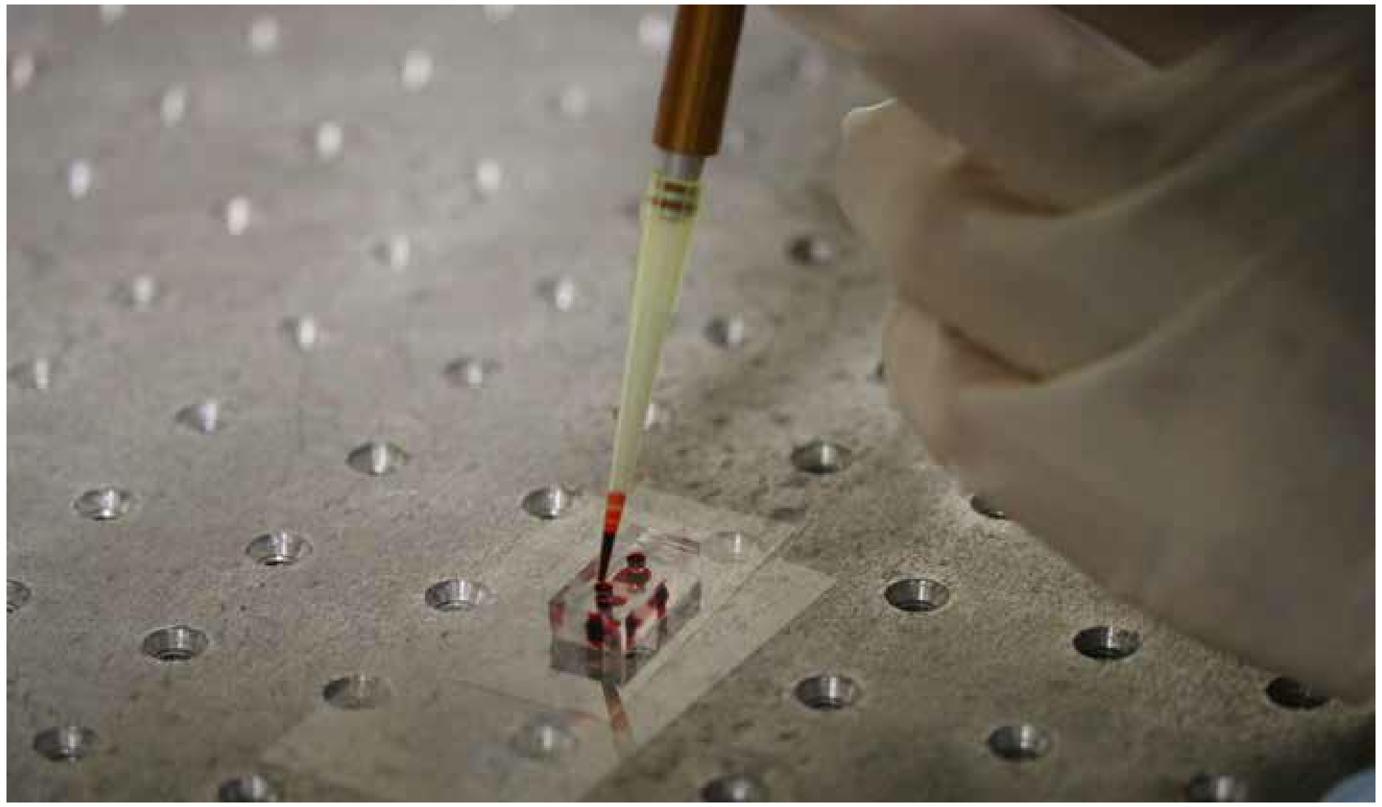
The collaborations keep growing. Dr Nock is now part of a successful Endeavour Programme bid led by CRIs Landcare and AgResearch. He will apply his microfluidic system to testing the influence of various natural compounds on these damaging pathogenic fungi, in the hope of finding new ways to stop the hyphae filaments from penetrating the cells of our native trees. He's also continuing his work with Associate Professor Ashley Garrill, and together they're developing a related microfluidic platform that will study how fungi spores react to electric fields.

The threat from pathogenic fungi is a global one. As our climate changes, the zones in which we can grow our staple crops will move too, making them more susceptible to attack by these microorganisms. This is why Dr Volker has big plans for extending the capabilities of his microfluidic lab-on-a-chip.

At the moment, the movement of the micropillars is detected optically. But in collaboration with MacDiarmid Institute Principal Investigator Professor Jadranka Travas-Sejdic, they're using her conductive polymer pillars to electrically detect the force exerted by the hyphae.

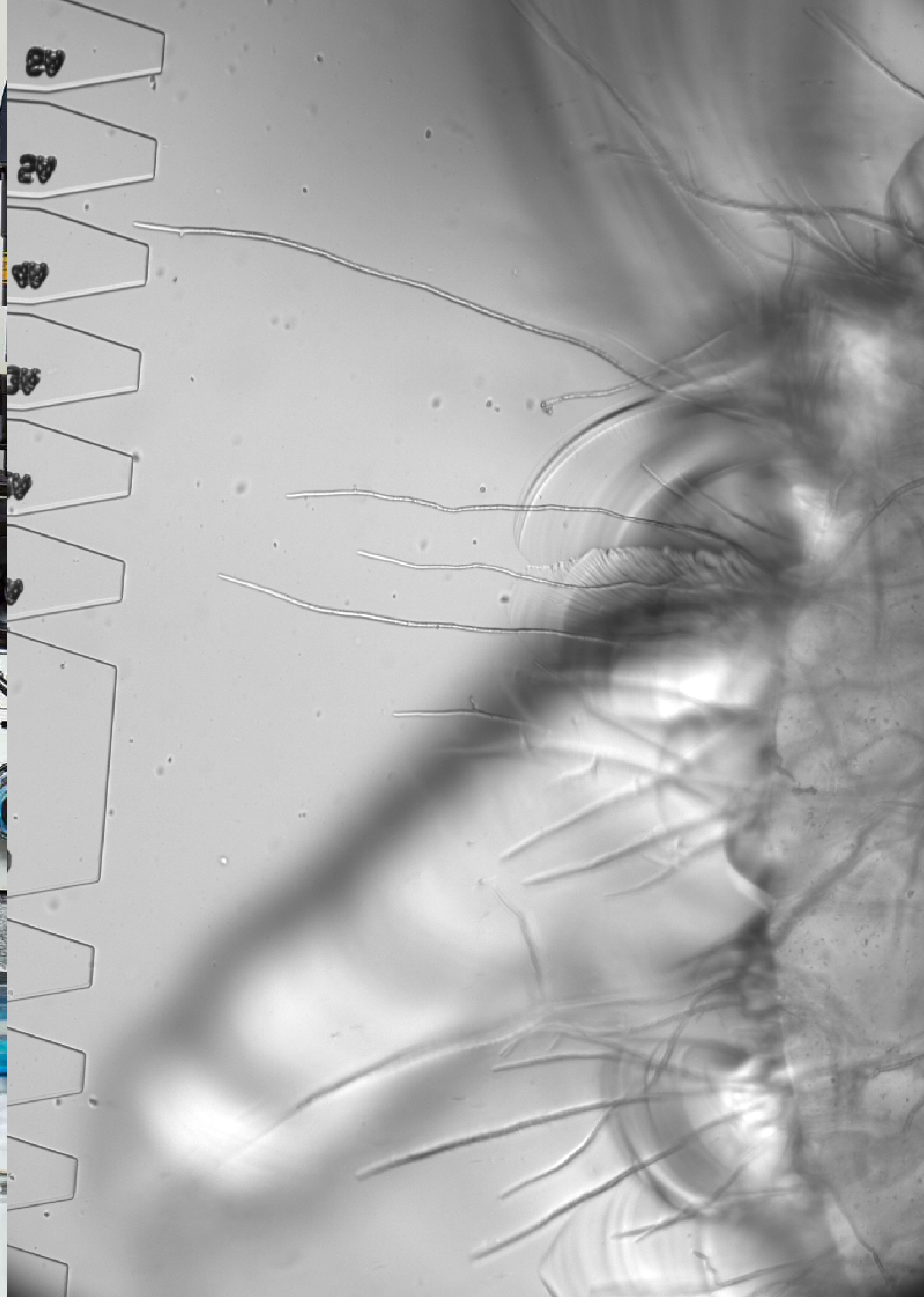
> "If it works, it will be so exciting, and could have a huge impact"
> DR VOLKER NOCK,





TOP: Dr Nock with University of Canterbury Colleagues Associate Professor Ashley Garrill and MacDiarmid Institute Research Assistant Dr Ayelen Tayagui.

ABOVE: A microfluidic chip for force measurement on A. bisexualis is filled with dye colored water using a pipette. The same process is used to exchange media needed to keep fungi and oomycetes alive in the chips.



BIOMATERIALS AS SURGICAL TOOLS

More than 250 corneal transplants are performed each year but the number is limited to donor numbers and there are not enough. Synthetic or naturally derived surgical substrates offer a solution.

The dream is to construct and repair what nature has taken billions of years to design — the eye, or at least parts of it. With this goal clearly in focus, MacDiarmid Institute Associate Investigator and University of Auckland lecturer, Dr Laura Domigan, is working in league with ophthalmic surgeons and specialists at the University of Auckland Faculty of Medical and Health Sciences, Dr Trevor Sherwin in particular.

Biomaterials may be used for surgical tools, such as adhesives, as well as for tissue engineering. Those derived from natural polymers like proteins have the advantage of being more biocompatible.

The cornea is the exquisitely composed tissue that covers the eye. It can tear and malfunction for a variety of reasons, and need replacing or repairing. Over 250 corneal transplants are performed in NZ every year, but as with all organ transplants, the number is limited by donors. There simply aren't enough of them.

Dr Domigan is quietly confident of achieving her goals and is tackling the hurdles one by one. The material has to be strong enough, last for a certain amount of time, then degrade at the right rate, and must also be biocompataible.

The main protein component of eye lenses are crystallins, packed in such a way as to be transparent and diffract light. These crystallins can be produced recombinantly in the lab, but not in sufficient volumes. Instead, they are extracting them from hoki fish eyes, which are a waste by-product.

Whether repairing or replacing corneal tissue, the synthetic or naturally derived substrates must be able to influence future cell growth in the right direction. Dr Domigan has recently used crystallin proteins to formulate transparent biomaterials – namely thin films, gels and adhesives. Crystallin protein thin films can be prepared with a range of mechanical properties and degradation rates, and micro-patterned to direct cell growth. One application that is currently being explored for these films is as stem cell carriers for the treatment of limbal stem cell deficiency that results in significant pain and loss of visual acuity.

Surgeons also want ophthalmic adhesives that work quickly to repair corneal tears, and can be handled easily. Existing surgical adhesives are not transparent, and there can be scarring and toxic effects. Dr Domigan's current work is focused on the tuning of degradation rates to match host cell infiltration, whilst maintaining adequate adhesive strength and curing time for surgical use. This is applied science with a capital A.

Dr Domigan was a MacDiarmid Institute PhD student, under the supervision of Professor Juliet Gerrard at University of Canterbury. Her postdoctoral research was at Tufts University, Boston, in a lab where they studied silk materials, renowned for their strength. When she returned to New Zealand in 2015, she contacted opthalmologists about her ideas for producing synthetic or naturally derived surgical products and implants. The subsequent partnership has involved the challenge of learning about eye anatomy in depth. Dr Domigan is a Health Research Council Emerging Researcher and has an MBIE Smart Ideas Grant.

Existing surgical adhesives are not transparent, and there can be scarring and toxic effects.

MacDiarmid institute Associate Investigator and University of Auckland lecturer Dr Laura Domigan

VIRTUAL MATERIALS

MacDiarmid Institute researchers use computers to reproduce conditions unachievable in a lab, such as the magnetic forces inside a white dwarf star.

Some of New Zealand's most innovative material science doesn't happen on a lab bench or in a fume hood, but in the circuit boards and hard drives of university computers across the country. Materials modelling is a rapidly expanding area of research, and here at the MacDiarmid Institute we're lucky enough to count some of the sector's leading scientists among our ranks. The materials modelling community is in itself a diverse field, but like our experimental work, our computational research has a distinctly interdisciplinary flavour. It touches on topics as diverse as fundamental physics, energy, bioscience, chemistry and industrial applications.

The one thing that unifies all of these fields is a desire to understand why materials behave in the way they do. This has always been the role of materials modelling and theory, but in recent years, enabled largely by ever-improving hardware and computational techniques, we've seen many more examples of 'theory first, experiment second'. And this trend shows no sign of slowing down.

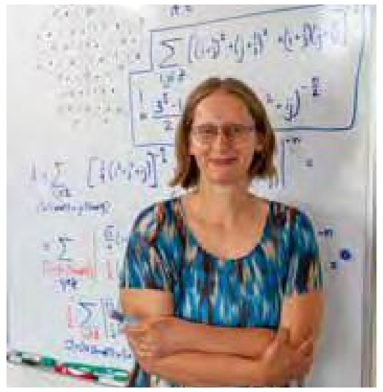
Occasionally, modelling is the only way to answer a materials question – where an experiment is either impossible or too dangerous to carry out. This is an area that Associate Investigator and Massey University Senior Lecturer, Dr Elke Pahl, is interested in. Through her computational techniques, she can virtually reproduce conditions that are simply unachievable in a lab, such as extreme magnetic fields and pressures more typical of the inside of a white dwarf star. Her work on analytic formulae for cohesive energy calculations provides new insight into solids. She also recently co-authored a paper that quantified the melting temperature of the element radon. Dr Pahl says,

> Some of New Zealand's most innovative materials science is happening not on a lab bench, but in the hard drives of university computers.

"Our work validated the only experimental result that exists, and that was from the beginning of last century. Radon's radioactive properties means that nobody wants to measure it in a lab anymore."

In addition to filling significant experimental gaps, computational tools are increasingly being used

> With high-performance computing tools, materials can be made – and even measured – virtually.



to speed up, and steer, the materials discovery process. In order to design a new material with a specific set of properties, an experimentalist would need to take an iterative approach. Synthesising and characterising compounds in a lab in this way can be slow and very expensive. But with high-performance computing tools, materials can be made – and even measured – virtually.

Much of this work has practical applications, too. Take Associate Investigator Dr Anna Garden, for example. Along with her group at the University of Otago, she's trying to develop new catalysts that will make industrial processes such as ammonia synthesis more sustainable. She's also investigating catalysts that could tackle New Zealand's nitrate problem, by selectively converting the water pollutant into harmless nitrogen gas. For Dr Garden, as well as solving particular problems, this work allows her to develop new methods and test their predictive power. "If we can develop methodology that reliably reproduces observed behaviour for known systems," she explains, "then we can start to make quantitative predictions of new and exciting materials that are yet to be synthesised."

This sentiment is echoed by Postdoctoral Fellow, Dr Krista

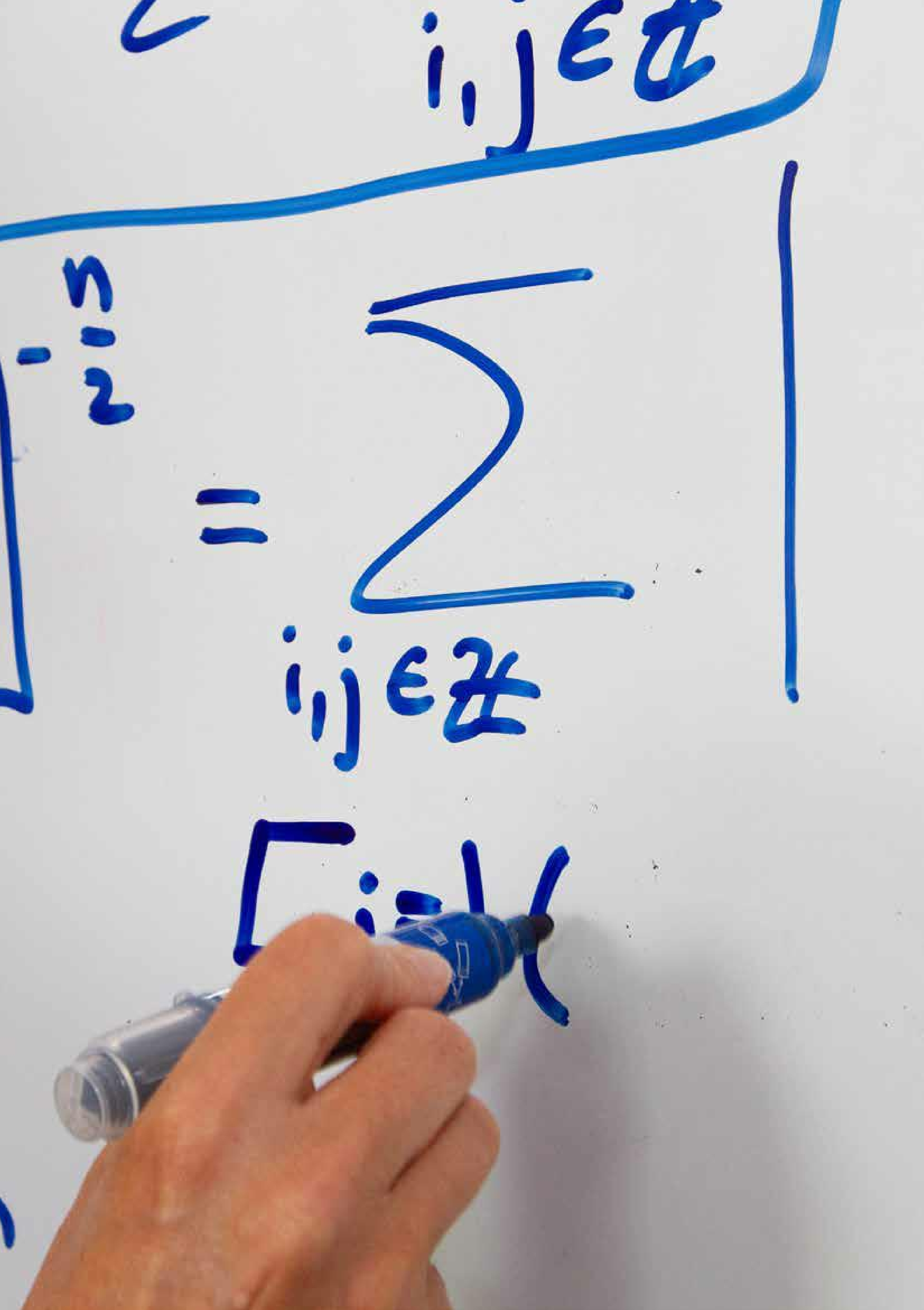
Steenbergen, who first joined the MacDiarmid Institute as a PhD student. For her, "theory is a tool for explanation, not reproduction," and high performance computing's strength lies in the fact that it can drive experiments and technology developments. In her work at Victoria University of Wellington, she explores low-dimensional materials, which tend to display very different behaviours from the bulk material. Explaining why this might be the case is a complex computational query, and is one that, for many material classes, remains unanswered. "My research focuses on how material properties change as their dimensions shrink,"

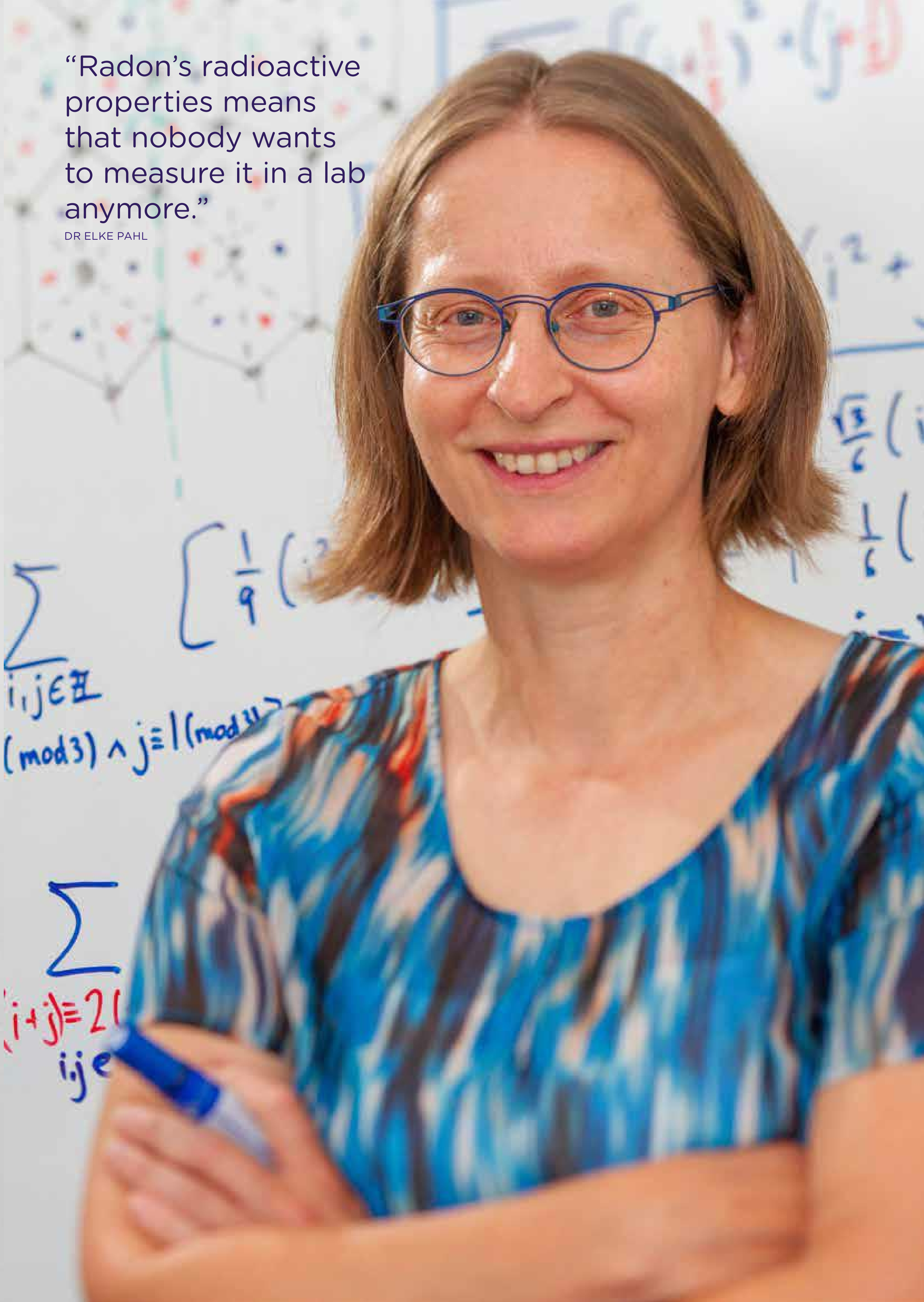
> Dr Garden is developing catalysts to tackle New Zealand's nitrate problem, by converting nitrate into harmless nitrogen gas.

Dr Steenbergen says. "So one question might be, what happens to the properties of gallium as you reduce the bulk material down to a 2D-surface or nanoparticle?"

MacDiarmid Institute Co-Director, Associate Professor Nicola Gaston, is also interested in the mysterious behaviour and structure of nanoparticles. Her research focuses on a particular class of particles known as superatoms. While she describes her work at the University of Auckland as "mostly a long way from application," it plays a key role in understanding how complex materials form. She explains; "Self-assembly processes are how nature makes materials, so we're trying to understand those processes via modelling." That could lead to materials design at an entirely new scale.

For these researchers, the future of materials will be led by modelling, but accurately and reliably describing complex materials remains a big question. As Dr Gaston describes; "Conceptually, we break down macroscopic materials into their constituent building blocks, and model their various interactions separately; we look at structure, properties, and environmental interactions in separate steps. We are getting closer to being able to put all these things together in order to predict the properties of novel materials – and that is exciting."





"Radon's radioactive properties means that nobody wants to measure it in a lab anymore."

DR ELKE PAHL

METAL ORGANIC FRAMEWORKS

AN ENTIRE RUGBY TURF IN A TEASPOON: THE TINY CRYSTAL GAME-CHANGERS IN COMBATTING CLIMATE CHANGE.

