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Board chair’s report
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2020 was an extraordinarily challenging year worldwide. It came as no surprise to us as directors of the Institute to find that in the midst of all of this, the community that the MacDiarmid Institute has become is an amazing resource and support network.

The plans of many of our people were turned upside down. Over half of the PhD students we fund would ordinarily head offshore for a period after graduation, often for postdoctoral research. As international opportunities disappeared, we re-prioritised funding to create a range of internships and research associate positions for our fresh PhD graduates, often in industry-facing roles, in international collaborations, or new interdisciplinary projects that continue to hone the skills of Aotearoa New Zealand’s future R&D leaders.

We offered 3-month scholarship extensions to over 60 PhD students as soon as the first lockdowns struck. As Aotearoa New Zealand moved out of lockdown, those students enthusiastically resumed their research knowing that they would have time to do the work that they spent the lockdown planning.

It will be talented and motivated people like these who will help Aotearoa New Zealand to rebuild and reshape a sustainable, inclusive, high-wage, zero-carbon economy in a post-Covid world. In 2020, more than ever, we were grateful to be able to invest in such people.

Our engagement plans were also quickly redeveloped in 2020, to address emerging needs. From our public lectures, to new podcasts and animations, to industry engagement – moving these conversations into the digital world has allowed us to strengthen our partnerships with stakeholders, as you will see throughout this report.

We were thrilled to be awarded funding to continue as a CoRE for 2021–2028. Our proposal addresses some of Aotearoa New Zealand’s most significant emerging challenges, and was built on energy and ideas contributed from all parts of the Institute. We are excited to be given the opportunity to deliver on these plans in the coming years.

The Government’s decision to refund the Institute through to the end of 2028 recognises the Institute’s pedigree, international reputation and track record. Most importantly, the decision also recognises the Institute’s ambition and ability to continue delivering great outcomes for Aotearoa New Zealand’s future, a zero-carbon future with materials science playing a pivotal role.

On behalf of myself and the Board, I would like to extend sincere thanks to the entire MacDiarmid Institute family for all the hard work that has led to this outstanding result.

In particular, I wish to thank our Co-Directors and Deputy Directors for their leadership, and the management team for all their excellent work supporting the Institute.

I also want to acknowledge those who work alongside the Institute and who enable us to extend our reach in all that we do. Our partners at the university tech transfer offices, our commercial industry collaborators and our colleagues within the wider education and outreach sectors.

The stories within this report are testament to the powerful impacts made possible by working together. I hope you enjoy reading it.
Chapter 1.

TE MOANA NUI A KIWA
The arrival of Covid has had a significant impact on the tourism industry. As a result, many businesses have had to pivot and develop new business approaches.

Our Partner, Whakarewarewa Village, is developing new and innovative approaches in response to the new tourism environment. We've continued to work closely to develop an education exhibit that showcases the Village, aligns materials science analyses alongside Mātauranga Māori that explores the synergies of these two knowledge systems. Planning is already in place to share the research that's been conducted in the village openly in a variety of ways, including Wānanga, educational resources and other outreach through local schools.

Two joint research papers about the research and work conducted were accepted for the World Geothermal Congress planned to run in Reykjavik, Iceland, in 2020. The Congress has been postponed to 2021.

**Discovery Scholarships Programme**

Our inaugural Discovery Scholarship Programme for Māori and Pacific peoples in tertiary science launched in 2020. The programme is led by Principal Investigator, Dr Pauline Harris, Senior Lecturer at Victoria University of Wellington, and is based on research looking at the barriers to Māori and Pacific students entering and staying in science. 15 Scholarships were awarded, paying up to $8k fees and up to $5k cash award, and were advertised widely, with emails to key groups, both directly and through our partners, as well as through social media and campaigns.

There were four awards categories available for 2020:

- **Te Kainga Rua Award** - Second Chance Learner Award - This category is for mature students either returning to tertiary education after having some time away, or those that are undertaking tertiary courses for the first time.
- **Piki Ake Award** - Step It Up Award - This category is for students who are passionate about science but have found it challenging to achieve highly. The aim of this particular award is to help enthusiastic students reach their potential and step up into achieving.
- **Te Taumata Award** - High Achiever Award - This category is for students who have excelled in their studies (B+ average or higher) and are looking toward continuing their study in the field.
- **Te Mātauranga Pūtiaiko Award** - Māori Science Award - This category is for students who are studying Mātauranga Māori Science and are looking toward continuing their study in the field.