Can nano-crystals clean up water, gas and air?

2018. CO_2 emissions rose. The IPCC issued warnings. World leaders gathered. And here in NZ, a group of MacDiarmid Institute scientists made significant headway on MOFs, or Metal-Organic Frameworks, tiny crystals that could be key to mitigating our changing climate.

MacDiarmid Institute Principal Investigator and Massey University Professor Shane Telfer says MOFs can be tailored to match the size and shape of target 'guest' molecules. One super topical and very welcome 'guest' is CO_2.

"MOFs are already being used for carbon dioxide capture from power plants and we're now looking to use them to sieve out the CO_2 that is already present in the atmosphere. While these materials don't break down the CO_2, they prevent it from being released into the atmosphere. Therefore, they can mitigate climate change."

And this year, Professor Telfer's PhD student Omid Taheri had a major breakthrough. He had been looking for MOFs that could separate oxygen and nitrogen in the air "...a sort of nanoscale air purification system," he says. Mr Taheri was making lots of new MOFs, and screening them on the group's MacDiarmid Institute-funded gas adsorption analyser. On one sample, his data pointed to something unexpected. "It didn't work for oxygen-nitrogen, but it was really good at separating ethane and ethylene," says Mr Taheri. "I was so surprised!" After that realisation, Professor Telfer says they, "...got on a bit of a roll," and started testing this group of MOFs – which are all chemically quite closely-related to one another – for other gas mixtures. Another surprise awaited – one of their new molecular sponges proved to be very efficient at absorbing carbon dioxide.

> "Shane is known internationally for delivering a lot of output from a team that is small by international standards. He has discovered a family of porous materials that are elegant in their simplicity and have all the functions embedded inside them with simple processes"
>
> ASSOCIATE PROFESSOR MATTHEW HILL, CHEMICAL ENGINEERING MONASH UNIVERSITY AND PRINCIPAL RESEARCH SCIENTIST, COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (CSIRO) AUSTRALIA.

"Carbon capture is one of the biggest challenges in gas separation," says Associate Investigator and MacDiarmid Institute alumnus Dr Matthew Cowan, a Chemical and Process Engineering lecturer at the University of Canterbury. Having spent three years in the United States working on carbon capture for coal-fired power plants, this is an area that Dr Cowan knows well. "Industry and governments are looking for low-cost options that let them make a difference. New technologies like Shane's can provide those options."

Professor Telfer admits that they're not yet at the stage of competing with existing carbon capture technologies, but says that they're certainly on the right track, "We've done a lot of the fundamental research and testing under idealised conditions, and it looks really wonderful," he says. "But the next stage is key – to answer specific industrially-relevant questions, and convert our provisional patent to a full patent. After that we'll switch our focus to packaging our MOFs into something that actually can be implemented in the field."

To support this, the MacDiarmid Institute has provided funding that will allow Mr Taheri to take a few months away from his PhD research, and specifically focus on the commercialisation questions that will be so vital to their patent. Professor Telfer and Mr Taheri have also engaged an intellectual property lawyer, and are talking to representatives from industry about the project.

All the while, their other MOF-related research continues,

as they have an even bigger prize in mind – sucking carbon dioxide directly out of the air. "Longer-term, this is something we want to explore," says Professor Telfer. "It's a far more challenging prospect, because the concentrations of CO_2 are relatively low, but MOFs certainly have the potential to do it. And if they can, it would be a total game-changer."

> Another surprise awaited – one of the new molecular sponges proved to be very efficient at absorbing carbon dioxide.

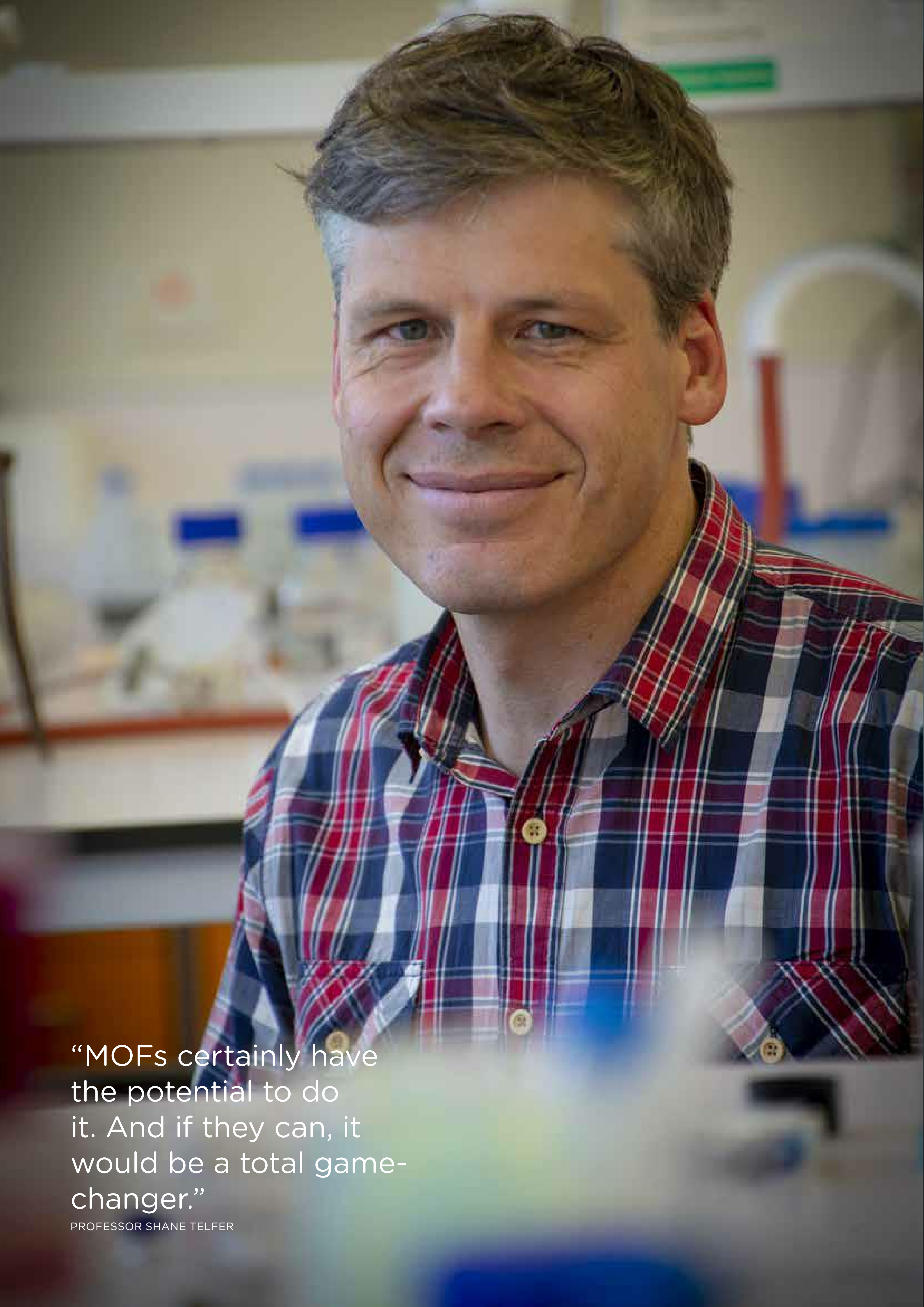
ANOTHER ROLE FOR MOFS

Quite apart from their potential role in sequestering CO_2 from the air, MOFs could lower industrial energy use, on a global scale. Gas separation is a process most of us give little thought to, yet it's a vast global business. Everything from water desalination companies, to gas separation industries to the pharmaceutical industry invest millions in separating mixtures as efficiently as possible. But existing techniques are incredibly energy-intensive, and account for 10–15% of the world's total energy use. Reducing that energy footprint is a huge priority for research groups across the globe, and in recent years, alternative separation materials have been finding their way out of the lab, and into widespread use in industry.

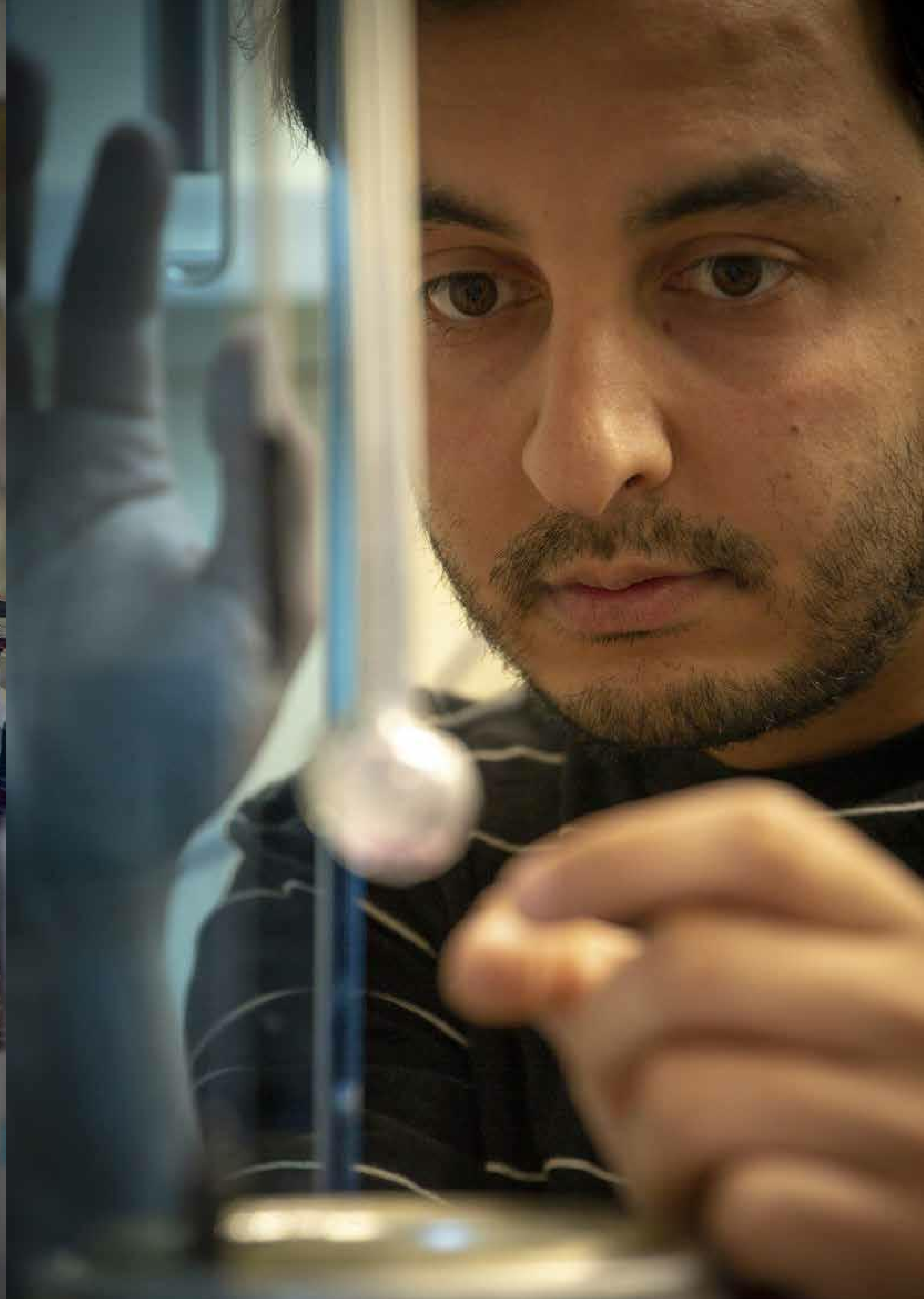
"The major challenge with separating gases like these is that they have very similar physical properties," says Professor Telfer. "But because we can engineer MOFs so precisely, and define exactly what pore size we want, we can make them highly selective. In other words, they can pick out specific molecules with minimal energy input."

And one of Professor Telfer's collaborators at CSIRO, Associate Professor Matthew Hill, says that there are ever increasing strains on global resources, and that processes need to become more and more efficient, whether they be cleaning water, making medicine, or nutrients for crops.

"Porous materials are the path to achieving all of this as soon as possible. Shane has discovered a family of porous materials that are elegant in their simplicity and have all the functions embedded inside them with simple processes. It is very encouraging to have new materials like Shane's that can help to save energy."



"MOFs certainly have the potential to do it. And if they can, it would be a total game-changer."
PROFESSOR SHANE TELFER



EXAMINING THE NANO-ENVIRONMENT BETWEEN CANCER CELLS

RESEARCH INTO MICRO-ENVIRONMENTAL CONDITIONS WITHIN AND BETWEEN CELLS MIGHT ULTIMATELY RESULT IN TAILORED CANCER MEDICATIONS.

Professor Maan Alkaisi is looking for the mechanism that triggers cancer. How is it, he asks, that people can carry a cancer-causing mutation from birth, but do not get the disease until much later in life? What nano- or micro-environmental conditions within and between cells might play a role in causing the breach in the carefully controlled 'code of cell conduct' that results in runaway cell growth? In 2018 Professor Alkaisi (University of Canterbury researcher and MacDiarmid Institute Principal Investigator) headed to France on a six month sabbatical, to work with international collaborators, to try to answer some of these questions..

Professor Alkaisi says the scope and size of the labs and facilities at Toulouse University were mind boggling.

"I was attached to the 'Engineering in Life Sciences applications' group, and hosted at the Laboratory for Analysis and Architecture of System, at CNRS, the French National Center for Scientific Research, by Professor Christophe Vieu. The lab was 1500 square metres, and there were 30 highly trained technical staff who could build what you wanted and knew how to measure whatever the desired metric."

He was particularly impressed by the advent and widespread use of 3D printers.

"There were no 3D printers when I last visited in 2014. Now the lab has 6 of them to produce different resolutions and scales." Essentially, Professor Alkaisi studies the interaction between engineered and living biological matter. He designs nano-scaffolds made of polymers such as polystyrene or the conductive polymer PEDOT:PSS, for the culture of biological cells, and studies the cells' general physiological response to these substrates and precisely applied nano-forces. Are different proteins expressed as a result of such stimulation? The research requires extremely sensitive structures to measure these tiny, tiny forces and displacements, and benchmark research to compare protein products; equipment not available in New Zealand.

> "How is it, that people can carry a cancer causing mutation from birth, but do not get the disease until much late in life?"
> PROFESSOR MAAN ALKAISI

While in Europe, Professor Alkaisi also visited labs in Denmark and the Netherlands, and again found the resources - both lab space and technical support - impressive.

"One billion euros has been allocated to Future Emerging Technologies in Europe. About fifteen per cent of Europe's GDP goes on health, and as the ageing population expands, there is pressure to make the health system more targeted. One-size-fits-all medications applied to the whole body results in huge waste. Trillions are spent on cancer drugs which are generally not very effective. The goal is to have genetic and medical history profiles for each person so that the right drug, and the right amount of it, can be administered."

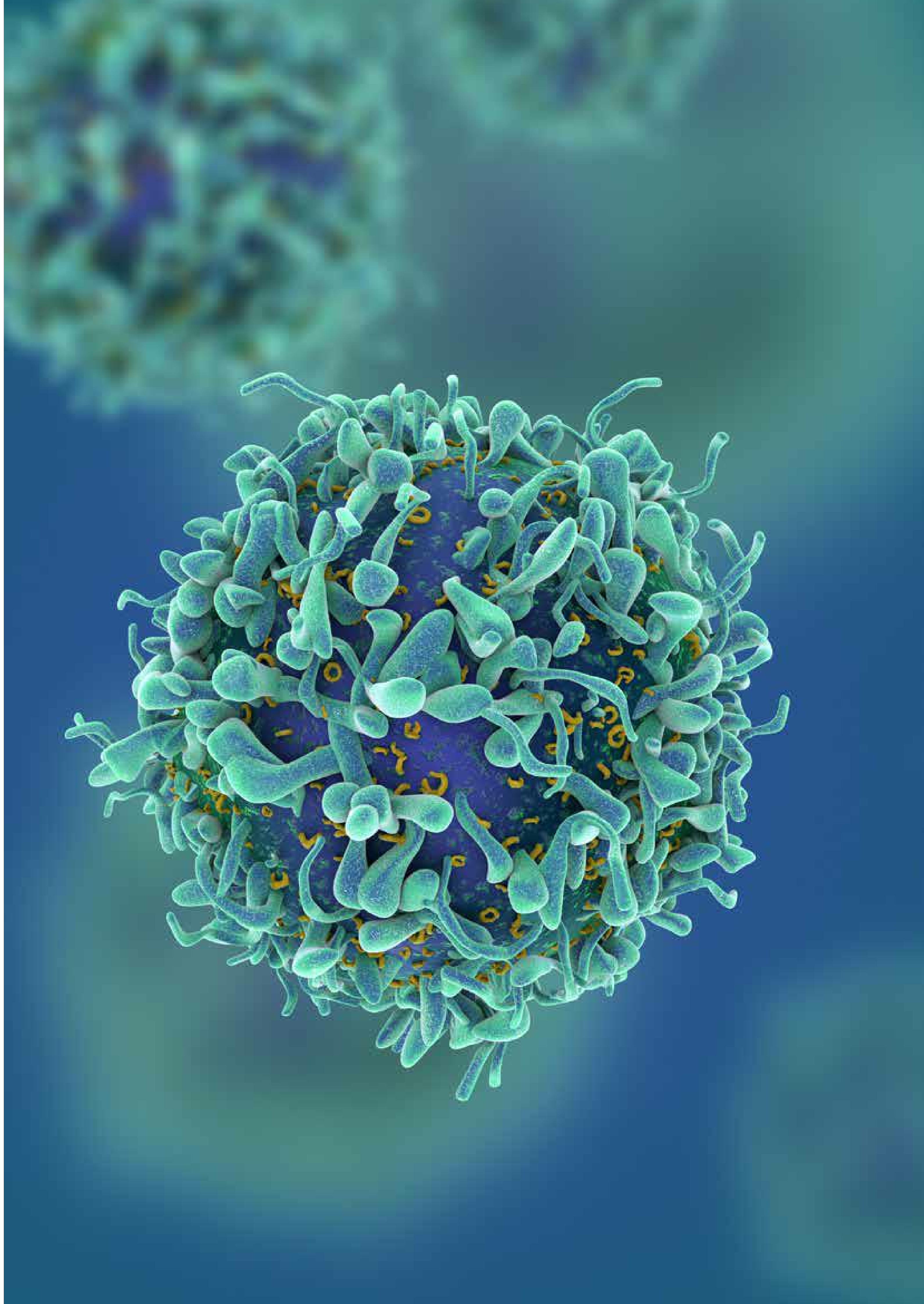
This is where his research comes in. "People do not all respond to a drug in the same way. Such individual profiles will also provide more accurate prediction of health risk. Invasive procedures may be replaced by simpler, cheaper diagnostic testing."

Having returned to the University of Canterbury with a refreshed mission and finer focus, Professor Alkaisi has support from two new MacDiarmid Institute-funded PhD students, Christine Franke and Sevgi Onal, who are going to study and measure applied and natural forces in cells. Professor Alkaisi, who is a founding member of the MacDiarmid Institute, says that overseas laboratories admire what the Institute has to offer its members – a high degree of effective and personally satisfying national collaboration and collegiality.

> "Invasive procedures may be replaced by simpler, cheaper diagnostic testing."
> PROFESSOR MAAN ALKAISI

"The collaboration with Professor Alkaisi is a vibrant example. Our two countries and laboratories now share a road map for future research."

PROFESSOR CHRISTOPHE VIEU, UNIVERSITY OF TOULOUSE, FRANCE



CONNECTING WITH RESEARCHERS AT UCLA

The discovery of conducting polymers - plastics that conduct electricity - won New Zealander Alan MacDiarmid the Nobel Prize in 2000. The research of MacDiarmid Institute Principal Investigator and University of Auckland Professor Jadranka Travas-Sejdic closely succeeds him in this field.

"The environment was dynamic, stimulating and energising."

PROFESSOR JADRANKA TRAVAS-SEJDIC ON HER FOUR MONTH SABBATICAL AT THE DEPARTMENT OF BIOENGINEERING, UCLA

Professor Travas-Sejdic's research involves the next generation of advanced polymers that have revolutionary potential for human health and medical treatments. She is now director of the University of Auckland's Polymer Electronic Research Centre.

Professor Jadranka Travas-Sejdic with her UCLA collaborators, from left to right: Dr Samad Ahadian (Development Engineer), Professor Jadranka Travas-Sejdic, Dr Shiming Zhang and Yihang Chen (MSc student).

Polymers are long-chain plastic-like materials that repeat their structure regularly, and can be engineered to be 'biocompatible' - able to be used as substrates for skin and other tissue. These materials are flexible, stretchable, adhesive, and can conduct electricity. One of the many things they can be designed to do is stimulate healing.

Professor Travas-Sejdic spent the last four months of her 2018 sabbatical working with Professor Ali Khademhosseini, Director of the Center for Minimally Invasive Therapeutics at the Department of Bioengineering, University of California, Los Angeles (UCLA). She met Khademhosseini when he was at Harvard University, Boston. The laboratory's main research field is the development of biomaterials and engineered systems for tissue engineering and 'organ-on-a-chip' systems that can mimic human response to various chemicals in vitro. Professor Travas-Sejdic says she found the experience invaluable, seeing from the inside how such a large and successful group operates with up to 70 (soon to be 100) researchers.

"It was a real advantage having people from different scientific backgrounds (biology, bioengineering, electrical and chemical engineering, chemistry, materials chemistry etc.) and all the necessary facilities in one lab. The research is intensely focussed with huge potential impacts in view."

The other valuable experiences for Professor Travas-Sejdic at UCLA were the almost daily high-level seminars, workshops or conferences.
"The environment was dynamic, stimulating and energising. And being stationed in LA for an extended period enabled me to easily attend other conferences in the US, including one on polymers in biomedicine, a point-of-care sensors conference in San Diego, and a large Materials Research Society meeting (MRS) in Boston."

Establishing connections and collaborations with groups at such large universities can be difficult, as the competition for a top academic's time is huge. Professor Travas-Sejdic says that this is where the real value of the MacDiarmid Institute lies – easy access to other expertise and facilities, and the willingness of members to collaborate.
'We must continue to consciously nurture, grow and utilise the MacDiarmid collaboration culture,' says Professor Travas-Sejdic, who became a Principal Investigator in 2007. She gained her PhD at the University of Auckland in 1999 and returned there in 2002, following work in the private sector for Genesis Research Corporation Limited and Pacific Lithium Limited. She works closely with MacDiarmid Institute Investigators Professor Maan Alkaisi, Professor Sally Brooker, Professor Justin Hodgkiss, Dr Volker Nock, and Professor David Williams.

On her return to New Zealand, Jadranka will be concentrating on an MBIE-funded project to make porous substrates that can capture metastasising cancer cells for analysis, another potentially powerful application of biomaterials science.

NEW ASSOCIATE INVESTIGATORS 2018

Dr Renee Goreham
Dr Renee Goreham's research niche focuses on the characterisation and synthesis of nanomaterials for biomedical application. For example, the synthesis of ultra-small metal nanoclusters for improved medical imaging or using nano-vesicles released by living cells for detection of disease or as a safe drug delivery system.

Dr Matthew Cowan
Dr Matthew Cowan's research revolves around improving the methods and technologies we use to purify all the building blocks of society. His overall goal is to reduce the amount of energy we need to use every day—so we have some spare for the things we want to do!

Dr Viji Sarojini
Dr Viji Sarojini's research is particularly interested in the structure and function of proteins and peptides and studies both designed and natural peptides using a range of analytical techniques which has led to the development of novel antimicrobial peptides, surface coatings and antifreeze peptides for use in frozen food.

Associate Professor Renwick Dobson
Proteins are biopolymers that do (almost) everything in a cell. Just as life is diverse, so too is the functional repertoire that proteins accomplish. Associate Professor Renwick Dobson's research focuses on how the structure and motion of a protein is linked to its function as well as proteins that interact with lipid membranes.

Dr Saurabh Bose
Inspired by the enormous power of the human brain, Dr Saurabh Bose's research focuses on development of unconventional architectures for computer chips. Using novel techniques, the nanomaterials network resembling structures in the brain are being harnessed for pattern-recognition tasks. The potential future applications include self-driving cars, automated agriculture technologies, medical imaging and care, among others.

Associate Professor Robin Fulton
Associate Professor Robin Fulton's research interests includes synthesis and reactivity of unusual low coordinate main-group and transition metal complexes as well as the generation of new materials for environmental remediation, with a particular focus on highly reactive iron-nanoparticles.

Dr Emilia Novak
Dr Emilia Novak's research is revolving around experimental interface physics, bridging hydrodynamics with surface chemistry and fundamental interfacial properties aided by theory and computations. Currently, the most exciting for her are the Marangoni flows at the fluids interfaces, and her research aims at exploiting these phenomena to form unique films and structures.

Associate Professor David Barker
Associate Professor David Barker's research focuses on the synthesis of organic molecules and whilst doing so exploring fundamental chemical principles to aid the development of efficient synthetic methods, the preparation of new molecular structures and to answer complex scientific questions. He is currently working to develop new treatments for cancer and other diseases. He also develops new polymers for various applications, including disease detection, antibacterial materials and selective extraction processes.

Associate Professor Tilo Söhnel
Associate Professor Tilo Söhnel's research is focused on theoretical and experimental inorganic materials chemistry. That involves studying the crystal structures and electronic states of a broad range of main group and transition metal compounds, preparation and physical characterization of potential application materials, and density functional theory calculations of electronic structure of solid materials.

NEW STAKEHOLDER RELATIONS PARTNER IWI

Diane Bradshaw
Diane Bradshaw has 25-years' experience working in Māori development and in the public service. Diane Bradshaw is Stakeholder Relations Partner Iwi at our partner GNS Science, where she is based at the Wairakei Research Centre, Taupo, and will continue in her position at GNS Science while undertaking this new role for the MacDiarmid Institute.

NEW PRINCIPAL INVESTIGATORS 2018

Dr Volker Nock
Dr Volker Nock is a Senior Lecturer in Electrical and Computer Engineering, and Co-Director and Principal Investigator of the Biomolecular Interactions Centre at the University of Canterbury, New Zealand. In his research he uses micro- and nanotechnologies to help increase our understanding of how biological systems function in health or disease.

Dr Craig Rofe
Dr Craig Rofe has always been interested in physics as a way to explain the deep workings of the world. He was given an amazing opportunity in working alongside Sir Paul Callaghan as his PhD student. Craig now conducts research in the field of Mātauranga Māori and education.

Derek Kawiti
Derek Kawiti, a senior lecturer in Architecture, has an exemplary track record of iwi engagement and collaboration. He has expertise in the use of digital tools and additive manufacturing (3D printing) and a growing research interest in the cultural value of materials and the intersection between digital design technologies and Māori knowledge.

Dr John Kennedy
Dr John Kennedy is a physics-based materials scientist focused on applied surface science for technological innovation. His team is developing new functional products underpinning ion beam science and nanoscience pioneered by Lord Rutherford.

Dr Jenny Malmström
Dr Jenny Malmström is a senior lecturer at the Department of Chemical and Materials Engineering at the University of Auckland. Her research group uses surface engineering to make new materials. Current applications include controlling cells on surfaces and making new magnetic materials.

Associate Professor Nigel Lucas
Associate Professor Nigel Lucas' research is focussed on the designed synthesis of carbon-rich molecules, so that structure-property relationships may be better understood. His well-defined "nanographene"-based molecules are not only photoactive, but have a propensity to stack providing a robust mechanism by which they can be assembled into ordered solids, often with high porosity.

Dr Pauline Harris
Dr Pauline Harris is a lecturer is the Faculty of Science at Victoria University of Wellington. She has a PhD in astrophysics from Canterbury University on gamma ray bursts as possible sites for high energy neutrino production. She also has significant experience and expertise in how to build bridges between Mātauranga Māori and currently topical areas of scientific research.

Dr Simon Granville
Dr Simon Granville's research is in the field of spintronics – he investigates the advanced magnetic materials needed to bring about a future generation of energy-efficient, ultra-high-speed and high-performance computer memory and logic that uses the magnetism, or "spin logic", of electrons.

INDEPENDENT POSTDOCTORAL FELLOWS

Dr Paul Hume
Organic solar cells are an emerging technology for low-cost, sustainable energy production. When these absorb light, this triggers electron-transfer from a donor molecule to an acceptor molecule, forming charges. This process occurs within 100 trillionths of a second. Dr Paul Hume will be exploring how the charge-generation process depends on the chemical structure of the acceptor.

Dr Frederick Steven Wells
Dr Frederick Wells plans to look at how a liquid superconductor would behave near a magnet. By drying these liquids like paint, he hopes to make a liquid superconductor! Superconductors carry electricity with 100% efficiency. They can also hover above a magnet. But what would a liquid superconductor do near a magnet? Also, by drying these liquids like paint, he hopes to make sturdier superconducting cables to transport huge amounts of electricity.

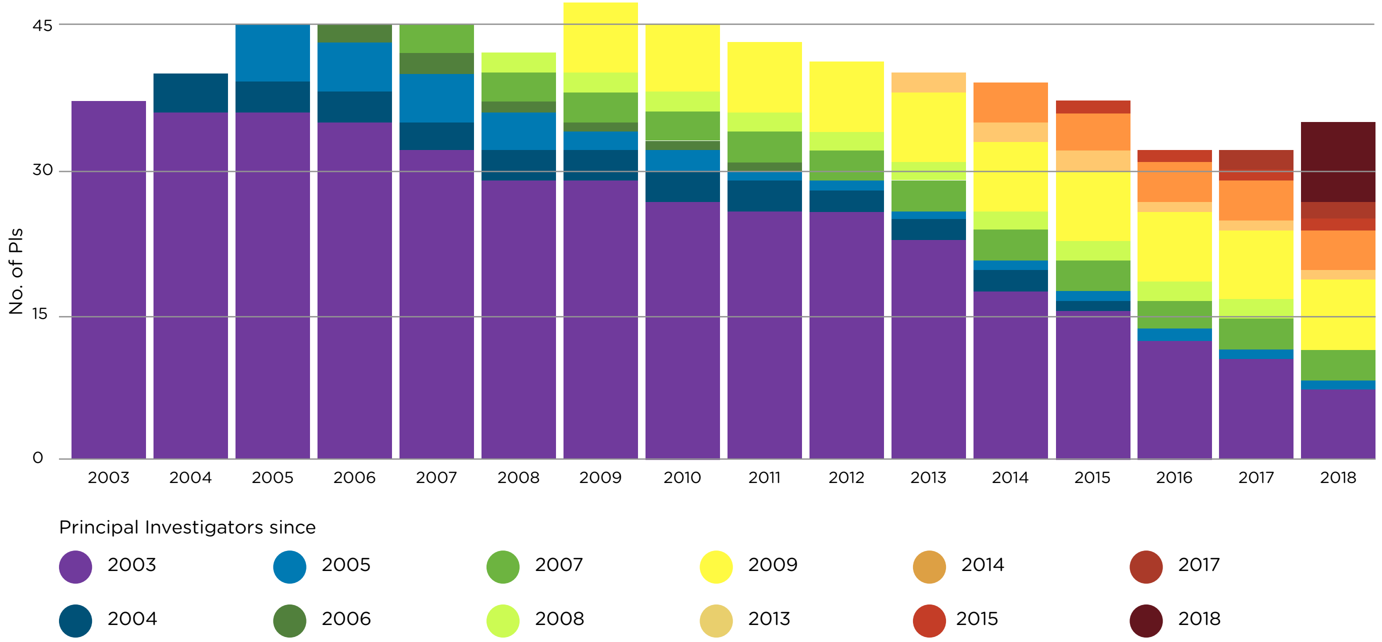
Dr Ben (Hand) Yin
Dr Ben Yin's research focuses on developing membrane technologies for gas separation and water treatment. Specifically, his MacDiarmid Institute project aims at producing high quality natural gas through a customized mixed matrix membrane process to remove impurities such as excess carbon dioxide.

Dr Krista Grace
Dr Krista Grace's proposed research hopes to advance our fundamental understanding of carbon nanotubes (CNTs) by developing a computational algorithm that enables electronic structure calculations for larger CNTs. A CNT consists of a thin sheet of carbon atoms (graphene) curled into a cylinder. Despite their small size and simple composition, this remarkable nanoscale system holds profound technological promise and power.

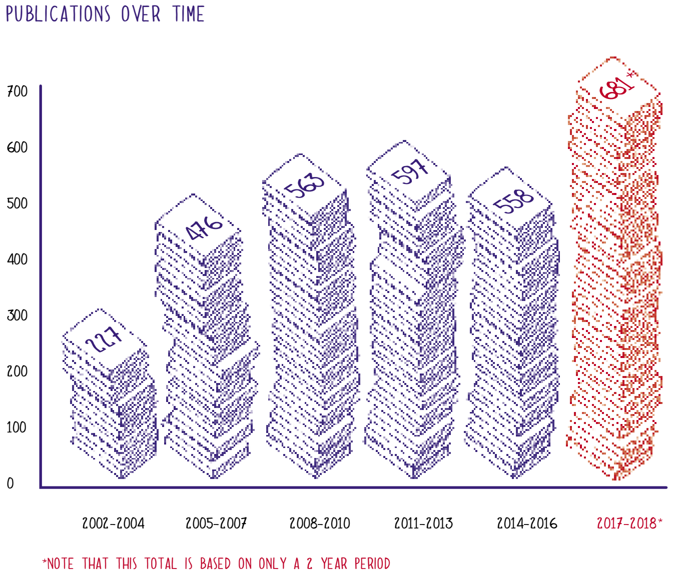
Dr Komal Patil
Dr Komal Patil's research aims to generate new knowledge and expertise in the area of carbon capture using novel porous materials called 'metal-organic frameworks' (MOFs). She will develop new MOFs with improved stability and modify the pores of these materials to target the reversible capture of carbon dioxide and other gaseous environmental contaminants such as hydrogen sulfide.

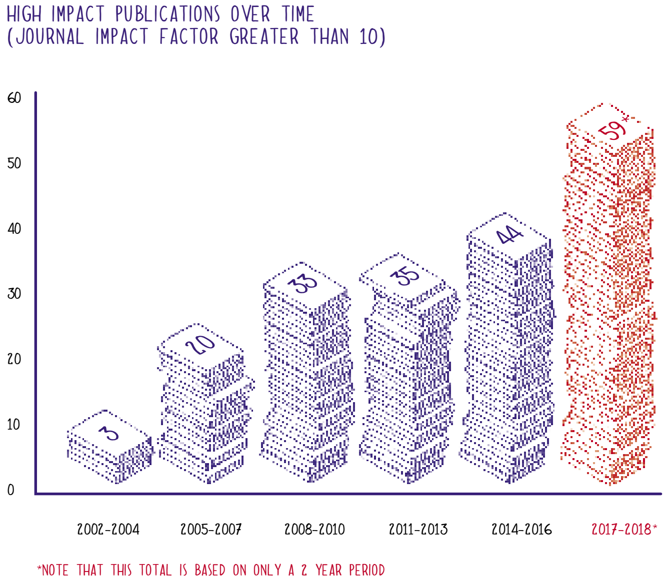
Dr Walter Somerville
Dr Walter Somerville's research examines how light behaves inside materials. By using computational techniques, the effect of different sample properties on light scattering statistics can be determined. This work has applications in improving the ability to measure properties of varied samples, including milk, paint, clouds, water or biological samples.

THE CHANGING FACE OF THE MACDIARMID INSTITUTE



MACDIARMID INSTITUTE PUBLICATION TRENDS



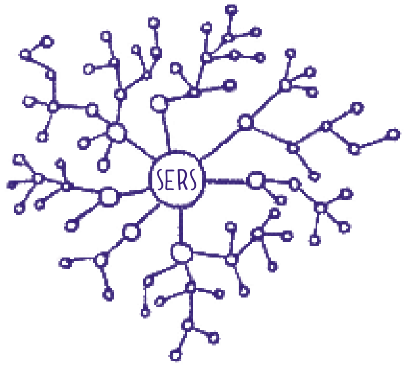


THE CONTINUED IMPACT OF OUR RESEARCH

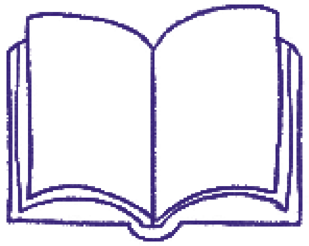
A CASE STUDY ON SURFACE ENHANCED RAMAN SPECTROSCOPY (SERS)

SERS is a new field of spectroscopy that is capable of detecting single molecules. It has potential applications in sensing technologies. The research into SERS at the MacDiarmid Institute has made major contributions to this sphere.

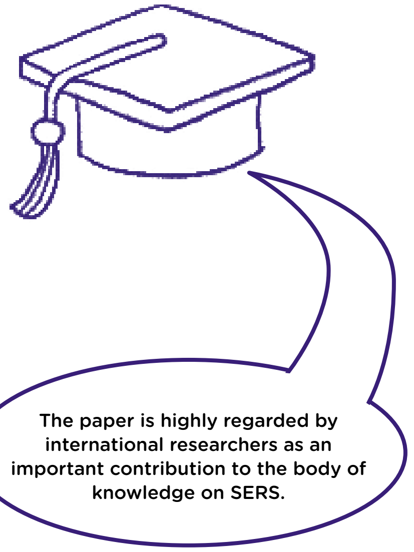
A paper from 2007 published in J. Phys. Chem. C. [SERS enhancement factors: a comprehensive study E. C. Le Ru, E. Blackie, M. Meyer, and P. G. Etchegoin, J. Phys. Chem. C 111, 13794 (2007)] is arguably one of the most important recent papers in the field of Surface Enhanced Raman Spectroscopy (SERS). It provides a comprehensive study, both theoretical and experimental, of one of the most important concepts in SERS: the SERS enhancement factors. It provides for the first time a classification along with rigorous definitions of the SERS enhancement factors and highlights limitations of previous measurements. Moreover, for the first time it provided a careful and credible estimation of the SERS enhancement factors required for single molecule detection, one of the ultimate applications of SERS to analytical chemistry. It is likely to serve as a long-standing reference for the SERS community.
It is the second most cited research paper (excluding reviews) in the Journal of Physical Chemistry C, one of the leading physical chemistry/nanoscience journal [A* ERA ranking], out of about 36,000 published articles. It has received over 1500 citations (according to Google Scholar).



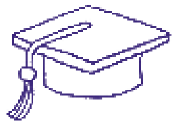
The paper by LeRu et al has been cited over 1500 times. It is the second most cited research paper in J. Phys Chem C.



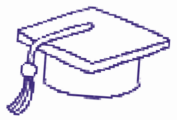
This work led to a textbook, which is the first foray into SERS for many students.



What the international scientific community says

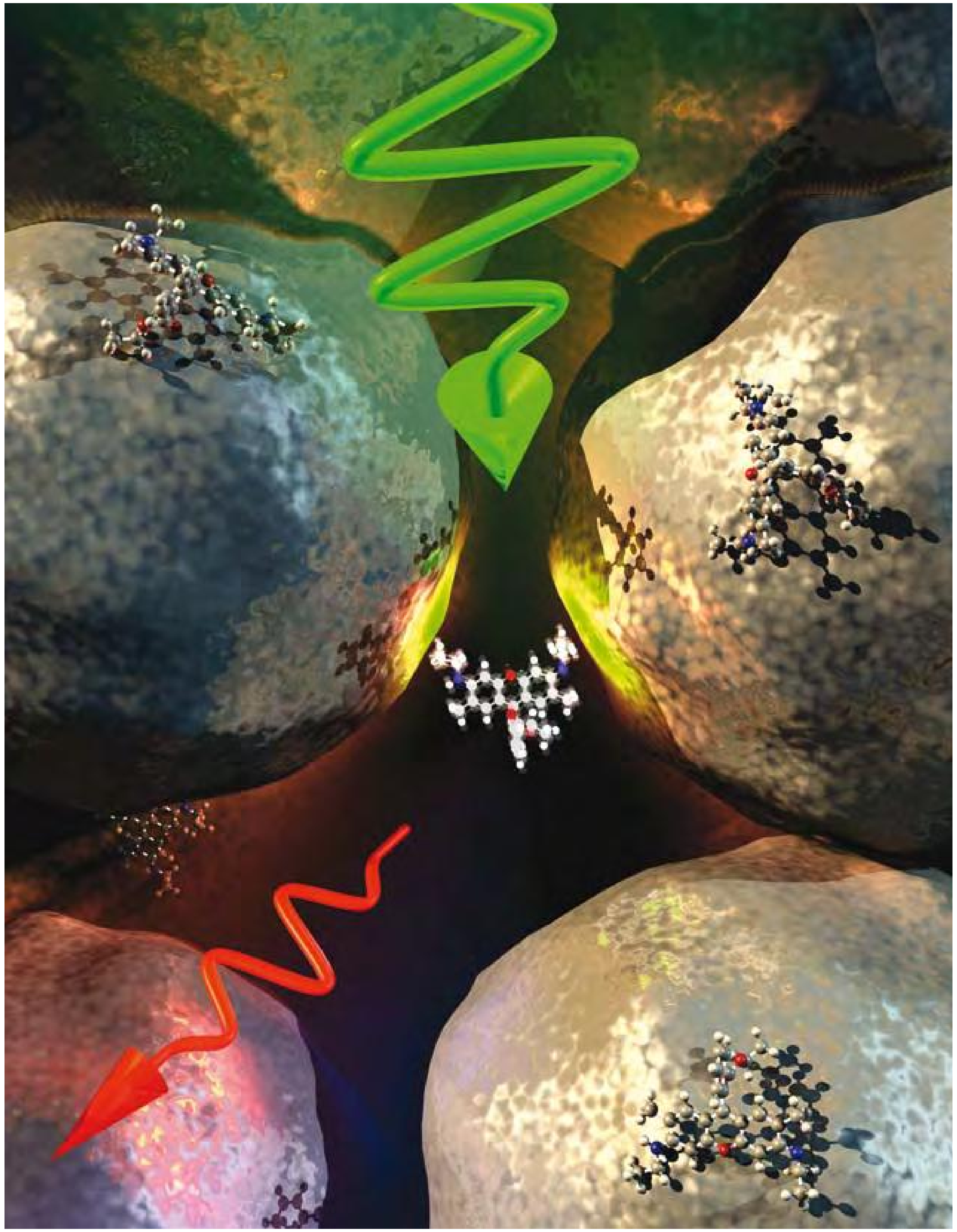


1: Citing author, over 15 years' experience, USA
... there was significant confusion concerning SERS enhancement factors for different particle structures and arrangements. The results presented clarified this issue in a decisive way... better SERS substrates have been developed ... it is possible for the field to move on to sensing applications with confidence that the best possible measurements are being done.



2: Citing author, over 15 years' experience, Italy
Understanding the SERS enhancement is a critical issue, the paper clearly identifies which quantities to look at... [the results of this paper may lead to] use of SERS sensors in the real world.

3: Citing author, over 15 years' experience, Canada
[The paper gave] a better description of enhancement factors in SERS... [Which may be] useful for the development of chemical sensing technologies based on SERS.



Artist impression of single-molecule detection with SERS. Credit: Matthias Meyer.

2018 FUNDING SUCCESSES

2018 MACDIARMID INSTITUTE INVESTIGATOR (MI) MARSDEN GRANTS

Philip Brydon – University of Otago	Superconductors with intrinsic magnetism: Origin, evidence and universal physics
Chris Bumby – Victoria University of Wellington	Over-critical currents in a superconducting dynamo
Paul Hume and **Geoff Waterhouse** University of Auckland	Next-generation small molecule acceptors for use in organic solar cells
Geoff Jameson and **Martin (Bill) Williams** Massey University	Pectin methylesterases: tuning pectin function with complex variations upon a simple theme
Nigel Lucas – University of Otago	Carbon nanocones by design: Atomically-precise molecular containers
Stuart Wimbush – Victoria University of Wellington	An ion-beam engineered microstructure for high-performance superconducting films

2018 MACDIARMID INSTITUTE INVESTIGATOR ROYAL SOCIETY GRANTS

Margaret Brimble – University of Auckland	• Unleashing new generation lanthipeptides from nature to combat antimicrobial resistance • Sweetening biological therapeutics-chemical synthesis of glycoprotein mimics
Sally Brooker – University of Otago	New complexes for photocatalytic hydrogen production
Renwick Dobson – University of Canterbury	New biophysical methods to understand how bacteria import metabolites across their cell membrane
Keith Gordon – University of Otago	Photovoltaics Korea

2018 MBIE GRANTS AWARDED TO MACDIARMID INSTITUTE INVESTIGATORS

Richard Blaikie and **Damian Carder** University of Otago and Callaghan Innovation	Highly efficient nanophotonic solar-hydrogen systems
Margaret Brimble – University of Auckland	• Fungal factories • Enzyme inhibitor therapeutics • Next-generation marine antifouling using designer peptides
Bob Buckley and **Grant Williams** Victoria University of Wellington	Water purification using solar energy captured by natural photonic crystals
Bob Buckley, Simon Granville, Michele Governale, Franck Natali, Ben Ruck and **Joe Trodahl** Victoria University of Wellington	Addressing the need for magnetic memory to enable superconducting computing
Keith Gordon – University of Otago	• Lake snow toolbox • Capturing the value of New Zealand red meat
Simon Granville, John Kennedy, Jerome Leveneur and **Grant Williams** – Victoria University of Wellington and GNS	Tuneable monolithic magneto resistive sensors for asset management
Michel Nieuwoudt – University of Auckland	Photonic device for rapid prostate cancer detection and mapping
Volker Nock – University of Canterbury	Beyond myrtle rust: Next-generation tools to 'engineer' forest ecosystem resilience to plant pathogens
Shane Telfer – Massey University	Metal-organic framework glasses as next-generation porous materials

2018 MBIE SMART IDEAS GRANTS

Ben Ruck and **John Kennedy** – Victoria University of Wellington and GNS	Transparent thermoelectric device

CALLAGHAN INNOVATION

Keith Gordon – University of Otago	New Zealand Steel

2018 HRC GRANTS

Margaret Brimble – University of Auckland	• Naturally occurring peptaibols: "magic bullets" for targeting breast cancer • Targeting pathogen energetics to produce new antimicrobials

2018 NSC (NATIONAL SCIENCE CHALLENGES)

Renee Goreham – Victoria University of Wellington	• Accelerate my impact • Magnetic metal nanoclusters
Simon Granville and **Ben Ruck** Victoria University of Wellington	A New transistor exploiting electron spin
Volker Nock – University of Canterbury	Medical technology: home and community care

2018 DOMESTIC GRANTS – GOVERNMENT FUNDING

David Barker – University of Auckland	Molecular sponges - MPI - Primary Growth Partnership with New Zealand winegrowers
Margaret Brimble – University of Auckland	• Nitroheterocycles as methanogen inhibitors - AgResearch funding • New generation methanogen inhibitors - AgResearch funding
Simon Brown – University of Canterbury	Topological 2D materials - Dumont d'Urville
Michele Governale and **Ben Ruck** Victoria University of Wellington	Ministry of Education networks of expertise funding
Volker Nock – University of Canterbury	Photonic professional GT 3D laser lithography system - Lottery Health Equipment funding