The Scholarships were hugely oversubscribed, showing the urgent need for this kind of support. The programme is being continued for 2021, with the addition of a new award for those who have previously received a Discovery Scholarship and wish to continue with their studies.

Mātauranga Māori has become imbedded within the research framework of the Institute. Led by Principal Investigator, Dr Pauline Harris, the research team includes Stakeholder Partner Iwi, Diane Bradshaw, and Principal Investigators, Derek Kawiti and Dr Craig Rofe. These researchers are working at the interface of multiple knowledge systems, bringing together Mātauranga Māori, Pūtiaiko Māori and Science.

"What's really important to us is the capacity and capability development of Māori and Pacific peoples in the sciences."

A key focus of the Institute’s Te Moana Nui a Kiwa work is the capacity and capability development of future Māori and Pacific scientists, supported by scholarships, internships, and more, creating a pathway to success for these future scholars.

"The goal I'm striving towards is to become a Kaitiaki o te Moana - a guardian of the sea. I wish to share with others how I view the ocean, to inspire people about the hidden wonders."

RACHEL GRANT
TE TAUMATA AWARD RECIPIENT
TOI OHOMAI INSTITUTE OF TECHNOLOGY

For left: Whakarewarewa project Research Assistants Ben Nielsen and Juliet Nelson at Te Papa, where they met with Head of Experience, Design and Content, Frith Williams.

Below: Rachel Grant out in the sea being a kaitiaki and developing her skills observing.
This research has geochemically fingerprinted these taonga, creating a digitised inventory of each item.

Below: Kawhia Museum Collections visit to GNS Science led by Kaumatua Rauanganga Mahara.

Below right: Istikolo Paasi works to evaluate geological and geochronological whakapapa and composition of stone artefacts from the Kawhia Museum.

Hangi stones research to continue

The research of former MacDiarmid Institute Principal Investigator, Dr Craig Rofe, (who in October took up a permanent Senior Māori advisory position within government) will continue, with plans for a summer RA to draw together his research on hangi stones and to develop this into resources for schools for the 2021 school year. Dr Rofe will remain with the MacDiarmid Institute as an Emeritus Investigator.

Te Ahi Tupua

Te Ahi Tupua, the largest 3D printed sculpture in the world, collaboratively designed by Principal Investigator, Derek Kawiti, and Māori Customary Artist, Tracy Ghirardone, of the New Zealand Māori Arts and Crafts Institute, was helicoptered into place inRotorua’s Hema Gorge this year.

Derek Kawiti is a Senior Lecturer in Architecture at Victoria University of Wellington. His research includes understanding the implications of digital technologies in the convergence with Indigenous traditional knowledge. With a background in advanced parametric design methods, he is heavily involved in generative digital modelling, digital heritage and ‘low and ‘high tech’ digital fabrication. He founded the collaborative research lab – SITUA (Site of Indigenous Technologies Understanding Alliance) with, including Ngā Tāmanuhi - of Murawai, Gisborne, and more recently with the New Zealand Māori Arts and Crafts Institute at Ta Puna, Rotorua. Left: Te Ahi Tupua, the largest 3D printed sculpture in the world.

Environmental monitoring and Maramataka

The environmental monitoring research of Dr Pauline Harris involves teaching people and communities how to monitor the environment and how to understand changes that may be occurring. The use changes relate to pollution, deforestation, changing temperatures and more. Working within the framework of the Maramataka system, this research investigates if changes are being observed in the environment and if so, why? The research reaches into communities to teach people how to reconnect with their environment so they can monitor changes themselves. Dr Harris is producing videos, running workshops and going into communities to work with people directly.

This research is being conducted in collaboration with the Society of Māori Astronomy Research and Traditions (SMART) that has some of the most knowledgeable Maramataka experts in Aotearoa New Zealand.