2018 DOMESTIC GRANTS – OTHER

Margaret Brimble – University of Auckland	• CGRP – Proof of concept studies – Living Cell Technologies (LCT) research project • Pramlintide – proof of concept studies – Living Cell Technologies (LCT) research project • Synthesis of loline alkaloids - Biotelliga research project
Matthew Cowan – University of Canterbury	Recovery of waste from feedstock - WNT Ventures
James Crowley – University of Otago	• Novel antibacterial and anticancer systems – Mrs Pauline Lane (donation) • Cancer drug delivery - Oceanbridge Golf Charity Trust (donation)
Keith Gordon – University of Otago	Non-destructive SBD detection by Laser - Zespri Group Limited
Pauline Harris – Victoria University of Wellington	Planetarium Dome Project - SMART
Jenny Malmström – University of Auckland	Ansto beamtime for GISAXS
Emilia Nowak – Massey University	Understanding and reducing labelling failure due to condensation on Gold3 - Zespri Group Ltd
Geoff Waterhouse – University of Auckland	• Rechargeable metal-air batteries - philanthropic donation • Low cost electrocatalysts for hydrogen production and rechargeable Zn-Air batteries - Energy Education Trust of New Zealand Project Funding

INTERNATIONAL – PUBLIC SECTOR FUNDING

Margaret Brimble – University of Auckland	Diabetic cardiomyopathy – new molecular intervention targets and a biomarker strategy
Petrik Galvosas – Victoria University of Wellington	Molecular mechanisms of mechanosensation and shape regulation in cells
Keith Gordon – University of Otago	Faster interfacial electron transfer: the effect of molecule shape and size
Duncan McGillivray – University of Auckland	The Australian Institute of Nuclear Science and Engineering (AINSE) postgraduate research fellowship
Richard Tilley – University of New South Wales	Nanoparticle enzyme mimics
Jadranka Travas-Sejdic – University of Auckland	Insect odorant receptors on conducting polymer thin films for odorant sensing
Geoff Waterhouse – University of Auckland	• XAS characterization of porphyrin-like single metal atom sites in MOF-derived N-doped porous carbons: Towards improved electrocatalysts for the oxygen reduction reaction (ORR) • Novel photocatalysts derived from layered double hydroxide nanosheets for CO hydrogenation to olefins under visible light • Effect of Particle Size on the Local Electronic Structure of Layered Double Hydroxide Nanosheets for Photocatalytic Ammonia Synthesis

David Williams – University of Auckland	Fellowship: Institute of Advanced Study, Durham University, UK

INTERNATIONAL – PRIVATE SECTOR FUNDING

Margaret Brimble – University of Auckland	• Synthesis of SapVax hPam2 constructs conjugated to TRP2 • Further synthesis hPam2 constructs, 6 peptides and 1 uPam self-adjuvanting construct • Synthesis of hPam2 synthesis
Jim Metson – University of Auckland	A new quality and low production cost alumina for aluminium production and PFC degradation
Geoff Waterhouse – University of Auckland	• Rechargeable metal-air batteries • Low cost electrocatalysts for hydrogen production and rechargeable ZN-air batteries

2018 KIWINET AWARDS

Matthew Cowan – University of Canterbury	Kiwinet Emerging Innovator Kiwinet Pre-seed accelerator funding
Aaron Marshall – University of Canterbury	Emerging Innovator Award

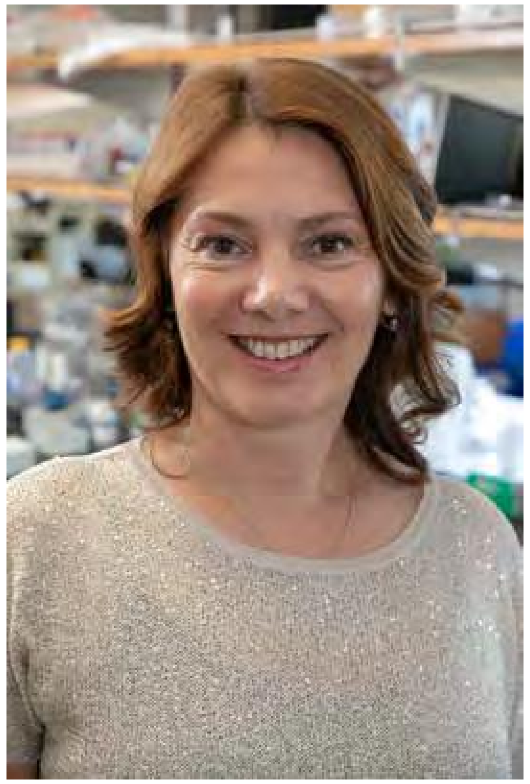
2018 UNIVERSITY INTERNAL FUNDING

Martin Allen – University of Canterbury	Australian Synchrotron Beamline Funding
Matthew Cowan – University of Canterbury	Correlation of heat of adsorption to gas transport within dense solids
Michel Nieuwoudt – University of Auckland	Sweat, tears and cortisol: non-invasive measurement of cortisol
Volker Nock – University of Canterbury	Innovative spin coating to create environmentally friendly materials
Emilia Nowak – Massey University	Establishing assumptions of the mathematical model of gastrointestinal tract
Viji Sarojini – University of Auckland	Environmentally benign antimicrobial technology
Jeff Tallon – Victoria University of Wellington	NMR and muon research on HTS superconductors
Geoff Waterhouse – University of Auckland	Novel catalytic technologies for carbon dioxide reduction to fuels and valuable commodity chemicals
Catherine Whitby – Massey University	• Interfacial rheometer • Armouring biomaterials for the challenges ahead

AWARDS 2018

Maan Alkaisi	College of Engineering Established Researcher Award – University of Canterbury Christchurch City Civic Award for Public Advocacy and Community Services
Margaret Brimble	Appointed by Her Majesty the Queen as Dame Companion of NZ Order of Merit (DNZM) for Service to Science Elected Fellow of The Royal Society (FRS) – first female New Zealander elected to the Royal Society Royal Society of Chemistry George & Christine Sosnovsky Award in Cancer Therapy Named as one of 125 New Zealand women trailblazers to commemorate 125 years Women's Suffrage in New Zealand
Matthew Cowan	'Silver' on the International Union of Pure and Applied Chemistry (IUPAC) periodic table of young chemists
Laura Domigan	University of Auckland School of Biological Sciences Early Career Research Award
Carla Meledandri	Prime Minister's MacDiarmid Emerging Scientist Prize for 2017 (awarded 2018)
Jim Metson	The Minerals, Metals & Materials Society (TMS) Light Metals Subject Award – Aluminium Reduction Technology
Michel Nieuwoudt	1st place: Innovative idea pitch, Innovation School, Optical Society of America, Washington DC
Jadranka Travas-Sejdic	New Zealand Association of Scientists (NZAS) Shorland Medal
Charles Unsworth	Awarded a Visiting Professorship at Tampere University, Finland
Geoff Waterhouse	Fellowship of the New Zealand Institute of Chemistry Chair Professorship at the South China University of Technology Visiting Fellowship under the Chinese Academy of Sciences (CAS) President's International Fellowship Initiative
Frederick Wells	University of Auckland Postdoctoral Society Symposium Prize

Dr Carla Meledandri with Prime Minister Rt Hon Jacinda Ardern



Professor Jadranka Travas-Sejdic

Professor Margaret Brimble

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2. Into the marketplace.

The aim of our materials science and nanotechnology research is to positively transform people's lives and to benefit New Zealand. To achieve this we seek to get our innovations into the marketplace, both nationally and internationally.

Since our inception in 2002, our scientists and their collaborators have developed many exciting innovations. Some have been patented, some are being field-tested and others have gone on to be produced and marketed.

IMPACT DATA

As a Centre of Research Excellence that was formed in 2002, the MacDiarmid Institute can give a long-term perspective of research impact by summarizing data over 16 years of achievement. The impact data shows that the 33 Principal Investigators of the MacDiarmid Institute and their groups have matched the performance of a well-performing NZ university. We believe this success reflects the MacDiarmid Institute's long-standing triple focus on research excellence, training and commercialisation.

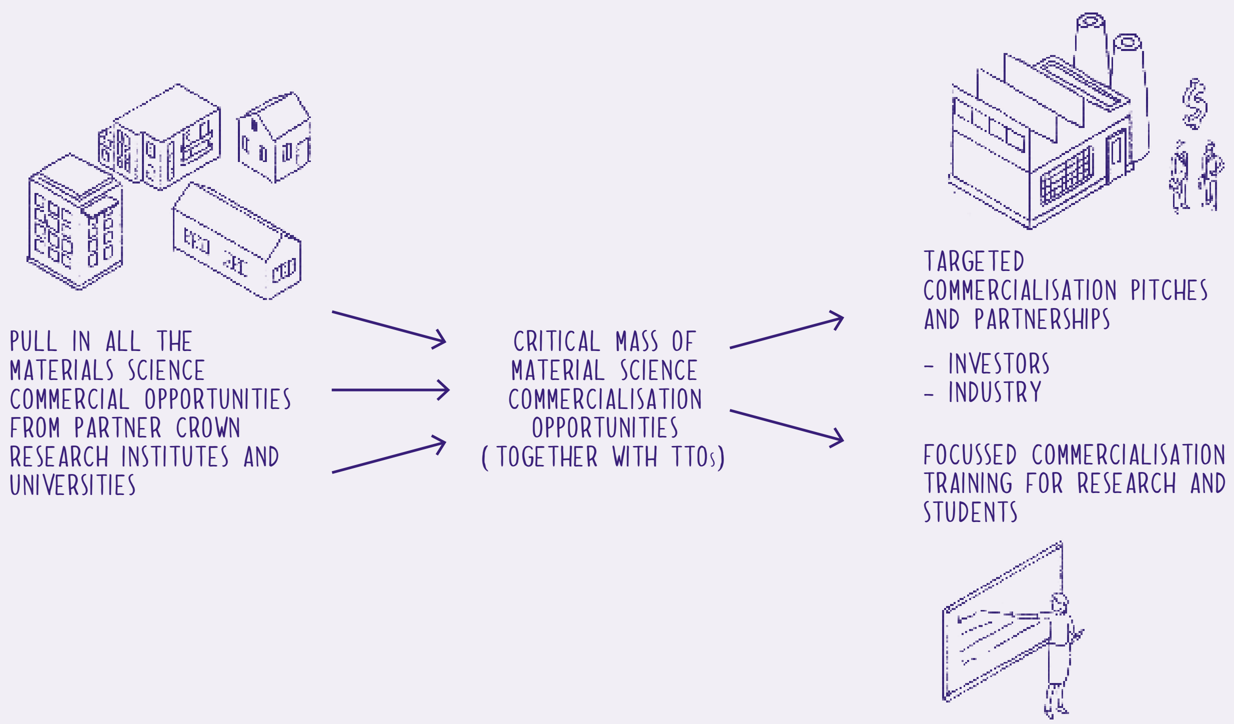
64 inventions patented

7 licence deals

15 spinout companies

>$9m royalties

>$17.2m investment



SPINOUTS

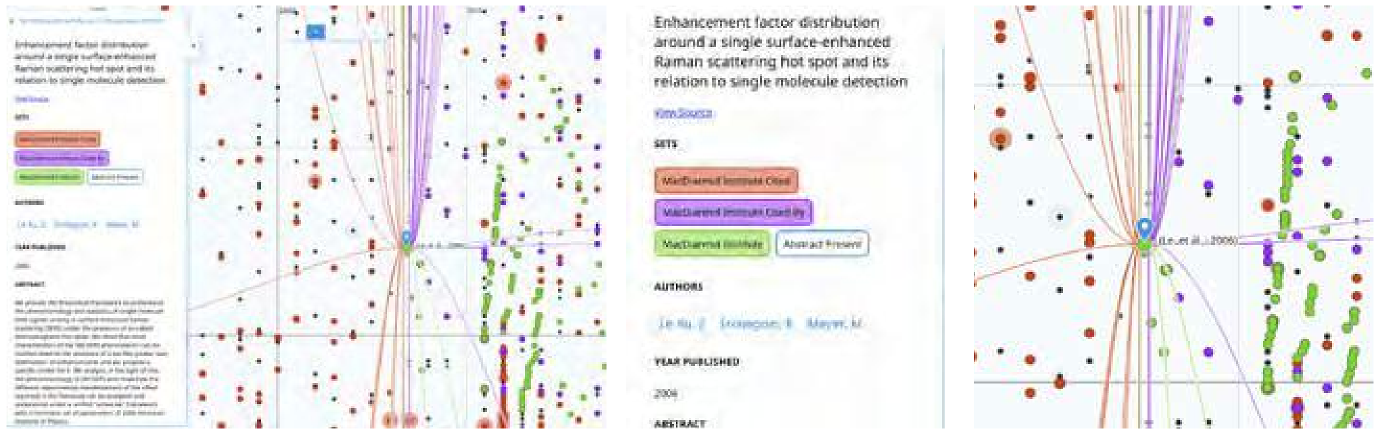
THE SCIENCE END OF BUSINESS MEETS THE BUSINESS END OF SCIENCE

NEW COMPANIES ASSOCIATED WITH THE MACDIARMID INSTITUTE BETWEEN 2002 AND 2018

Three of the 15 spinouts associated with the MacDiarmid Institute have matured and grown to the point where they are demonstrating their benefit to society in terms of jobs created and product sold. While the specific numbers cannot be disclosed, two of the 15 companies are making overseas sales at the scale of millions of dollars per year.

LITMAPS

Litmaps uses a game-like interface to show connections between scientific papers over time, and can map the entirety of peer-reviewed academic and patent literature of a field.



CASE STUDY

SCIENCE ENTREPRENEURSHIP DELIVERS SOLUTIONS

Engender Ltd was formed by MacDiarmid Institute Principal Investigator and University of Auckland Professor Cather Simpson in 2011 to provide a solution to the problem dairy farmers have of selecting the sex of their calves. It's a pressing unmet need – in 2017, 1.77 million four-day-old bobby calves were sent to the freezing works, making farmers and the dairy industry the target of bitter criticism by animal welfare groups. The company pioneered new techniques to sex semen, using high-tech microfluidic and photonic chips that sort sperm by sex. After a seven year journey in which the company raised over $5M to fund technology development and won the Agtech category of the prestigious 2016 Silicon Valley Forum Tech World Cup, in November 2018 the company was acquired by animal genetics company CRV International for an undisclosed sum. Professor Simpson said the R&D team operating out of the University of Auckland were "over the moon" with the deal with an international leader in the livestock industry because it would accelerate translating the technology to benefit farmers. Kiwi farmers will not be the only ones to benefit from the technology. In India because of the "sacred cow" principle, farmers have to keep all cattle for their natural life, whether they provide an income or not, a situation that would ease if they could select the animal's sex. The R&D will continue to be carried out here in New Zealand, a win-win for both our primary and high-tech industries.

Professor Cather Simpson of Auckland University and scientist for the company Engender.

After a seven year journey in which the company raised over $5M to fund technology development and won the AgTech category of the prestigious 2016 Silicon Valley Forum Tech World Cup, in November 2018 Engender was acquired by animal genetics company CRV International for an undisclosed sum.

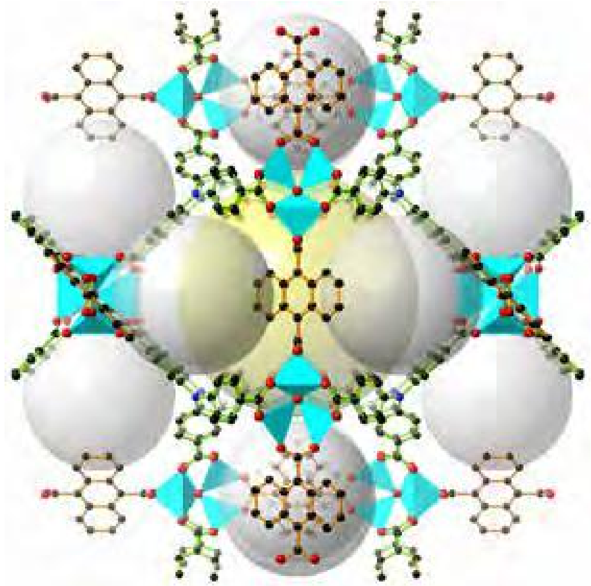
CASE STUDY

FUNDAMENTAL SCIENCE FEEDS PIPELINE OF HIGH IMPACT TECHNOLOGIES.

MacDiarmid Institute Principal Investigator and Massey University Professor Shane Telfer is a materials chemist and global research leader in the field of Metal Organic Frameworks (MOFs). MOFs are tiny crystals full of holes which are widely used to capture gases out of the atmosphere. This family of materials serve vital but invisible roles in industry and there is a huge interest in discovering new and better MOFs to enhance industrial efficiency and sustainability. Professor Telfer has established an international reputation and a wide range of industry partnerships. "While my group focuses on deep science, at the same time we are looking to identify and commercialise new materials. We have one such opportunity emerging now from PhD student Omid Taheri. We developed a material with surprisingly good properties for the selective capture of a greenhouse gas. With the assistance of the MacDiarmid Institute and our university enterprise support, we have filed a provisional patent with IP Australia, and we are developing a business plan to map the multiple potential routes to market. It's the only way to ensure that society capture the full benefits of our research."

"While my group focuses on deep science, at the same time we are looking to identify and commercialise new materials."

PROFESSOR SHANE TELFER



MEETING UNMET TECHNOLOGY NEEDS IN THE INDUSTRIAL SECTOR

While spinouts are an important and high profile measure of our focus on delivering benefit to society, they are not the only mechanism. We also have an even greater number of research partnerships and licences with companies, the details of which must usually remain commercial-in-confidence. Many of these have been catalysed by our industry interface events which provide a platform for company partners to pitch unmet technology needs for which MacDiarmid Institute researchers can then provide solutions. In 2018 there has been a strong focus on sustainability, with industry partners including Mint Innovation (uses bio-based techniques to recover metals from electronic waste and mining residues), Avertana (extracts commodity materials from industrial waste) and Aquafortus (has developed a material for wastewater treatment that operates with unprecedented energy efficiency). Through the MacDiarmid Institute these companies are accessing expertise and tools to advance their technology and product ranges.

Building partnerships with Māori remains a priority and in 2018 we engaged with Poutama to explore the potential to contribute scientific expertise to their initiatives, and we participated in the launch of NUKU ki te Puku, a nutrition venture led by Māori entrepreneurs and involving scientists, investors, marketers and horticulturalists.

POUTAMA

Interface partners

AVERTANA

aquafortus

MINT innovation

LANACO

“By working and workshopping with MacDiarmid researchers, we have identified a variety of project opportunities. We are moving towards a collaboration where the deep science at our New Zealand universities can be applied to a range of market-ready products.”

GREG OLSEN, R&D MANAGER, FISHER & PAYKEL HEALTHCARE.

"Powerhouse Ventures and the MacDiarmid Institute worked together to enable Silventum to take on a sponsored PhD, supporting the company to achieve its dual goals of enhancing current industry products while also developing a pipeline of innovative new products."

STEVE SILVEY, INVESTMENT MANAGER AT POWERHOUSE VENTURES & NOW DIRECTOR OF SILVENTUM LTD.

"We were delighted when the MacDiarmid Institute quickly identified and funded a recent graduate to work on this project as a Research Assistant."

DR WILL BARKER, CEO OF MINT INNOVATION LTD.

PATENTS AND SPINOUTS 2018

DETAILS OF INVENTION DISCLOSURES

Chris Bumby
- *Ultrafast curing of wood glue using magnetic microparticle heating*

Laura Domigan
- *Lens protein ocular adhesive*

Aaron Marshall
- *Treatment of waste from galvanising industry*
- *Novel carbon electrodes for redox batteries*

Shane Telfer
- *Metal-organic frameworks for gas adsorption*

DETAILS OF PATENT APPLICATIONS

Saurabh Bose
- *Neuromorphic network*
  US Patent Application 15/740,791

Justin Hodgkiss
- *Optical system for narrowing the bandwidth of radiation*
  NZ Patent Application 737899

Eric Le Ru
- *A spectrometer apparatus for measuring spectra of a liquid sample using an integrating category*
  PCT application WO2018070882A1

Jerome Leveneur
- *Ion beam sputtering apparatus and method*
  PCT/NZ2018/050183

Jadranka Travas-Sejdic
- *Sensor device and methods*
  PCT Application WO2018116186A1

Geoff Waterhouse
- *Hydrogen production from aqueous alcohol mixtures over noble metal titanium dioxide supported photo-catalysts*
  PCT Application WO2018020344

David Williams
- *Conducting polymers and uses thereof*
  PCT Application WO2018047101
- *A fluid analytical device*
  PCT Application WO201810661

DETAILS OF PATENTS GRANTED

Margaret Brimble
- *Peptide compounds, conjugates thereof, and uses thereof*
  NZ Patent Application 784041
- *Quinoline sulfonamide compounds and their use as antibacterial agents*
  PCT/NZ2018/050182
- *Peptide conjugate CGRP receptor antagonists and methods of preparation and uses thereof*
  PCT/IB2018/058684
- *Carbon-monoxide releasing norbornenone compounds*
  US Patent Application 2018/0346420
- *Amino acid and peptide conjugates and uses thereof*
  US Patent Application 15/535,956

Vladimir Golovko
- *Photocatalytic conversion of carbon dioxide and water into substituted or unsubstituted hydrocarbon(s)*
  PCT/AU2016051175

Carla Meledandri
- *Assembly of micelle aggregates of surfactant micelles and silver nanoparticles and use as antibacterial agent*
  US Patent 10,064,891
- *Glass ionomer cement containing silver nanoparticles*
  PCT/NZ2018/050073

Franck Natali
- *Rare earth nitride and group III – nitride structure or device*
  US Patent 10,043,871 B1

Jadranka Travas-Sejdic
- *Methods and apparatus for amplifying nucleic acids*
  US Patent Application 14/738,179

David Williams
- *Methods and apparatus for quantification of nucleic acid amplification by monitoring of impedance*
  US Patent Application 2016/0046977

SPINOUT FORMED IN 2018

Kyle Webster
Litmaps

3. Into the community

Science is People

One of Alan MacDiarmid's favourite sayings was "Science is People". Once again, we have truly put people in the centre of our science outreach this year with new and significant partnerships, and more than 50 public engagement activities throughout New Zealand.

PARTNERING TO DEEPEN AND FURTHER OUR ENGAGEMENT

Using science knowledge to develop key technologies that address national and global issues is at the heart of what we do.

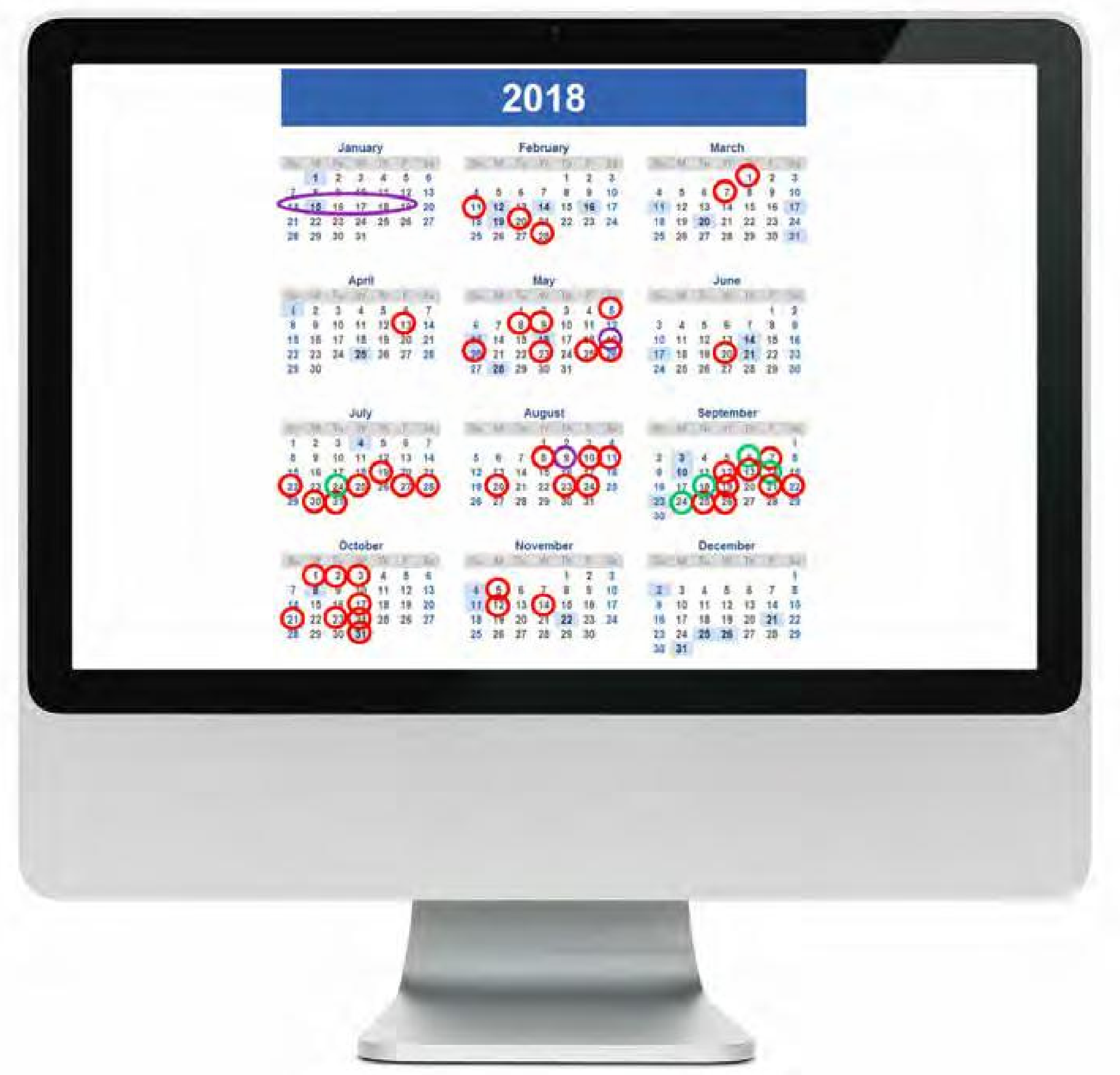
We have this year partnered with Whakarewarewa Village in Rotorua to foster whanaungatanga with Māori communities and to contribute towards ways Māori knowledge can be woven together with western science. We have also partnered with two New Zealand museums. Our relationship with Te Papa Tongarewa will see materials science and future sustainable technologies based on materials science part of Te Papa's new 'Nature' exhibition. Our traveling exhibition of science - from the lab to the marketplace - will open at MOTAT and then travel around regional museums. These two museum partnerships will showcase MacDiarmid Institute science and innovation stories to visitors of all ages all around New Zealand.

Our researchers, along with some of our alumni, again travelled the country for our annual Regional Lecture Series. This year they highlighted the many pathways to industry for science graduates, andused personal stories to inspire secondary students to study science and be part of innovative technologies research.

We have continued our public talks, science camps, hands-on experiment sessions for kids, and professional development programmes and resources for teachers. Public engagement is a collective endeavour and the MacDiarmid Institute takes our science to the community and interacts with people wherever they are, so activities have been held in a wide range of venues all over New Zealand, including schools, science festivals, cinemas, regional cities, and universities.

Ringahora Huata, Research Assistant, speaking at the MacDiarmid Institute symposium.

PUBLIC ENGAGEMENT EVENTS 2018



1 EVENT
2 EVENTS
3+ EVENTS

EXPLORING SYNERGIES BETWEEN TWO KNOWLEDGE SYSTEMS - MĀTAURANGA MĀORI AND WESTERN SCIENCE

We partnered with the Whakarewarewa Village Charitable Trust to use materials science to better understand the natural colours of geothermal rocks and waters at the Whakarewarewa Village and surrounding areas within the Taupō volcanic zone.

Welcoming the partnership, Whakarewarewa Village Charitable Trust Chief Executive Blair Millar said: "By working with traditional knowledge around the colours in the rocks and waters of Whakarewarewa and surrounding areas, this project will provide new knowledge where skills and experiences can be shared with schools, and relevant curriculum-linked activities based on the themes of mātauranga and science in practice. It's about bringing the stories, the legends, the waiata and the science together."

The work will include chemical analysis of trace elements, and the study of the crystalline structures of the materials. MacDiarmid Institute Co-Director Professor Justin Hodgkiss, who grew up in Rotorua, said: "The project will incorporate and explore synergies between the two knowledge systems' of mātauranga Māori and western science."

The research findings and experience from the joint project will be shared openly and a range of communication and knowledge transfer mechanisms with be utilised. Wānanga will be held at the village to transfer knowledge that will in turn be passed on to visitors through the on-going guiding legacy. Educational resources and information collateral (e.g. audio-visual, media, printed material) will be developed and made available through Te Mātāpuna o Papatūānuku, GNS Science – Whakarewarewa facility and online on the MacDiarmid Institute website.

Whakarewarewa Village Charitable Trust chairman James Warbrick collects samples for the study.

"This partnership with MacDiarmid provides new knowledge where skills and experiences can be shared with whānau and relevant curriculum-linked activities based on the themes of mātauranga and science in practice."

BLAIR MILLAR, CEO, WHAKAREWAREWA - THE LIVING MĀORI VILLAGE

SHOWCASING SCIENCE FOR FUTURE SUSTAINABILITY AT TE PAPA

We've partnered with Te Papa Tongarewa to include future sustainability science in the national museum's new Te Taiao | Nature exhibition, opening in May 2019.
As our Board Chair pointed out in his intro, materials science is the basis of all sustainable technologies, including new batteries, new solar photovoltaics and new types of low energy computing. We're looking forward to working with Te Papa to showcase some of these materials science technologies and the contribution they can make to mitigating our changing climate.

"Our new partnership with the MacDiarmid Institute allows us to showcase some of New Zealand's leading research on materials science relating to building a more sustainable future."
DR DEAN PETERSON, DIRECTOR OF STRATEGY AND PERFORMANCE, TE PAPA.

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TAKING HI-TECH STORIES TO MUSEUMS AROUND THE COUNTRY, WITH MOTAT

We are developing a travelling science showcase that can be exhibited at different museums around New Zealand. The project is a collaboration with another CoRE, the Dodd-Walls Centre, the Museum of Transport and Technology and the Otago Museum, and will bring hi-tech our research into an engaging exhibition format. Look out for the showcase, which will open in the Museum of Transport and Technology in May 2019, and then travel to different museums around the country throughout 2019 and 2020.

Rebecca Britt, Exhibitions Manager at MOTAT says they are excited to partner with the MacDiarmid Institute on this project. "We're excited by this valuable opportunity to

"MOTAT is proud to partner with the MacDiarmid Institute to inspire the innovators of tomorrow."
REBECCA BRITT, EXHIBITIONS MANAGER, MOTAT MUSEUM OF TRANSPORT AND TECHNOLOGY

science stories to the general public in a novel way.
The showcase will make use of interactive exhibits around material science, nanotechnology and photonics to engage people in the work of the two Centres of Research Excellence and to illustrate the journey of science from the lab to New Zealand homes and businesses. It will make use of hands-on activities, videos, live displays and virtual reality, as well as examples of end-product materials and technologies that are the result of our research.
The travelling exhibition will address the challenge of delivering information to different areas around New Zealand by designing a showcase that is portable and adaptable to different spaces.
Working in partnership with the two museums has allowed us to leverage the deep science communication and exhibition design knowledge and skills within the museums to translate

partner with the MacDiarmid Institute and inspire visitors by showcasing the science and technology occurring right here in New Zealand, helping MOTAT inspire the innovators of tomorrow." Rebecca Britt, Exhibitions Manager, MOTAT Museum of Transport and Technology.

CLUSTER HUI

Other meetings included a sensors meeting in Masterton in January, a joint TED theme/ FLEET (http://www.fleet.org.au/) meeting in Wellington in February, a redox active materials and device fabrication meeting in Christchurch in March, a superconductivity workshop in Wellington in April, a soft materials workshop in Palmerston North in August, and the 15th annual cluster meeting at the Forest & Bird Ruapehu Lodge, Whakapapa in September.

"2018 jump-started our nascent partnership between FLEET and MacDiarmid Institute, with joint meetings in Wellington and New South Wales, producing a buzz of new collaboration ideas."
PROFESSOR MICHAEL S. FUHRER
DIRECTOR, ARC CENTRE OF EXCELLENCE IN FUTURE LOW-ENERGY ELECTRONICS TECHNOLOGIES (FLEET)

MATERIALISE - A SUSTAINABLE FUTURE FORUM

We held a one-day forum - "MATERIALise: a sustainable future" - at Te Papa Tongarewa Museum of New Zealand, in October. We heard from four international keynote speakers, each doing pioneering, discovery-driven, work in their fields of fundamental chemistry, physics, and materials science more generally. It is worth emphasising the fundamental nature of their research; they are seeking to understand chemical bonding, how atoms and ions move, and how electrons flow.

Discovering how these things work would be an important enough goal in itself, and was undoubtedly the goal from which these research programs were born. And deep problems like this are now absolutely critical, and central, for our sustainability.

Our keynote speakers confronted us with uncomfortable truths – looming problems that we were not yet aware of. But we were equally heartened to learn about our growing collective knowledge, and about potential solutions being put on the table.

We are faced with unprecedented challenges. Climate change. Fresh water. Plastics in the environment. Waste. Depletion of finite resources.

Here in New Zealand, we are at a significant juncture. The Zero Carbon Bill is expected to pass in 2019, putting us on a path to a carbon neutral economy by 2050.

But we cannot get close toreaching thisgoal with today's technology; we must innovate, building on the best of what we know, and we must create new knowledge.

When it comes to carbon and sustainability, one of the things that matters most is the stuff that we make things from; materials.

> "The call for materials science has never been louder."
> ASSOCIATE PROFESSOR NICOLA GASTON, CO-DIRECTOR, THE MACDIARMID INSTITUTE

Solar photvoltaics, wind turbines, batteries, electric vehicles, passive cooling, renewable fuels, fertilisers, waste, even computers and data centres – these are areas where substantial innovation may get us a long way to a sustainable future.

For this to happen, we need to create new materials:

- Materials that convert light into electricity with higher efficiency and lower cost.
- Materials that conduct electricity without producing heat.
- Materials that can store or transform different forms of energy with little loss.
- Materials that can make themselves colder than their surroundings without requiring energy.
- Materials to build powerful computers in which information flows freely.
- Materials to catalyse the efficient production and recycling of fertilisers.
- Materials that filter, separate, and transform waste at the molecular or atomic level. Materials that purify and desalinate water.
- Materials that filter CO_2 out of exhaust.

And materials that are themselves made from abundant and clean sources, and recycled at the end of their life.

The call for materials science has never been louder.

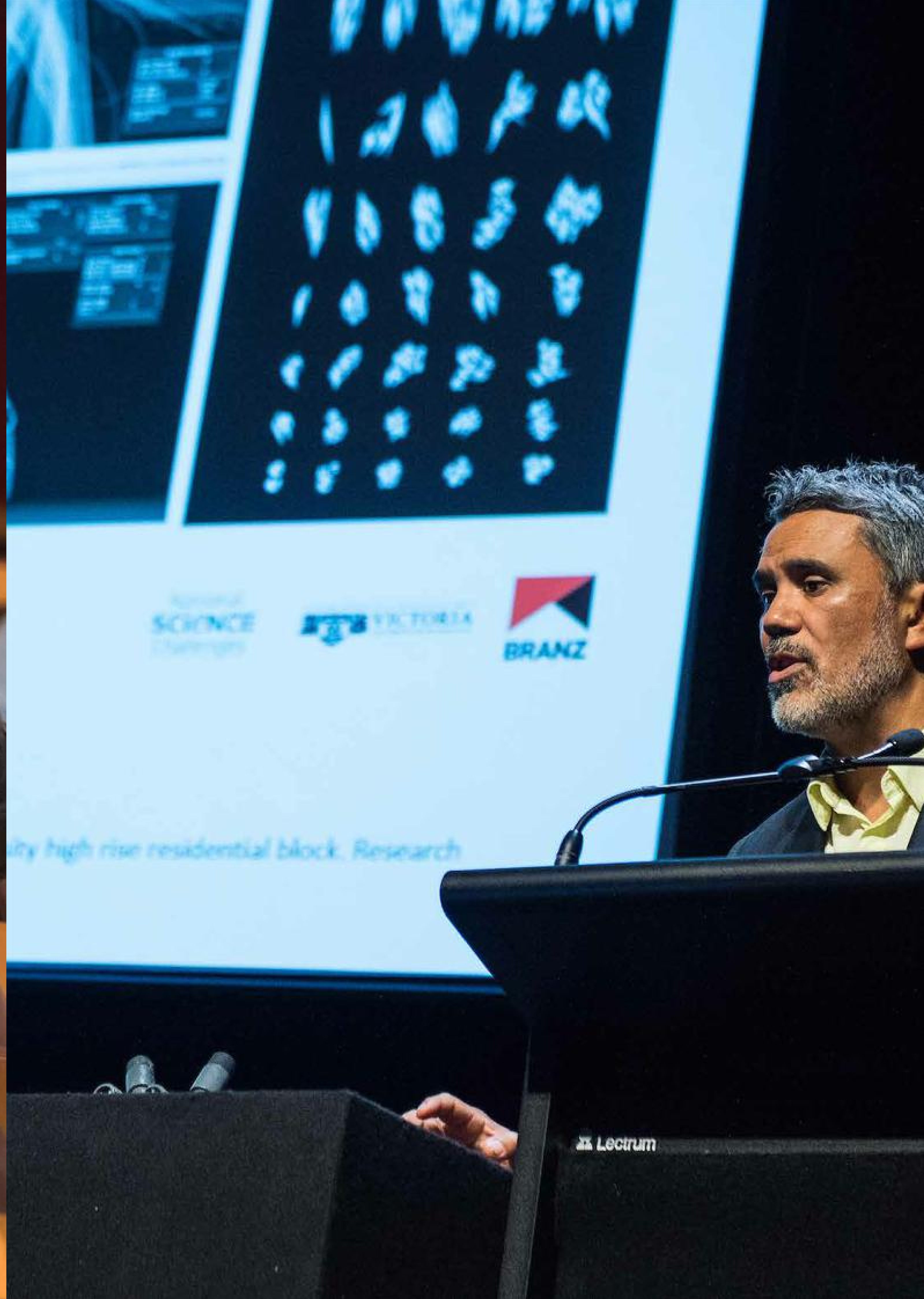
As well as helping to reduce emissions for countries with a much larger carbon footprint than ours, New Zealand could benefit from the growing value of zero carbon technologies in a world where carbon costs.

The world is already coming to New Zealand for our deep expertise in some low-carbon technologies. Kiwi researchers at our partners at the Victoria University of Wellington Robinson Research Institute are collaborating on a number of international projects to deliver efficient electric transportation systems incorporating superconducting components. The seeds of these ambitious projects were sown some time ago through discovery-driven research here in New Zealand. Like many tech successes, our opportunities will be in the niches.

For sustainable technology to be an economic opportunity for New Zealand, it will be advanced by tech companies with an export focus. We heard in the afternoon from some of those companies, and about the future workforce that we need to make them thrive.

"Solar PVs, wind turbines, batteries, electric vehicles, passive cooling, renewable fuels, fertilisers, waste, even computers and data centres – these are areas where substantial innovation may get us a long way to a sustainable future."

PROFESSOR JUSTIN HODGKISS,
CO-DIRECTOR, THE MACDIARMID INSTITUTE



GAMING A WAY TO A SUSTAINABLE FUTURE

We took the opportunity of the day to launch a new computer game – 'Materialise: a science quest'. Players of the computer game go on a quest to help the four keynote speakers from MATERIALise (Amy Prieto, Michael Fuhrer, Anita Hill and Kit Cummins) solve science challenges related to the creation and storage of clean energy and creating computers that use less energy. During the quest, players discover how one atom thin materials like graphene can be used to make next generation, low-energy computing materials; the role of phosphorus in solar photovoltaics; and the role of lithium in making more efficient and safer batteries; as well as the need for cleaner ways of extracting lithium and recycling phosphorus.

Plans are afoot to work with schools to develop the game further in 2019, for broader engagement with players aged 11-14 years.

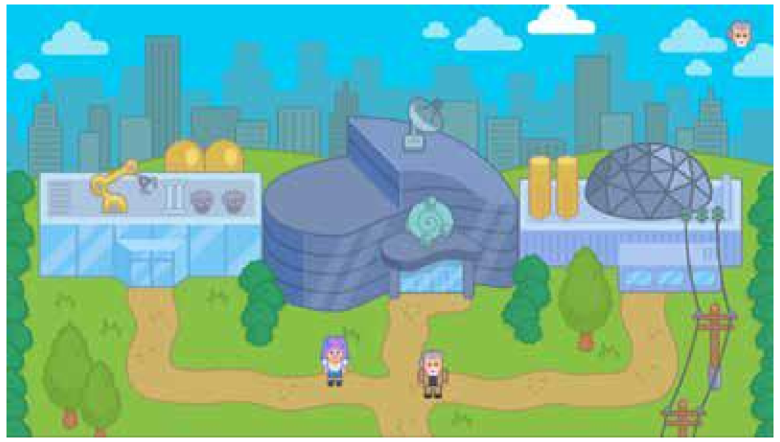
Zero Carbon 2050
– Economic threat or opportunity?
- Are there technologies in which New Zealand has a competitive advantage?
- What part does renewables driven by materials technology play in this long term goal?
- What science that we do now will make the biggest difference 20 years in the future?

DOORS TO A SUSTAINABLE FUTURE

'*Materialise*' was not just about science and technology. It was about people. Joining people up; inspiring kids to become scientists and engineers and crack the science problems that will pay off 20 years later, celebrating Māori knowledge forged throughout centuries of sustainability, building the business case for sustainability, and empowering the public.

Over 230 people attended, including iwi, school students, teachers, industry, professionals, investors, and many from government.

Videos of all of the day's talks are available on our website (link).



"The breadth and depth of the program was terrific and I was impressed to see a scientific institute so attuned to the communities and cultures of its country."

PROFESSOR MICHAEL S. FUHRER, DIRECTOR, ARC CENTRE OF EXCELLENCE IN FUTURE LOW-ENERGY ELECTRONICS TECHNOLOGIES (FLEET)

"If a zero carbon economy is within our grasp, New Zealand must seize the opportunity to become low-carbon technology exporters and sustainability pioneers."

PROFESSOR JUSTIN HODGKISS, CO-DIRECTOR, THE MACDIARMID INSTITUTE

EXISTING PARTNERSHIPS

We have ongoing partnerships with many inspiring organisations and individuals throughout New Zealand to help share science knowledge and a passion for discovery with others. The aim is to generate a nationwide culture change where science and innovation are celebrated as the keys to New Zealand's future prosperity.

Partners include The House of Science, NanoGirl Labs and the New Zealand Educational Institute. Their work is mainly focused on making science accessible, fun and engaging for students and teachers. This is vitally important given that New Zealand's future relies on committed scientists who can explore new ways to address technological, societal and environmental challenges. Bringing science to life for the young people of today will hopefully create the passionate investigators of tomorrow.

Bringing science to life for the young people of today will hopefully create the passionate investigators of tomorrow.

HOUSE OF SCIENCE

Each of the eight House of Science regions has one MacDiarmid Institute-sponsored Nano-Chem kit, plus the Hutt Valley and Rotorua regions have each purchased a second kit, so there are currently 10 kits in circulation. 238 classrooms around the country used a Nano-Chem kit for a week in 2018. Over 9500 primary school students (including 2800 (30%) Maori, and 760 (8%) Pasifika students) have used the kit this year. Feedback continues to be extremely positive.

"We love the partnership with the MacDiarmid Institute – our first national sponsor. The activities in the MacDiarmid Nano-Chem resource kit are hands-on and fun."
CHRIS DUGGAN, NATIONAL CEO, HOUSE OF SCIENCE NZ

HOUSE OF SCIENCE NANOCHEM KIT 2018

10 kits in circulation

238 classrooms used a Nano-Chem kit in 2018.

Over **9500** primary school students (including...

2800 (30%) Maori,

and **760** (8%) Pasifika students)

TEACHER FEEDBACK:

"The Nano-Chem kit is amazing. Hydrophobic sand was the kids favourite as was flubber. It was all cool."
MATANGI SCHOOL, CENTRAL WAIKATO:

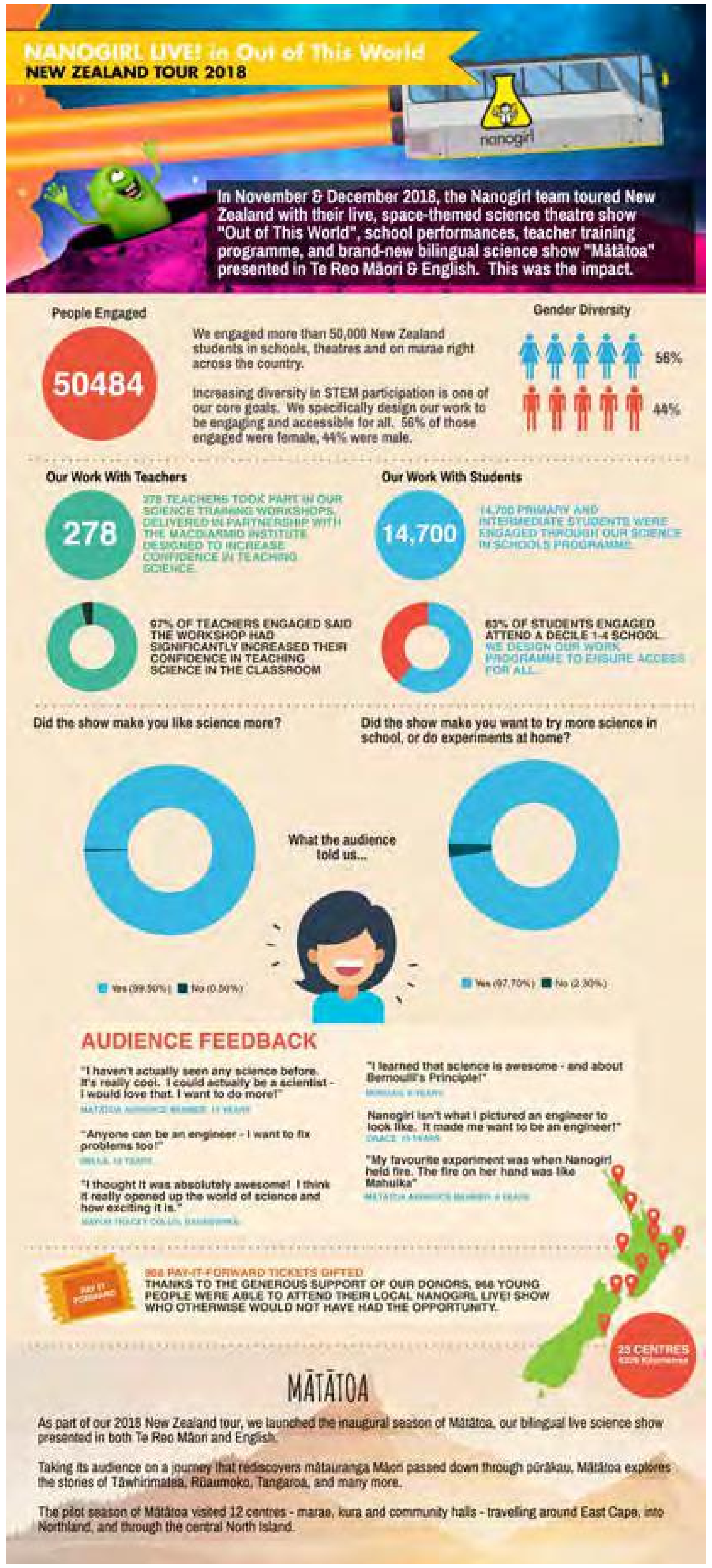
"Wow, the kids loved it. I loved it. So fun and educational. So much in the kit. No way I could supply all these items."
ROTOTUNA SCHOOL

"The experiments were great and it's actually the first time she has ever seen crystals made properly."

It is by far the favourite kit when used by classes. The glow worms blows them away, and to actually know how slime is made makes them feel smart."
SEVENTH DAY ADVENTIST, EASTERN BAY OF PLENTY

"Fantastic work! Quick reactions – fabulous."
HUTT VALLEY: ST PETER AND PAUL

"Look forward to having this back again."
TE ARA WHANUI KURA KAUPAPA MAORI



NANOGIRL

In 2018 we partnered again with Nanogirl Labs to extend our programme into regional New Zealand, in partnership with their *Nanogirl Live!* stage show.

> "The data shows that our work with teachers through the MacDiarmid Institute's Kōrero programme is transformational."
>
> JOE DAVIS, FOUNDER & CEO, NANOGIRL LABS LTD.

INSPIRE FESTIVAL 2018

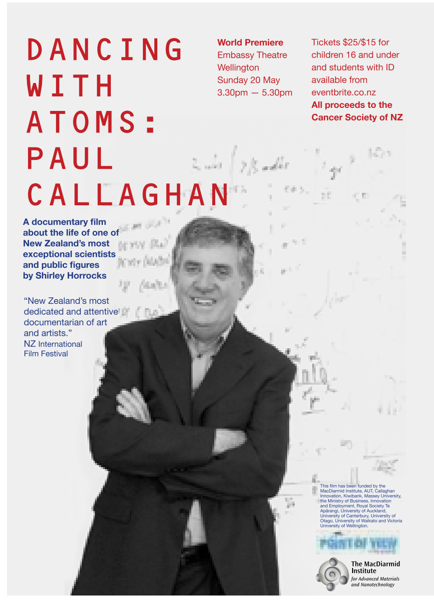
This year we ran workshops at the annual INSPIRE Festival in Nelson in September. The Ministry of Inspiration is a charity in the South Island that each year runs the INSPIRE Festival with the goal of inspiring young minds with hands on science, technology, engineering, arts, maths and society (STEAMS) learning (https://ministryofinspiration.org). Associate Investigator and Victoria University of Wellington Associate Professor Robin Fulton and Principal Investigator and University of Otago Professor Keith Gordon each delivered a series of one hour long sessions to 9-12 year old students, and a group of MESA students delivered three hour long workshops to 11-14 year old students.

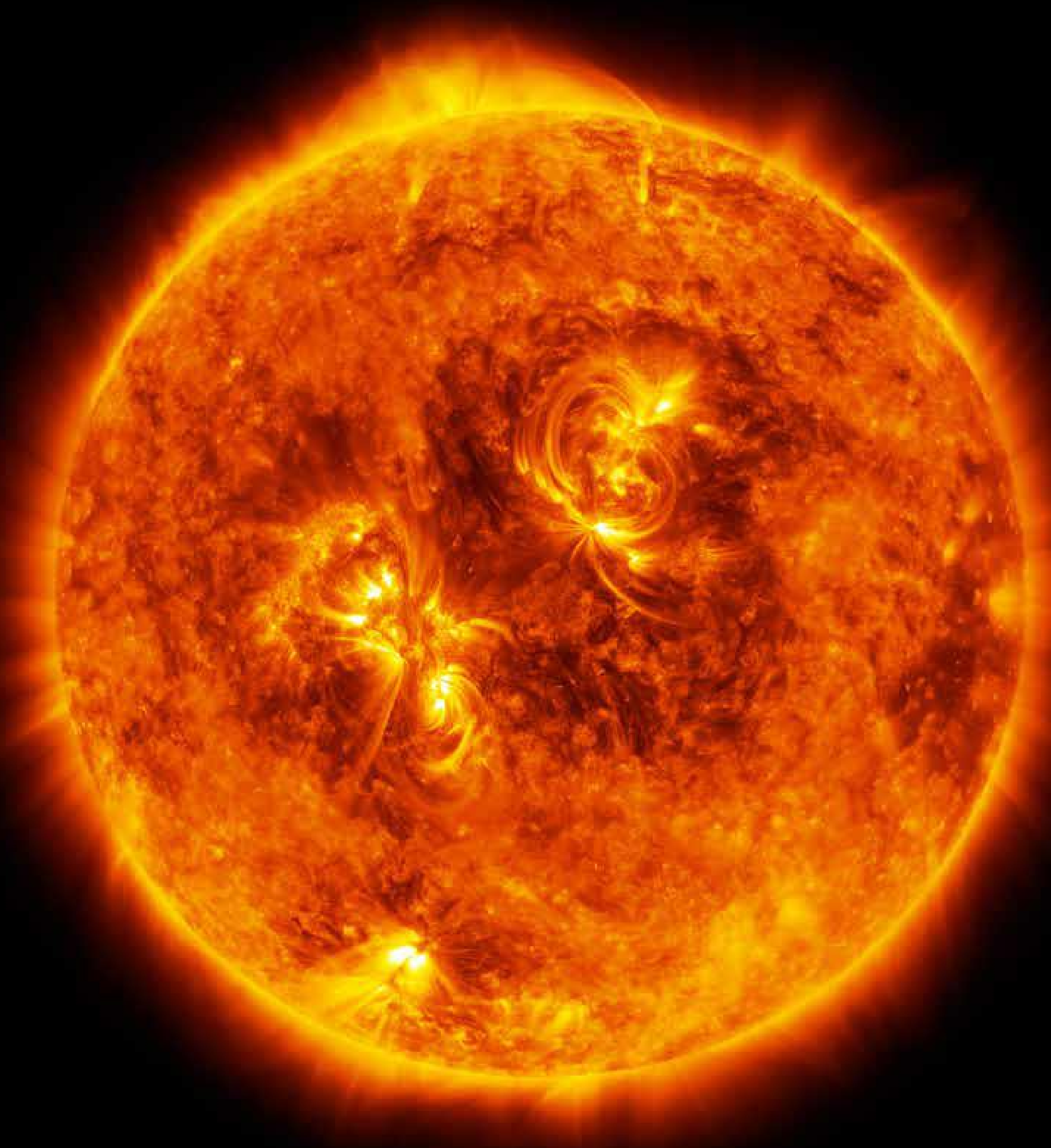
KŌRERO PARTNERSHIP WITH NZEI

Kōrero sessions were again held around the country - with two sessions held in each of three centres (Auckland 120 attendees, Wellington 32, Christchurch 49). These were again run by Principal Investigators Associate Professor Duncan McGillivray, Professor Eric Le Ru and Professor Paul Kruger. Associate Investigator Dr Anna Garden (University of Otago) attended the first session in Christchurch and plans to extend Kōrero to Dunedin in 2019.

DANCING WITH ATOMS

MacDiarmid Institute funding was pivotal in helping bring about the first documentary about Sir Paul Callaghan. Sir Paul, who established the MacDiarmid Institute and was the Institute's first Director, played a major role in New Zealand as a scientist, environmentalist, public commentator, lecturer and mentor. Over 400 people attended the premiere of Shirley Horrocks' documentary on Sir Paul. The film then headed around New Zealand as part of the New Zealand International Film Festival. The Wellington screening was held as a fundraiser for the Cancer Society (with all proceeds going to cancer research) and raised $5,500 from ticket sales.





“The programme was a great opportunity for the students to learn to keep themselves safe in the sun.”
STANLEY BAY PRINCIPAL LUCY NAYLOR

SUNSMART SCIENCE FOR SCHOOLS

Principal Investigator and University of Canterbury Associate Professor Martin Allen has designed and made lightweight, wearable, electronic UV dosimeters for skin cancer prevention and vitamin D research. This year, with MacDiarmid Institute support, Associate Professor Allen trialled the dosimeters at a SunSmart programme at Stanley Bay School in Auckland. Over several days, 245 students used the dosimeters to measure the reduction in UV radiation from shade, sunglasses, school clothing, and sunscreen.

Dr Alana Hyland, a former student of Associate Professor Allen, has designed a cartoon character called Kara Chameleon. The cartoon demonstrates New Zealand’s recommended SunSmart behaviours and also shows students the SunSmart UV Lab. Associate Professor Allen says chameleons are remarkable creatures that can sense UV light and rapidly change colour in response to their environment. “Chameleons actually change colour by changing the spacing between nanocrystals in their skin,” he says.

Stanley Bay Principal Lucy Naylor said the programme was a great opportunity for the students to learn to keep themselves safe.

SPACE AND SCIENCE FESTIVALS

We had broad based and high profile MacDiarmid Institute engagement across the entire Space and Science Festival in the Wairarapa and Wellington. The MESA team ran the largest and busiest area of activities. Associate Investigator Dr Catherine Whitby gave a talk in the main hall, and then took part in a four-strong 'Women in Science' live panel alongside NASA Astronaut Dr Yvonne Cagle, NASA scientist Dr Jen Blank and engineer Emily Melhuish from Rocket Lab. Principal Investigator Professor Thomas Nann spoke about the energy revolution. We were also delighted to be able to support the free talk by physicist and former astronaut Trainer Laura Winterling. Ms Winterling spoke in Wellington on astronaut training and life onboard the International Space Station.

DISCOVERYCAMP AND NANOCAMP

The annual NanoCamp and DiscoveryCamp for Year 12 and 13 secondary school students are hugely popular and attract many more applications than there are places available. The five day, all-expenses-paid residential programmes give students an opportunity to learn about nanoscience through lectures and lab experience with MacDiarmid Institute investigators.

The DiscoveryCamp programme is for Māori and Pasifika students to enhance their science knowledge, inspire a love of discovery and help them carve out a career in science. Designed for Māori and Pasifika students in their final years of high school, MacDiarmid Institute DiscoveryCamp – Te Tohu Huraina - is an annual programme, now in its tenth year, where students from all around the country gather to do real research with the country's leading scientists from the MacDiarmid Institute.

It is well documented that Māori and Pasifika are under-represented in New Zealand across the sciences. DiscoveryCamp aims to enhance their interest in science, and provide a real understanding of what a career in science looks like.

DiscoveryCamp alumni have told us the programme also plays a significant role in Māori students appreciation of their culture's place in science.

Danielle Sword (Muaūpoko, Te Ati Awa ki Whakarongotai, Ngāti Tahu) is now in her final semester of a Bachelor of Biomedical Science. Four years ago her chemistry teacher urged her to attend DiscoveryCamp.

"I'd say it was one of the key moments in my life. It was an eye opener. It influenced and inspired me to take that science path," she says.

As the completion of her undergraduate degree approaches, Sword is deciding whether to pursue further study. She's seen the way her understanding of tikanga Māori has informed her understanding of her discipline, and she is interested in pursuing research that considers the potential Māori science has to intersect with Western science, and what both cultures have to offer each other.

> "I'd say it was one of the key moments in my life. It was an eye opener. It influenced and inspired me to take that science path."
> DANIELLE SWORD

"For Māori, I do know there is this other side, there's science, then there is this Māori science. They don't fully meet together but one of my goals is to bring it into my western science practices," she says.

In January 2019, 10 DiscoveryCampers and 18 NanoCampers learned about nature at the smallest scales through hands-on nanotechnology experiments in physics, chemistry, biochemistry, and engineering. Campers made icecream in the lab, or created dye-sensitive solar cells, and some also made chocolate from 3D printed food-grade silicon moulds.

NanoCamp – University of Canterbury - 18 students (hosted by Associate Professor Martin Allen)

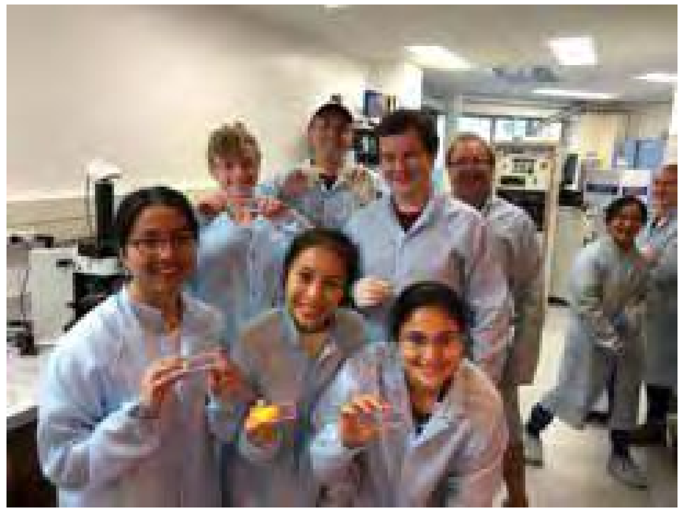
DiscoveryCamp – University of Otago – 5 students (hosted by Professor Keith Gordon)

DiscoveryCamp – Massey University – 5 students (hosted by Associate Investigator Dr Catherine Whitby)

DISCOVERYCAMP ALUMNI RESEARCH ASSISTANTSHIPS

We again offered summer scholarships to our DiscoveryCamp alumni. These are aimed at Māori and Pasifika undergraduates, and provide research-related work opportunities over the December-February period – Two three-month scholarships of a value of ($6000) were awarded and the alumni were based in Wellington (Victoria University of Wellington and GNS Science).

This summer, one of our scholarship holders worked on the project relating to our Whakarewarewa Thermal Village partnership. This included on-site visits and regular meetings at the village.



> "The entire experience has really opened my eyes to new paths of science that I have never even imagined"
> TAMIARA BARCHAM, DISCOVERYCAMP OTAGO.

> "We got to explore the boundaries of our own thinking and it made me realise what it truly means to research science."
> AARON BERTELINK, NANOCAMP CANTERBURY

> "It was incredible to see how science is having an immense impact on the things we use and see in society."
> CECILIA KOLOMATANGI, DISCOVERYCAMP MASSEY

> "It opened my eyes to how I could contribute to today's society through the study of science and the development of new materials and technology that I could use to help people's lives all over the world, especially in the Pacific Islands and here in New Zealand."
> CECILIA KOLOMATANGI, DISCOVERYCAMP MASSEY

HOW DO YOU GO FROM A PHYSICS LAB TO ROCKET LAB? OR FROM A CHEMISTRY LAB TO A NEW START-UP COMPANY? INDUSTRY PATHWAYS FOR SCIENCE GRADUATES

Inspiring and informing people, particularly students, about the diversity of careers that science studies enable was the focus of the 'MacDiarmid Science – to Industry and Beyond!' Regional Lecture Series and the Regional Breakfast Series of Rotary Club talks. In 2018, these events toured regional New Zealand including to the Hawkes Bay, Wanaka, Nelson and Tauranga, with talks given by Principal Investigator Professor Keith Gordon and alumna Dr Bhuvana Kannan, Principal Investigator Associate Professor Ben Ruck and alumnus Dr Harry Warring, Principal Investigator Professor Alison Downard and alumnus Dr Ojas Mahapatra and Principal Investigator Dr Franck Natali, and alumna Dr Manmeet Kaur.

MacDiarmid Institute Co-Director Professor Justin Hodgkiss told Radio New Zealand's Kathryn Ryan that: "When we look at our science graduates, even at PhD level, and we look at where they end up, they are doing really an amazing range of jobs."

Professor Hodgkiss explained that while some science and engineering graduates stay in research, they are also in diverse areas like business, law, and government. "When people in high schools think about science they don't really have any idea that these possibilities exist," he said.

In explaining the crucial skills gained from studying science, Victoria University of Wellington post-doctoral fellow and MacDiarmid Institute alumnus, Brendan Darby, put it this way: "You solve hard problems and you try and do something that hasn't been done before and apply that to an industry."

> "Kids today want to know they can make a difference in their lives. We're wanting to show that you can study science and end up in all sorts of interesting and varied careers."
>
> MACDAIRMID INSTITUTE CO-DIRECTOR ASSOCIATE PROFESSOR NICOLA GASTON

GERMAN DELEGATION

We welcomed a delegation from the German research organisations the German Federal Ministry of Education and Research (BMBF) and the Fraunhofer Society, led by Mr Frithjof Maennel Deputy Director General, International Cooperation in Education and Research, BMBF and including Mr Maximilian Jedemann Deputy Director of Division Cooperation with Asia and Oceania, BMBF and Dr Eckart Bierdümpel Team Head, Department of International Business Development and Head of Multinational Networking, Fraunhofer Society.

SCIENCE OF SURFACES BOOTCAMP

This year 30 MacDiarmid Institute students - chemists and physicists - met up in Wanaka to discuss the science of surfaces, a key concept when working with nanomaterials of any type. Professor Shane Telfer, Dr Colin Doyle, and Dr Shen Chong, presented their expertise on the topic. Informal breaks included group hikes up Mt. Iron and around Lake Wanaka. Formal talks and informal activities gave the opportunity to engage and collaborate with students from other MacDiarmid Institute labs around the country, and led to new collaborations, equipment sharing and general advice sessions.

MESA 2018

The MacDiarmid Emerging Scientists Association (MESA) has been running for eight years, and facilitates networking and training for all MacDiarmid Institute students and postdoctoral researchers. In 2018, the MESA executive was: Erin Service (MESA Chair) Shalini Divya (Treasurer) David Perl (Secretary) and Geoffrey Weal, Geoffrey Laufersky, Edoardo Galli, and Tarek Kollmetz. This year the committee organised and paid for workshops on electrochemistry, writing, graphics and atomic force microscopy, and awarded six $2000 travel grants for students to attend an international conference.

> "When we look at our science graduates, even at PhD level, and we look at where they end up, they are doing really an amazing range of jobs."
>
> PROFESSOR JUSTIN HODGKISS, MACDIARMID INSTITUTE CO-DIRECTOR

PARTNERING WITH THE SPINOFF

We partner with The Spinoff online magazine to provide a platform for all kinds of science content for their large and growing audience. Here are some of the articles about MacDiarmid Institute science that made their way onto The Spinoff in 2018.

Feeling the force of fungi to stop it killing our forests
Page views: 610 / Ave. time on page: 04:35 / Facebook Reach: 6,667

https://thespinoff.co.nz/science/20-11-2018/feeling-the-force-of-fungi-to-stop-it-killing-our-forests/

There's no renewable energy future without lithium
Page views: 1,877 / Ave. time on page: 07:29 / Facebook Reach: 19,959 / App views: 112

https://thespinoff.co.nz/science/30-10-2018/theres-no-renewable-energy-future-without-lithium/

Nicola Gaston on taking the wheel at the MacDiarmid Institute
Page views: 811 / Ave. time on page: 04:06 / Facebook reach: 10,002

https://thespinoff.co.nz/science/20-06-2018/nicola-gaston-on-taking-the-wheel-at-the-macdiarmid-institute/

Dancing with Atoms: the new documentary honouring the 'Sir Ed of science'
Page views: 451 / Ave. time on page: 04:34 / Facebook reach: 4,523

https://thespinoff.co.nz/science/17-05-2018/dancing-with-atoms-the-new-documentary-honouring-the-sir-ed-of-science/

The bionic leaf: how artificial plant life could wipe out poverty
Page views: 1,739 / Ave. time on page: 05:38 / Facebook reach: 7.755

https://thespinoff.co.nz/science/23-02-2018/the-bionic-leaf-how-artificial-plant-life-could-wipe-out-poverty/

Computers have grown into energy gluttons, and it can't go on like this
Page views: 3,214 / Ave. time on page: 04:50 / Facebook Reach: 23,113 / App views: 173

https://thespinoff.co.nz/science/22-10-2018/is-the-environmental-cost-of-the-technological-revolution-sustainable/

How to cool down your data
Page views: 884 / Ave. time on page: 2:81

https://thespinoff.co.nz/science/19-07-2018/how-to-cool-down-your-data/

MacDiarmid Institute
Annual Report
2018

4. Into the future.

Each year our graduates head into the wider world. Some delve into worlds of their own making and create their own startup companies, others explore industries large and small, government policy, research, and more. Some end up in disciplines and industries which did not exist at the start of their science journey. This is the future we're all living in – bright materials science futures created student by student, discovery by discovery.

FUTURE LEADERS PROGRAMME

Running alongside our annual symposium in Auckland, serial entrepreneur and pitch coach Daniel Batten facilitated a two-day ‘Future Leaders Programme’ for our students and postdocs. The Future Leaders Programme is our annual workshop for our emerging scientists to prepare them for life after a PhD or Postdoctoral study. Each year the programme is focused around either science communication, presentation skills and leadership or entrepreneurship.

This year the programme covered ‘soft skills’, such as how to have difficult conversations, the different stages of learning, and coaching techniques for different scenarios. Members had a safe environment to actively practise the skills presented. The skills learnt will allow members to be leaders - both personally and in working environments.

“My expectations were exceeded. Daniel provided us leadership techniques, skills and mindsets that are relevant not only in laboratory environments, but in all areas and levels of work.”

FUTURE LEADERS PROGRAMME STUDENT ATTENDEE





ALUMNI STORIES

Over 850 MacDiarmid Institute alumni are now using their expertise to make amazing scientific breakthroughs, mentor students, achieve commercial success, and be business leaders. Our alumni have amazing stories to tell.

We created short (90 second) videos for school students who are considering whether to continue with science, to show them some of the many different places (mostly outside academia) where science studies might take them. The videos are all available from https://macdiarmid.ac.nz/alumni-talk-about-their-projects/

Dr Nihan Aydemir and bees

A postdoctoral chemist at Plant and Food Research, Dr Nihan Aydemir is focused on mimicking how insects use proteins to smell. Her ultimate aim is to insert biosensors into cellphones that can smell explosives and illegal drugs at airports.

Dr Elf Eldridge and hackers

Dr Elf Eldridge is a cyber security analyst at Cybertoa (www.cybertoa.com).
For his PhD in physics he specialised in nanotechnology, in particular working out a method to affordably and easily detect nanoparticles.

Dr Julie Kho and technical sales

Dr Julie Kho has a PhD in chemistry and uses her expertise to help other scientists access the best scientific equipment for their needs.

Dr Ojas Mahapatra and Photonic Innovations

Dr Ojas Mahapatra came to New Zealand from India on a MacDiarmid Institute doctoral scholarship. He is now CEO of Photonic Innovations, which creates ultra-sensitive gas detection equipment.

Dr Matthew Cowan and solar energy

MacDiarmid Institute Associate Investigator, Dr Matthew Cowan, is a chemical engineer at the University of Canterbury. His current research, in partnership with a chemical engineering group, is focused on how we can make the most out of solar energy.

Dr Bhuvana Kannan and nanofibres

Dr Bhuvana Kannan works as a Research and Innovation Manager at Revolution Fibres - a nanofibre production company based in Auckland.

Dr Rebecca Hawke and travelling the world

Dr Rebecca Hawke is currently using her PhD in Physics to investigate how to control droplets on a surface. This work could address a range of needs such as easy health diagnostic tools. Her exciting career in science has taken her all over the world.

Dr Kirsten Edgar and tech disruption

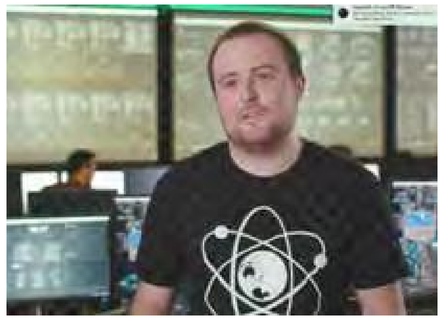
Dr Kirsten Edgar is a futures insights manager at Callaghan Innovation. She uses her degree in history combined with her PhD in chemistry to help New Zealand businesses embrace new technology to advance their products and services.

"You never know what your future job will be. Doing science gives you such a great skillset."

Dr Brendan Darby and cloudy liquid

Dr Brendan Darby has a PhD in physics and has helped develop a new technique to analyse 'cloudy' solutions. This technique has been commercialised and is being used in industries such as viticulture and water treatment.

"During a PhD you need a very high level of endurance, a level of passion and a level of commitment. Those three elements are extremely important in the start-up world as well."



Dr Harry Warring and Rocket Lab

Dr Harry Warring is now Senior Vehicle Test Engineer at Rocket Lab. Harry submitted his physics PhD thesis on a Thursday, interviewed for Rocket Lab on the Friday and started work a week later. He says the skills he picked up during his MacDiarmid Institute PhD were easily transferred to the hi-tech sector.

"It was all the extras – the 'other' skills we built up, through being part of the MacDiarmid - especially the seminars, and boot-camps. On the one hand you're the world expert on a certain topic, but on the other, you have a bunch of skills that can lead you onto some really exciting job options."

"I really had to get out of my comfort zone; you need to know what makes an idea unique."

DR NIHAN AYDEMIR, 2017 BUSINESS SCHOLARSHIP RECIPIENT

"It was a bit of a black box for me – how do I gain an appreciation of how the business world works?"

DR MATTHEW COWAN, 2017 BUSINESS SCHOLARSHIP RECIPIENT

BUSINESS SCHOLARSHIP RECIPIENTS 2018

Eldon Tate
Eldon Tate will undertake the Advanced Management Program offered by Melbourne Business School. After completing his PhD at Victoria University of Wellington, Eldon co-founded and became CEO of Inhibit Coatings Ltd. In his role as CEO Eldon hopes to use the skills learnt through The Advanced Management Program to develop his leadership capabilities and build Inhibit Coatings into a successful deep tech company.

Hannah Zheng
Hannah Zheng will take a Postgraduate Diploma in Global Business at AUT. Hannah did her PhD in Physics at Victoria University, studying with MacDiarmid Institute Principal Investigator Dr Natalie Plank, and is currently working as a Materials Scientist at Revolution Fibres. Hannah is keen to learn more about global business, to reinforce the technical knowledge she currently brings to the projects.

Sam Yu
Sam Yu will take professional development short courses in governance and leadership management from the Institute of Directors and Icehouse, which will further develop his Board and Investor experiences. Sam did a PhD at Canterbury University supervised by Professors Alison Downard and Richard Blaikie. Since then, he had been heavily involved in business development and marketing for start-ups to commercialise technologies from New Zealand. This involves exporting value-added products to the United States and Asia such as nanopore-based diagnostic tools and agricultural products with Lanaco's innovative wool-based filters.

Akshita Wason
Akshita Wason will take the Masters of Commercialisation and Entrepreneurship at Auckland. Akshita did her PhD at the University of Canterbury, worked at the start-up Hi-Aspect, and is currently with the Office of the Prime Minister's Chief Science Advisor. She will use the scholarship to develop skills to incorporate the challenges faced by typical deep-tech projects from local market launch to establishing a global presence while studying general policy-induced effects (successes and failures) on the innovation ecosystem. She is presently a New Zealand curator for Hello Tomorrow, a global non-profit organisation to promote collaborations between entrepreneurs, industries and investors.

Rob Staniland
Pressure is constantly increasing on the scientific community to provide answers to the broad range of complex issues we face as a society. Since Rob has finished his Ph.D. and started working for Mint Innovation, a deep-tech start-up company, he has come to appreciate the significance of the role that such companies hold in addressing these issues. By studying a Masters of Commercialisation and Entrepreneurship, Rob will ensure that he is in a position to help take scientific solutions to these issues out of the laboratory and to the market.

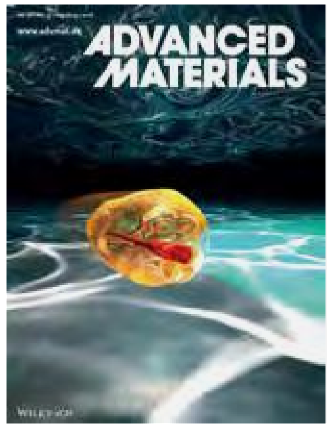
5. Into the metrics.

JOURNAL COVERS

Sally Brooker and co-workers
Substituents drive ligand rearrangements, giving dinuclear rather than mononuclear complexes, and tune $Co^{II/III}$ redox potential.
Dalton Transactions **47**, 11749-11759 (2018)

Sally Brooker and co-workers
Spin crossover in discrete polynuclear iron(II) complexes.
Chemical Society Reviews **47**, 7303-7338 (2018)

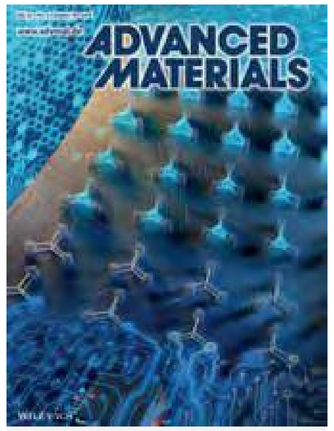
Nigel T. Lucas, Keith C. Gordon and co-workers
Walking the emission tightrope: spectral and computational analysis of some dual-emitting benzothiadiazole donor-acceptor dyes.
Journal of Physical Chemistry A **122**, 7991–8006 (2018)



Keith C. Gordon and co-workers
Moving droplets in 3D using light.
Advanced Materials **30**, 18018219 (2018)

Jenny Malmström and co-workers
Engineered systems to study the synergistic signalling between integrin-mediated mechanotransduction and growth factors (Review).
Biointerphases **13**, (2018)

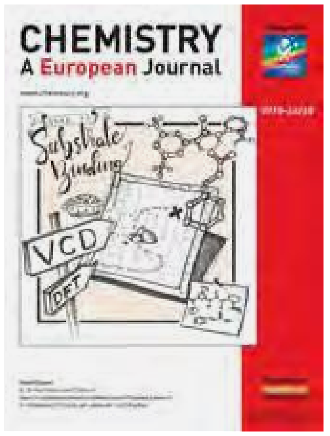
Geoffrey I.N. Waterhouse and co-workers
Photothermal catalysis: co-based catalysts derived from layered-double-hydroxide nanosheets for the photothermal production of light. Olefins
Advanced Materials **30**, 1870230 (2018)



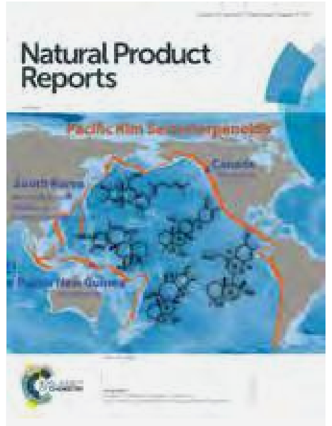
Geoffrey I.N. Waterhouse and co-workers
Photothermal CO_2 hydrogenation: alumina-supported CoFe alloy catalysts derived from layered-double-hydroxide nanosheets for efficient photothermal CO_2 hydrogenation to hydrocarbons.
Advanced Materials **30**, 1870015 (2018)

Martin A.K. Williams and co-workers
On the electrophoretic mobilities of partially charged oligosaccharides as a function of charge patterning and degree of polymerization.
Electrophoresis **39**, 1497-1503 (2018)

David Barker and co-workers
Synthesis and absolute stereochemical reassignment of Mukanadin F: A study of isomerization of bromopyrrole alkaloids with implications on marine natural product isolation.
European Journal of Organic Chemistry **24**, 3065-3074 (2018)



Margaret A. Brimble and co-workers
Chemical synthesis of bioactive naturally derived cyclic peptides containing ene-like rigidifying motifs.
Chemistry - A European Journal **24**, 17869-17880 (2018)



Margaret A. Brimble and co-workers
A new family of sesterterpenoids isolated around the Pacific Rim.
Natural Product Reports ***35***, 210-219 (2018)

James D. Crowley and co-workers
Strategies for reversible guest uptake and release from metallosupramolecular systems.
Chemistry - A European Journal **24**, 14878-14890 (2018)

FINANCIALS

	2017	2018
Core funding	5,826,451	8,150,408
Other funding (mainly interest income)	287,715	268,007
Total revenue	6,114,167	8,418,415
Salaries and salary related costs		
Director and Principal Investigators	846,473	854,688
Post-Doctoral Fellows	446,326	640,724
Research / Technical Assistants	579,307	225,487
Others	227,223	444,317
Total salaries and salary related costs	2,099,329	2,165,216
Other costs		
Overheads	1,281,815	1,893,583
Project Costs	1,125,808	1,823,281
Travel	375,388	549,967
Postgraduate Students	1,231,827	1,986,368
Total other costs	4,014,838	6,253,199
Total expenditure	6,114,167	8,418,415
Net surplus / (Deficit)	-	-

AT A GLANCE

Broad category	Detailed category
Headcounts by category	Emeritus Investigators 20 Principal Investigators 35 Stakeholder Relations Partner Iwi 1 Associate Investigators 37 Postdoctoral researchers 58 Students 239
	Total 389
Peer reviewed research outputs by type	Journal articles 378 Book chapters 9 Conference papers 17 Keynote Speaker and Invited Addresses 49
	Total 453

BOARD, EXECUTIVE, STAFF AND STUDENTS

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Chair of the Board

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Professor of Process Engineering
Massey University

Dr Ian Graham*
Research, External Relations and
Commercialisation
GNS Science

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GNS Science

Professor Wendy Lawson
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Victoria University of Wellington

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Victoria University of Wellington

*Partial year

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Associate Professor Nicola Gaston
Co-Director, MacDiarmid Institute
University of Auckland

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Co-Director, MacDiarmid Institute
Victoria University of Wellington

Dr Geoff Willmott
Deputy Director Commercialisation and
Industry Engagement, MacDiarmid Institute
University of Auckland

Dr Franck Natali
Deputy Director Stakeholder Engagement,
MacDiarmid Institute
Victoria University of Wellington

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MacDiarmid Institute
University of Otago

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Centre Manager, MacDiarmid Institute
Victoria University of Wellington

Sonia Hutton*
Administrator, MacDiarmid Institute
Minute-taker
Victoria University of Wellington

Carol Wheatley*
Administrator, MacDiarmid Institute
Minute-taker
Victoria University of Wellington

*Partial year

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Chairperson & CEO
EverEdge IP

Mr Simon Arnold
Managing Director
Arnold.co.nz – Investing with Science
Part-time CEO of NZ's National Energy
Research Institute

Dr Andrew Coy
CEO
Magritek

Ms Suse Reynolds
Executive Director
The Angel Association New Zealand
Board member of Wellington region's
Angel HQ

Mr Greg Shanahan
Managing Director & Co-founder
Veriphi and Founder of the
Technology Investment Network

Dr Shaun Tan
Head of Technology
Lanaco

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Chairman
Aquafortus
General Partner of Matu

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University of Cambridge, United Kingdom
Organic Optoeletronics

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University of New South Wales, Australia
Nano-medicine and electrochemistry

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University of Cambridge, UK
Electro-optic materials and devices

Professor Jeffery Long
Professor of Chemical & Biomolecular
Engineering
University of California, Berkeley, USA
Inorganic and solid state chemistry

Professor Tomonobu Nakayama
Deputy Director, Administrative Director,
Group Leader of WPI-MANA
Deputy Director of ICYS
Professor at the University of Tsukuba
National Institute for Materials Science | NIMS
International Center for Materials
Nanoarchitectonics (MANA)
University of Tsukuba, Japan
Surface science and nanotechnology

Professor Daniel Nocera
Patterson Rockwood Professor of Energy
Harvard University, USA
Catalysis and energy

Professor Teri Odom
Associate Chair of the Department of
Chemistry
Charles E. and Emma H. Morrison Professor
Northwestern University, IL, USA
Designing structured nanoscale materials with
exceptional properties

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Dean of Mathematical and Physical Sciences
Faculty
University College London, UK
Nanostructured, organic, magnetic, and
superconducting materials

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Director, Institute of Applied Physics
Head of Department, Institute of
Nanotechnology
Karlsruhe Institute of Technology
Institute of Applied Physics and Institute of
Nanotechnology
Germany
Scanning probe microscopy and
nanolithography

Professor Michelle Simmons
Director, Australian Research Council Centre
of Excellence for Quantum Computation and
Communication Technology
Laureate Fellow
Scientia Professor of Physics
University of New South Wales, Australia
Quantum physics

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Professor of Chemistry, University of
Queensland
Deputy Director and co-founder,
Australian Institute for Bioengineering and
Nanotechnology
University of Queensland, Australia
Nanoscience, nanotechnology, and molecular
diagnostics

Dr David Williams
Chief Research Scientist and Laboratory
Manager, Hitachi Cambridge Laboratory
University of Cambridge, United Kingdom
Nano engineered electronic devices

SCIENCE EXECUTIVE

Associate Professor Nicola Gaston
Co-Director, MacDiarmid Institute
University of Auckland

Professor Justin Hodgkiss
Co-Director, MacDiarmid Institute
Victoria University of Wellington

Dr Franck Natali
Deputy Director Stakeholder Engagement
Victoria University of Wellington

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Deputy Director Commercialisation and
Industry Engagement
University of Auckland

Professor Penny Brothers*
Principal Investigator Representative
University of Auckland

Professor Simon Brown
Science Leader: Tomorrow's Electronic Devices
University of Canterbury

Dr Renee Goreham*
Associate Investigator Representative
Victoria University of Wellington

Professor Paul Kruger
Science Leader: Energy
University of Canterbury

Dr Jenny Malmström*
Associate Investigator Representative
University of Auckland

Dr Carla Meledandri
Principal Investigator Representative
University of Otago

Dr Natalie Plank
Principal Investigator Representative
Victoria University of Wellington

Erin Service
MESA Chairperson
Victoria University of Wellington

Professor Jadranka Travas-Sejdic*
Science Leader: Functional Nanostructures
University of Auckland

Professor Martin (Bill) Williams*
Science Leader: Functional Nanostructures
Massey University

Ex-Officio

Catherine Gibbs
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Victoria University of Wellington

Dr Gavin Clark*
Commercialisation Manager,
MacDiarmid Institute
Victoria University of Wellington

Sonia Hutton*
Administrator, MacDiarmid Institute
Minute-taker
Victoria University of Wellington

Carol Wheatley*
Administrator, MacDiarmid Institute
Minute-taker
Victoria University of Wellington

Vanessa Young
Strategic Engagement Manager,
MacDiarmid Institute
Victoria University of Wellington

*Partial year

MACDIARMID EMERGING SCIENTIST ASSOCIATION (MESA) 2018

Erin Service
Chair
PhD Student
Victoria University of Wellington

David Perl
Secretary and Centre Representative
PhD Student
Massey University

Dr Renee Goreham
Treasurer
Postdoctoral Fellow
Victoria University of Wellington

Tarek Kollmetz
Centre Representative
PhD Student
University of Auckland

Geoffry Laufersky
Centre Representative
PhD Student
Victoria University of Wellington

Alexandra McNeill
Centre Representative
PhD Student
University of Canterbury

Geoffrey Weal
Centre Representative
PhD Student
University of Otago

Shalini Divya
Social Media Representative
PhD Student
Victoria University of Wellington

PRINCIPAL INVESTIGATORS (35)

Maan Alkaisi
Martin Allen
Sally Brooker
Penny Brothers
Simon Brown
Alison Downard
Nicola Gaston
Keith Gordon
Michele Governale
Simon Granville*
Jonathan Halpert***
Pauline Harris**
Justin Hodgkiss
Derek Kawiti**
John Kennedy*
Paul Kruger
Eric Le Ru
Nigel Lucas*
Jenny Malmström*
Duncan McGillivray
Carla Meledandri
Thomas Nann
Franck Natali
Volker Nock*
Natalie Plank
Craig Rofe**
Ben Ruck
Cather Simpson
Shane Telfer
Jadranka Travas-Sejdic
Geoff Waterhouse
Grant Williams
Martin (Bill) Williams
Geoff Willmott
Ulrich Zuelicke

*Partial year – shift from Associate Investigator to Principal Investigator – October 2018
**Partial year – new Principal Investigator – October 2018
***Partial year – left MI mid-2018

STAKEHOLDER RELATIONS PARTNER IWI (1)

Diane Bradshaw*

*Partial year – October 2018

ASSOCIATE INVESTIGATORS (37)

Baptiste Auguie*
David Barker**
Saurabh Bose**
Margaret Brimble
Philip Brydon*
Chris Bumby
Damian Carder
Shen Chong
Matthew Cowan**
James Crowley*
Michelle Dickinson***
Renwick Dobson**
Laura Domigan*
Guy Dubuis*
Christopher Fitchett*
Robin Fulton**
Petrik Galvosas
Anna Garden
Vladimir Golovko
Renee Goreham**
Shaun Hendy
Bridget Ingham
Geoff Jameson
Erin Leitao*
Jerome Leveneur
Ben Mallett*
Aaron Marshall*
Michel Nieuwoudt*
Emilia Nowak**
Elke Pahl*
Viji Saronjini**
Tilo Söhnel**
James Storey
Charles Unsworth*
Mark Waterland
Catherine Whitby
Stuart Wimbush

*New Associate Investigator – Jan 2018
**Partial year – new Associate Investigator – July 2018
*** Partial year – left March 2018

EMERITUS INVESTIGATORS (20)

Richard Blaikie
Ian Brown
Bob Buckley
Sally Davenport
John Evans
Juliet Gerrard*
Simon Hall
Jim Johnston
Alan Kaiser
Tim Kemmitt
Ken MacKenzie
Andreas Markwitz*
Kate McGrath
Jim Metson
Roger Reeves*
Mike Reid
Jeff Tallon
Richard Tilley
Joe Trodahl*
David Williams*

*Partial year - shift from Principal Investigator – October 2018

PROFESSIONAL STAFF

Catherine Gibbs
Centre Manager, MacDiarmid Institute
Victoria University of Wellington

Dr Gavin Clark*
Commercialisation Manager
Victoria University of Wellington

Genevieve Fitzjames*
Administrator, MacDiarmid Institute
University of Auckland

Alice Girton*
Administrator, MacDiarmid Institute
Victoria University of Wellington

Sonia Hutton*
Administrator, MacDiarmid Institute
Victoria University of Wellington

Gary Turner
Research Engineer
University of Canterbury

Carol Wheatley*
Administrator, MacDiarmid Institute
Victoria University of Wellington

Vanessa Young
Strategic Engagement Manager, MacDiarmid Institute
Victoria University of Wellington

*Partial year

MI STUDENTS IN 2018 (239)

MSc (11)

Djorovic	Aleksa	Victoria University of Wellington
Dobhal	Garima	Victoria University of Wellington
Matthews	Campbell	Victoria University of Wellington
Owen	Jessie	Massey University
Parke	Liam	University of Otago
Pike	Matthew	University of Canterbury
Robins	Allyn Mitran	University of Otago
Rov	Rosanna	University of Auckland
Singh	Arnold	University of Auckland
Thomas	Annabella	University of Canterbury
Van Hilst	Quinn Vernon Charles	University of Otago

PhD (228)

Abd Wahid	Nor Azila	University of Canterbury
Abudayyeh	Abdullah	University of Otago
Akers	Peter	University of Auckland
Akogun	Fola	University of Otago
Alkas	Adil	Massey University
Altenhuber	Nicola	University of Canterbury
Anand	Aljo	University of Auckland
Anil	Anusree	University of Auckland
Arshad	Faiza	University of Otago
Ashforth	Simon	University of Auckland
Auer	Bernhard Stephan	Massey University
Ayed	Zeineb	Victoria University of Wellington
Ayupova	Deanna	Victoria University of Wellington
Baek	Paul	University of Auckland
Baldhoff	Tobias	University of Canterbury
Bandara	Nisansala	Massey University
Barnsley	Jonathan	University of Otago
Bason	Nic	University of Canterbury
Bernach	Michal	University of Canterbury
Bhatia	Rishabh	Victoria University of Wellington
Bhugra	Vaibhav	Victoria University of Wellington
Bioletti	Gabriel	Victoria University of Wellington
Bodman	Samantha	University of Canterbury
Bondi	Luca	University of Otago
Borah	Rohan	Victoria University of Wellington
Brooke	Sam	Massey University
Broom	Matheu	University of Auckland
Browning	Leo Anthony	Victoria University of Wellington
Burke-Govey	Conor	Victoria University of Wellington
Canever	Nicolo	Victoria University of Wellington
Carroll	Liam	University of Canterbury
Casey-Stevens	Caitlin	University of Otago
Castillo	Kristel	University of Auckland
Chan	Andrew	University of Auckland
Chan	Jay	Victoria University of Wellington
Chandrabose	Sreelakshmi	Victoria University of Wellington
Cheema	Jamal	University of Auckland
Chen	Xiaohan	Victoria University of Wellington
Chen	Linda	University of Canterbury
Christopher	Tim	University of Auckland
Cink	Ruth	University of Auckland
Cleland	Josiah	Massey University
Clyde	Daniel	University of Auckland
Conroy	Francesca	University of Auckland
Cornelio	Joel	Massey University
Crump	Wayne	Victoria University of Wellington
Cryer	Matthew	Victoria University of Wellington

Darbi	Nur Maizura Mohd	University of Auckland
Divya	Shalini	Victoria University of Wellington
Dong	Yusong	University of Auckland
Dosado	Aubrey	University of Auckland
Emeny	Chrissy	University of Canterbury
Fadakar	Farzaneh	Victoria University of Wellington
Findlay	James Alan	University of Otago
Fisher	Ewan	University of Auckland
Francis	Adam	Victoria University of Wellington
Franke	Christine	University of Canterbury
Galli	Eduardo	University of Canterbury
Gangotra	Ankita	University of Auckland
Gilmour	James	University of Auckland
Goodacre	Dana	University of Auckland
Guehne	Robin	Victoria University of Wellington
Guo	Lun	University of Auckland
Hackett	Alissa	University of Auckland
Hall	Thomas	University of Otago
Harvey-Reid	Nathan	University of Canterbury
Hashemi	Azadeh	University of Canterbury
Hedley	Gavin Smethurst	University of Canterbury
Hensley	Noah	University of Otago
Hermanspahn	Lily	University of Canterbury
Hernandez	Pablo	Massey University
Hindcapie Florez	Edison	Massey University
Holmes-Hewett	Will	Victoria University of Wellington
Hong	Fan	University of Otago
Horocek-Glading	Miriana	University of Auckland
Hosking	Peter	University of Auckland
Hou	Caixia	University of Canterbury
Howard	Ben	University of Canterbury
Hsieh	Pei-Huan	University of Auckland
Hughson	Fraser	Victoria University of Wellington
Hyndman	Adam	University of Canterbury
Ilina	Aleksandra	Victoria University of Wellington
Irani	Amir	Massey University
Itumoh	Emeka	University of Auckland
Kanyan	Deepika	University of Auckland
Karabulut	Fabrice	University of Otago
Kavuri	Hima	University of Auckland
Khadka	Roshan	University of Auckland
Khalil	Bushra Anam	University of Auckland
Khan	Wasim	University of Canterbury
Kihara	Shinji	University of Auckland
Kim	Taeyang	University of Otago
Kleinjan	Carline	University of Canterbury
Kollmetz	Tarek	University of Auckland
Kotulla	Markus	Victoria University of Wellington
Kumar	Vipin	University of Auckland
Kurian	Mima	Victoria University of Wellington
Lacalendola	Nicola	University of Auckland
Landon-Lane	Leatham	University of Canterbury
Latif	Qaisar	University of Auckland
Laufersky	Geoffry	Victoria University of Wellington
Le Ster	Maxime	University of Canterbury
Lee	Subo	Massey University
Li	Si	University of Auckland
Loho	Thomas	University of Auckland
Lolohea	Taniela	University of Auckland
Lu	Ziqi	University of Auckland
McNicoll	Campbell	Callaghan Innovation/University of Canterbury
McNeill	Alexandra	University of Canterbury
Maddah	Mohsen	Victoria University of Wellington

Maity	Tanmay	Victoria University of Wellington
Majic	Matt	Victoria University of Wellington
Makinde	Zainab	University of Auckland
Mallinson	Joshua	University of Canterbury
Malthus	Stuart J	University of Otago
Manuguri	Sesha	University of Auckland
Mapley	Joseph	University of Otago
Masouleh	Farzaneh	Victoria University of Wellington
Mautner	Ira Nathan	University of Auckland
Meffan	Claude	University of Canterbury
Metin	Danielle	University of Auckland
Menke	Henri	University of Otago
Miller	Jackson	Victoria University of Wellington
Minnee	Thomas	Victoria University of Wellington
Miskell	Georgia	University of Auckland
Mohandas	Nimisha	Massey University
Monteiro	Isabela	University of Auckland
Moteshakeri	Mahsa	University of Auckland
Munro	Ben	Massey University
Murugathas	Thanihaichelvan	Victoria University of Wellington
Nalumaga	Hellen	Victoria University of Wellington
Narasimhan	Badri Narayanan	University of Auckland
Neiman	Alex	University of Canterbury
Nesbitt	Sam	University of Canterbury
Nguyen	Hong Phan	Victoria University of Wellington
Nott	Thomas Stuart William	Victoria University of Wellington
Novikova	Nina	University of Auckland
Onal	Sevgi	University of Canterbury
Onyema	Chikwzie	University of Canterbury
Orcheston-Findlay	Louise	University of Canterbury
Ortega	Kenneth	University of Otago
Pandian	Santhosh Kumar	University of Auckland
Patel	Sneh	University of Auckland
Perl	David	Massey University
Pradhan	Susav	Massey University
Prasad	Shyamal	Victoria University of Wellington
Pugliese	Silvina	Victoria University of Wellington
Rabanzo-Castillo	Kristel Mae	University of Auckland
Rajchakit	Urawadee	University of Auckland
Ramamirtham	Sashikumar	Massey University
Rani	Aakanksha	University of Auckland
Raos	Brad	University of Auckland
Reis	Miguel	University of Canterbury
Ridings	Kannan	University of Auckland
Ross	Daniel Arthur Winston	University of Otago
Ruffman	Charlie	University of Otago
Safaei	Sina	University of Auckland
Salehitaleghani	Sara	University of Canterbury
Sarwar	Mian Makhdoom	University of Otago
Savoie	Maxime	University of Canterbury
Schuyt	Joseph	Victoria University of Wellington
Scott	Jonty	University of Canterbury
Schroeder	Kathryn	Victoria University of Wellington
Sen	Anindita	Victoria University of Wellington
Service	Erin	Victoria University of Wellington
Sester	Clement	Victoria University of Wellington
Shaib	Ali	Victoria University of Wellington
Sharma	Shailendra	University of Canterbury
Shashidar	Vinay	University of Auckland
Sheikholeslami	Sina	University of Auckland
Shilito	Georgina	University of Otago
Shirai	Shota	University of Canterbury
Shojaei	Maryam	University of Canterbury

Singh	Sandhya	University of Otago
Smith	Jordan	University of Otago
Smith	Alexander	University of Auckland
Smits	Odile	Massey University
Spasovski	Martin	University of Auckland
Staniland	Robert	University of Canterbury
Sultana	Nishat	University of Auckland
Sun	Yiling	University of Canterbury
Sundaresan	Sriram	University of Otago
Suschke	Konrad	Victoria University of Wellington
Sutton	Joshua	University of Otago
Taheri Qazvini	Omid	Massey University
Tailby	Jonathan	Victoria University of Wellington
Taleshiahangari	Hani	University of Canterbury
Tamming	Ronnie	Victoria University of Wellington
Tang	Chhayly	Victoria University of Wellington
Tayagui	Ayelen	University of Canterbury
Tesana	Siriluck	University of Canterbury
Thorn	Karen	Victoria University of Wellington
Ting	Sheng Hao	University of Auckland
Tino	Alex	University of Otago
Tollemache	Cherie	University of Auckland
Tran	Loc	Victoria University of Wellington
Uhrig	David	Robinson Research Institute
Ullstad	Felicia	Victoria University of Wellington
Vadakkedath	Praveen George	University of Auckland
Vargas	Matheus	University of Auckland
Vasdev	Roan Alexander Singh	University of Otago
Vashishtha	Parth	Victoria University of Wellington
Vella	Joe	University of Auckland
Vyborna	Natalija	University of Auckland
Wagner	Isabella	Victoria University of Wellington
Wan	Ziyao	University of Auckland
Wang	Jie	Victoria University of Wellington
Wang	Min	University of Auckland
Wang	Qing	University of Auckland
Wang	Xindi	University of Auckland
Wang	Yi	University of Auckland
Watkin	Serena	University of Canterbury
Weal	Geoffrey	University of Otago
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Wildervanck	Martijn Jo	University of Auckland
Wilson	Ben	University of Canterbury
Wong	Jin Xiang	Massey University
Wu	Ting	University of Canterbury
Xu	Guangyuan	University of Auckland
Xu	Xiaoyi	University of Auckland
Yang	Mingrui	Massey University
Ye	Liu	Victoria University of Wellington
Ye	Piao	University of Auckland
Zhang	Karl	University of Auckland
Zhang	Peikai	University of Auckland
Zhang	Yao	Victoria University of Wellington
Zhoiu	Huihua	University of Auckland

MI POSTDOCTORAL RESEARCHERS & RAS IN 2018 (58)

Post Docs (47)

Akbarinejad	Alireza	University of Auckland
Acharya	Susant	University of Canterbury
Aydemir	Nihan	University of Auckland
Baek	Paul	University of Auckland
Chan	Jay	Victoria University of Wellington
Chen	Kai	Victoria University of Wellington
Clements	John	Massey University
Cornuault	Valerie	Massey University
Cotton	Gemma	University of Otago
De Zoysa	Gayan heruka	University of Auckland
Dolamore	Fabian	University of Canterbury
Falconer	Jonathan	University of Otago
Feltham	Humphrey	University of Otago
Ghaus	Zahraa Al	University of Auckland
Goreham	Renee	Victoria University of Wellington
Grand	Johan	Victoria University of Wellington
Healy	Colm	University of Canterbury
Hume	Paul	Victoria University of Wellington
Kammermeier	Michael	Victoria University of Wellington
Kaur	Manmeet	University of Auckland
Maerkl	Tobias	University of Canterbury
Martinez Gazoni	Rodrigo	University of Canterbury
Menges	Julian	University of Canterbury
Meyer	Matthias	Victoria University of Wellington
Miller	Sara	University of Otago
Miskell	Georgia	University of Auckland
Monahan	Nicholas	Victoria University of Wellington
Patil	Komal	University of Canterbury
Price	Mike	Victoria University of Wellington
Raudsepp	Allan	Massey University
Rodriguez Jimenez	Santiago	University of Otago
Rodriguez-Otazo	Mariela	Massey University
Scott	Hayley	University of Canterbury
Seal	Christopher	University of Auckland
Shahlori	Rayomand	University of Auckland
Soffe	Rebecca	University of Canterbury
Somerville	Walter	Victoria University of Wellington
Steenbergen	Krista	Victoria University of Wellington
Sun-Waterhouse	Dongxiao	University of Auckland
Ullah	Rifat	Victoria University of Wellington
Van der Heijden	Nadine	University of Auckland
Voorhaar	Lenny	University of Auckland
Ward	Rob	Massey University
Weissert	Lena	University of Auckland
Wells	Frederick	University of Auckland
Yin	Hang	Massey University
Zhou	Tian-You	Massey University

RAs (11)

Aguergaray	Claude	University of Auckland
Arul	Rakesh	University of Auckland
Bose	Saurabh	University of Canterbury
Chen	Wan-Ting	University of Auckland
Findlay	James Alan	University of Otago
Hashemi	Azadeh	University of Canterbury
Nam	Seong	University of Auckland
Preston	Daniel	University of Otago
Raos	Brad	University of Auckland
Schebarchov	Dmitri	Victoria University of Wellington
Tay	Aaron	University of Auckland

JOURNALS

AUTHORS	TITLE	JOURNAL
de la Torre Gomez, C., **Goreham, R.V**., Bech Serra, J.J., **Nann, T.**, Kussmann, M.	"Exosomics"-A review of biophysics, biology and biochemistry of exosomes with a focus on human breast milk	*Frontiers in Genetics* **9**, 92 (2018)
Movassaghi, S., Singh, S., Mansur, A., Tong, K.K.H., Hanif, M., Holtkamp, H.U., **Söhnel, T.**, Jamieson, S.M.F., Hartinger, C.G.	(Pyridin-2-yl)-NHC organoruthenium complexes: antiproliferative properties and reactivity toward biomolecules	*Organometallics* **37**, 1575-1584 (2018)
Heikal, A., Nakatani, Y., Jiao, W., Wilson, C., Rennison, D., Weimar, M.R., Parker, E.J., **Brimble, M.A.**, Cook, G.M.	'Tethering' fragment-based drug discovery to identify inhibitors of the essential respiratory membrane protein type II NADH dehydrogenase	*Bioorganic and Medicinal Chemistry Letters* **28**, 2239-2243 (2018)
North, R.A., Horne, C.R., Davies, J.S., Remus, D.M., Muscroft-Taylor, A.C., Goyal, P., Wahlgren, W.Y., Ramaswamy, S., Friemann, R., **Dobson, R.C.J.**	"Just a spoonful of sugar..": import of sialic acid across bacterial cell membranes	*Biophysical Reviews* **10**, 219-227 (2018)
Fiedler, H., Gupta, P., **Kennedy, J.**, **Markwitz, A.**	28Si+ ion beams from Penning ion source based implanter systems for near-surface isotopic purification of silicon	*Review of Scientific Instruments* **89**, 123305 (2018)
Yasin, M.N., Brooke, R.K., Rudd, S., Chan, A., Chen, W-T., **Waterhouse, G.I.N**., Evans, D., Rupenthal, I.D., Svirskis, D.	3-Dimensionally ordered macroporous PEDOT ion-exchange resins prepared by vapor phase polymerization for triggered drug delivery: Fabrication and characterization	*Electrochimica Acta* **269**, 560-570 (2018)
Foglizzo, M., Middleton, A.J., Burgess, A.E., Crowther, J.M., **Dobson, R.C.J.**, Murphy, J.M., Day, C.L., Mace, P.D.	A bidentate Polycomb Repressive-Deubiquitinase complex is required for efficient activity on nucleosomes	*Nature Communications* **9**, 3932 (2018)
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Fahey, L.M., **Nieuwoudt, M.K.**, Harris, P.J.	Using near infrared spectroscopy to predict the lignin content and monosaccharide compositions of Pinus radiata wood cell walls	*International Journal of Biological Macromolecules* **113**, 507-514 (2018)
Archer, R.J., Scott, H.S., Polson, M.I.J., Williamson, B.E., Mathoniere, C., Rouzieres, M., Clérac, R., **Kruger, P.E.**	Varied spin crossover behaviour in a family of dinuclear Fe(ii) triple helicate complexes	*Dalton Transactions* **47**, 7965-7974 (2018)
Xie, H., Dong, J., Duan, J., **Waterhouse, G.I.N.**, Hou, J., Ai, S.	Visual and ratiometric fluorescence detection of Hg2+based on a dual-emission carbon dots-gold nanoclusters nanohybrid	*Sensors and Actuators, B: Chemical* **259**, 1082-1089 (2018)
Barnsley, J.E., Shillito, G.E., Mapley, J.I., Larsen, C.B., **Lucas, N.T.**, **Gordon, K.C.**	Walking the Emission Tightrope: Spectral and Computational Analysis of Some Dual-Emitting Benzothiadiazole Donor-Acceptor Dyes	*Journal of Physical Chemistry A* **122**, 7991-8006 (2018)
Kaviyarasu, K., Mola, G.T., Oseni, S.O., Kanimozhi, K., Maria Magdalane, C., **Kennedy, J.**, Maaza, M.	ZnO doped single wall carbon nanotube as an active medium for gas sensor and solar absorber	*Journal of Materials Science: Materials in Electronics,* (2018)

CHAPTERS

AUTHORS	CHAPTER TITLE	BOOK TITLE
Glossop, H.D., Pearl, E., De Zoysa, G.H., **Sarojini, V.**	Linear Analogues of the Lipopeptide Battacin With Potent In Vitro Activity Against S. aureus	*Advances in Protein Chemistry and Structural Biology* **112**, 385-394 (2018)
Gangotra, A., **Wilmott, G.R.**	Comprehensive Nanoscience and Nanotechnology (Second Edition)	*Cellular and Sub-Cellular Mechanics: Measurement of Material Properties* **3**, 227-244 (2018)
Hackett, A.J., Strover, L.T., Baek, P., **Malmström, J.**, **Travas-Sejdic, J.**	Polymer-Grafted Conjugated polymers as Functional Biointerfaces	*Conjugated Polymers for Biological and Biomedical Applications,* (2018)
Kowalczyk, R., Kaur, H., Fairbanks, A.J., **Brimble, M.A.**	Synthesis of N-Linked Glycopeptides Using Convergent Enzymatic Glycosylation Combined with SPPS	*Coupling and Decoupling of Diverse Molecular Units in Glycosciences,* 1-36 (2018)
Amalthas, A. P., **Alkaisi, M. M.**	Nanopyramid Structures with Light Harvesting and Self- Cleaning Properties for Solar Cells	*Emerging Solar Energy Materials* **2**, 25-44 (2018)
Williams, M.A.K., **Whitby, C.P**, Pradhan, S.	Applications of microrheology in food systems	*Encyclopedia of Food Chemistry,* 130-133 (2018)
Kerr-Phillips, T., **Travas-Sejdic, J.**	Electrospun Conducting Polymer Materials	*Encyclopedia of Polymer Applications,* (2018)
Amalathas, A. P., **Alkaisi, M. M.**	Fabrication and Replication of Periodic Nanopyramid Structures by Laser Interference Lithography and UV Nanoimprint Lithography for Solar Cells Applications	*Micro/Nanolithography* **2**, 13-41 (2018)
Mallett B. P. P, Marsik, P., Khmaladze, J., Minola, M., **Simpson, M.C**, Bernhard, C.	Superconductor sandwiches: strongly interacting states in thin-film multilayers.	*Our Changing World in the South Pacific: Australasian and German Perspectives,* 83-88 (2018)

CONFERENCE PAPERS

AUTHORS	PAPER TITLE	TITLE OF PROCEEDINGS
Sun, Y., Tayagui, A., Shearer, H., Garrill, A., **Nock, V.**	*A microfluidic platform with integrated sensing pillars for protrusive force measurements on neurospora crassa*	Proceedings of the IEEE International Conference on Micro Electro Mechanical Systems (MEMS) (2018)
Aref, S., Friggens, D., **Hendy, S.**	*Analysing scientific collaborations of New Zealand institutions using scopus bibliometric data*	ACM International Conference Proceeding Series (2018)
Risos, A., Broderick, N.G.R., **Williams, D.E.**, **Simpson, M.C.**	*Critical setup parameter for ultrafast whitelight coherent antistokes raman scattering spectroscopy of living plankton in sea water*	Proceedings of SPIE - The International Society for Optical Engineering (2018)
Prabowo, S., **Bumby, C.**, Monaghan, B., Del Puerto, D., Ryan, M., Longbottom, R.	*Design and Commissioning of an Experimental Fluidized Bed Reactor for the Hydrogen Reduction of Titanomagnetite Ironsand*	Proceedings of the 8th international congress on the science and technology of ironmaking (2018)
Moghaddam, S.M., Piraghaj, S.F., O'Sullivan, M., Walker, C., **Unsworth, C.P.**	*Energy-efficient and SLA-aware Virtual Machine Selection Algorithm for Dynamic Resource Allocation in Cloud Data Centers*	11th IEEE/ACM Conference on Utility and Cloud Computing (2018)
Amalathas, A.P., **Alkaisi, M.M.**	*Enhancing the performance of solar cells with inverted nanopyramid structures fabricated by UV nanoimprint lithography*	2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC) (2018)
Mehta, M., **Waterland, M.R.**	*Highly sensitive surface-enhanced Raman scattering detection of brodifacoum and 1080 rodenticide in milk*	Proceedings of SPIE - The International Society for Optical Engineering (2018)
McIntosh, G.J., Wijayaratne, H., Agbenyegah, G.E.K., Hyland, M.M., **Metson, J.B.**	*Impacts of sodium on alumina quality and consequences for current efficiency*	Minerals, Metals and Materials Series (2018)
Sturov, E., **Bumby, C.W.**, Rayudu, R., Badcock, R.A.	*Influence of fluid selection on synchronous generators power output in compressed air energy storage systems*	2017 IEEE Innovative Smart Grid Technologies - Asia: Smart Grid for Smart Community
Panya Panya, S.N., Galmed, A.H., Maaza, M., Mothudi, B.M., Harith, M.A., **Kennedy, J.**	*Laser-Induced Breakdown Spectroscopy (LIBS) on Geological Samples: Compositional Differentiation*	MRS Advances (2018)
Hassan Sk, M., Abdullah, A.M., Ryan, M.P., Ko, M., **Williams, D.E.**, Laycock, N., **Ingham, B.**	*Mo-mediated corrosion behaviour of 1 Cr - Carbon steel in sweet medium under hydrodynamic control*	NACE - International Corrosion Conference Series (2018)
Makin, R.A., York, K., Senabulya, N., Mathis, J., Clarke, R., Feldberg, N., Miska, P., Jones, C.M., Williams, L., Kioupakis, E., **Reeves, R**., Durbin, S.M.	*Order Parameter and Band Gap of ZnSnN2*	7th IEEE World Conference on Photovoltaic Energy Conversion (2018)
Bjareborn, O., **Bumby, C**., Ryan, M., Longbottom, R., Mongagan, B.	*Phase Development of Titanomagnetite Ironsand During Oxidizing Conditions.*	Proceedings of the 8th international congress on the science and technology of ironmaking (2018)
Khadka, R., Zondaka, Z., **Travas-Sejdic, J.**, Tamm, T., Kiefer, R.	*Polypyrrole with polyethylene oxide: Linear actuation in organic and aqueous electrolytes*	Proceedings of SPIE - The International Society for Optical Engineering (2018)
Sturov, E., **Bumby, C.W**., Rayudu, R., Badcock, R.A.	*Rapid synchronisation procedure for a pneumo-hydraulically driven synchronous generator*	2017 IEEE Innovative Smart Grid Technologies - Asia: Smart Grid for Smart Community
Zhang, A., Nusheh, M., Longbottom, R., **Bumby, C.**, Monaghan, B.	*Reduction of Titanohematite Pellets by Hydrogen Gas*	Proceedings of the 8th international congress on the science and technology of ironmaking (2018)
Mallett, B.P.P., Marsik, P., Khmaladze, J., Arul, R., **Simpson, M.C.**, Bernhard, C.	*Superconductor sandwiches: Cuprate-manganite multilayers with a remarkable new ground state*	Proceedings of SPIE - The International Society for Optical Engineering (2018)

MacDiarmid Institute
Annual Report
2018

KEYNOTE & INVITED SPEAKER ADDRESSES

NAME	DETAILS
Margaret Brimble	Keynote talk at 24th Royal Australian Chemical Institute Organic Division Conference. 2-6 December 2018, Perth, Australia
	Keynote talk at 8th Peptide Engineering Meeting. 8-10 November 2018, Berlin, Germany
	Andrews Lectureship. 2018, Sydney
	Keynote talk at XVIII Edition of the Ischia Advanced School of Organic Chemistry. 22-25 September 2018, Naples, Italy
	Keynote talk at XXXVIII Convegno Nazionale della Divisione di Chimica Organica 9-13 September 2018, Milan, Italy
	Keynote talk at Royal Society of Chemistry Chemical Biology Meets Drug Discovery Symposium. 6 September 2018, Stevenage, United Kingdom
	Keynote talk at 8th International Meeting on Antimicrobial Peptides. 2-4 September 2018, Edinburgh, United Kingdom
	Keynote talk at 29th International Carbohydrate Symposium. 15-19 July 2018, Lisbon, Portugal
	Keynote talk at Royal Society of Chemistry Organic and Biomolecular Chemistry Symposium, 7 June 2018, Shanghai, China
Sally Brooker	Keynote talk at MacDiarmid Session of the Pacific Climate Change Conference. 21-23 February 2018, Te Papa, Wellington
	Keynote talk at 10th International Symposium on Nano & Supramolecular Chemistry. 9-12 July 2018, Dresden, Germany
	Invited department and 3MET seminar. 6 July 2018, Karlsruhe Institute of Technology, Germany
	Invited Francis Lions Memorial Lecture. 10 October 2018, Sydney, Australia
Penny Brothers	Invited speaker at Women in Science conference. 9-11 December 2018, Erlangen, Germany
	Keynote talk at 1st international Akamptisomerism Symposium. 24-26 October 2018, Shanghai, China
	Keynote talk at Conference on New Advances in the Chemistry of Porphyrinoids. 28-30 June 2018, Warsaw, Poland
James Crowley	Keynote talk at 43rd International Conference on Coordination Chemistry. 30 July – 4 August 2018, Sendai, Japan
Petrik Galvosas	Keynote talk at the 7th Pacific Rim Conference on Rheology. 10-15 June 2018, Jeju, Korea
	Invited speaker at MRFood2018. 17-21 September 2018, Rennes, France
Nicola Gaston	Invited speaker at the 42nd Condensed Matter and Materials Meeting, 30 January – 2 February 2018, Wagga Wagga, Australia
Juliet Gerrard	Keynote talk at Lorne Protein Engineering Satellite. 9 February 2018, Melbourne, Australia
Keith Gordon	Invited speaker at the Australasian Community for Advanced Organic Semiconductors (AUCAOS) Symposium. 3-5 December 2018, Hahndorf, South Australia
	Keynote speaker at the WITEC Raman Imaging Conference & Symposium. 24-26 September 2018, Ulm, Germany
	Keynote speaker at the 26th International Conference on Raman Spectroscopy (ICORS 2018). 26-31 August 2018, Jeju, Korea
	Invited speaker at the Riddet Institute Conference 2018. 10-12 July 2018, InterContinental Hotel, Wellington
	Invited speaker at Pittcon, 26 February-1 March 2018, Orange County Convention Center, West Building, Orlando, Florida
Shaun Hendy	Keynote talk at GOVIS, 21-22 June 2018, Wellington
Justin Hodgkiss	Keynote talk at APEC Symposium on Material Technologies. 3 February 2018, Sydney, Australia
	Keynote talk at University of Canterbury, School of Physical and Chemical Science Postgraduate student research showcase, 26 November 2018, Christchurch

NAME	DETAILS
John Kennedy	Keynote talk at 3rd International Conference on Precision Machinery and Manufacturing Technology, 4-8 February 2018, Auckland
Aaron Marshall	Invited speaker at APEnergy2018, 17-21 July 2018, Singapore
	Invited speaker at International Symposium on Electrocatalysis. 28 August-1 September 2018, Szczyrk, Poland
Jim Metson	Keynote speaker at AUPEC international power engineering conference. 27-30 November 2018, Auckland
	Keynote talk at Global Federation of Competitiveness Councils Annual Meeting & Innovation Summit. 18-20 September 2018, Buenos Aires, Argentina
	Keynote talk at TMS Annual Meeting. 11-15 March 2018, Phoenix, Arizona, USA
James Storey	Keynote talk at CIMTEC 8th Forum on New Materials. 10-14 June 2018, Perugia, Italy
Jeff Tallon	Keynote talk at Kyoto/Victoria University Joint Symposium. 19-20 March 2018, Kyoto, Japan
	Keynote talk at COSAC University Queensland. 26-29 March 2018, Brisbane, Australia
	Keynote talk at CIMTEC. 10-15 June 2018, Perugia, Italy
	Keynote talk at Ceramics for Energy Conversion. 19-24 July 2018, Singapore
	Keynote talk at M2S Material and Mechanisms of Superconductivity. 19-24 August 2018, Beijing, China
Shane Telfer	Keynote talk at Materials Design Strategies for Advanced Functions Symposium. 4 July 2018, Ulsan, Korea
Richard Tilley	Keynote talk at 6th International Solvothermal Hydrothermal Associate Conference, 8 August 2018, Japan
Jadranka Travas-Sejdic	Keynote talk at Australia and New Zealand Nano and Microfluidics (ANZNMF). 27-29 June 2018, Auckland
	Invited speaker at The World Polymer Congress MACRO18. 1-5 July 2018, Cairns, Australia
	Invited speaker at Polymers in Medicine and Biology. 9-12 September 2018, Napa, California, USA
David Williams	Keynote talk at Electrochem 2018. 16-18 September 2018, Lancaster, United Kingdom
Uli Zuelicke	Keynote talk at Kavli ITS-APW-Tsinghua-RIKEN Workshop on Highlights of Condensed Matter Physics. 1-3 November 2018, Beijing, China
	Keynote talk at 4th International Conference on 2D Materials and Technologies. 10-13 December 2018, Melbourne, Australia

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