Summer studentships for our DiscoveryCamp and Discovery Scholarship Alumni

NAME OF STUDENT | PROJECT TITLE | SUPERVISOR
---|---|---
Juliet Nelson | Whakatiaowea project | Pauline Harme (VUW); Nicola Gaston (UnA)
Rachel Grant | Environmental monitoring and remediation | Pauline Harme (VUW)
Sydney Kots | Capturing Carbon Dioxide with Solvent Materials | Paul Kruger (UnA)
Renee Harris | Replicating Mycelial Networks to Study Mass Transport in Fungi and Cyanobacteria | Volker Riedel (UnA)
Leiana Talaki | The link to polyphosphate acid-soluble sponges | Erin Lastos (UnA)
Istikolo (Kai) Pears | Understanding the unique geological attributes and biological materials in Aotea-South Kawhia | Diane Bradshaw (GNS)
Ben Nicholson | Whakatiaowea Summer Project | Pauline Harme (VUW)
“A big highlight of our partnership for us is to be able to connect with the people of the village and experience their Matauranga, tikanga and te reo first hand.”
Whether it is catalysing the generation of clean fuels, cutting the energy cost of industrial processes, or understanding mechanical forces in biology, MacDiarmid Institute researchers are addressing important questions that impact our lives and our environment. This work is carried forward by people who bring their diverse backgrounds to collaborations spanning different disciplines.

Here, we introduce you to some of our people and their work.

Reducing the energy costs of gas separation

For Dr Matthew Cowan it’s all about working to make a difference for the environment. The MacDiarmid Institute Associate Investigator is developing technology he hopes will cut the amount of energy used to produce many common consumer products.

A senior lecturer in chemical and process engineering at the University of Canterbury, Dr Cowan is leading a project developing energy saving alternatives to the industrial gas separation and purification processes currently used to produce key raw materials used in plastics and chemicals.

The project received a $300,000 Marsden Fund Fast-Start grant in 2020 to explore creating the new membrane technology that could replace the current energy intensive distillation methods used to produce materials such as polyethylene and polypropylene.

Dr Cowan and his collaborators in Aotearoa New Zealand and internationally are examining ways to fabricate the metal-organic framework (MOF) membranes to be used in the process of gas separation.

“My whole idea behind these MOF membranes was to separate these gases without having to boil them and we should therefore be able to use much, much less energy to do that separation process,” he says.

Dr Cowan’s goal is to reduce the amount of energy we need to use every day to slow climate change and make lives richer.

“That’s why I got into this [research]. I wanted to make a difference for the environment and climate change.”

But he is also a passionate believer in “getting research to where people can use it. That is the whole point.”

He says some rough calculations suggest that globally the energy used separating these materials is between three and five times the amount of energy Aotearoa New Zealand uses every year.

“So I thought if we can save half that amount of energy then we can save an Aotearoa New Zealand’s worth of energy and the carbon emissions associated with that.”

The MOF membranes act like a molecular sieve. A pressure differential is created with high pressure on one side of the membrane and low pressure on the other and the gas flows from the high pressure area to the low pressure area.

The process can be used to separate ethylene from ethane or propylene from propane and that gas can then be purified. Current processes for gas separation are energy-intensive, complex and expensive.

He acknowledges the biggest challenge and the focus of the project is fabricating the membranes, but he says the research team has made some progress.

Dr Cowan is also pursuing other technological solutions to these energy intensive distillation processes.

He is collaborating with researchers in Texas, USA, on the potential of adsorbent materials for use in gas separation.

“They have sent us some materials to test including one last year, a completely new material made specifically for this project, that produced some exciting results.”

“Results from testing using this material featured on the covers and as a research articles in the International Edition of the prestigious scientific journal Angewandte Chemie and ChemSusChem.”

Dr Cowan sees this work as part of a possible suite of solutions to the issue of reducing energy use alongside MOF membranes.

To cap a busy year, Dr Cowan also presented at Parliament at the Speaker’s Science Forum which aims to present new research to MPs and decision-makers to inform the issues being addressed in Parliament.

“Amazing amounts of energy are hidden in the objects all around us.”

His presentation ‘Hidden Energy: Revolutionising hidden high-energy processes’ focused on his research around improving the methods and technologies we use to purify all the building blocks of society.

“The kai we eat is separated from the earth, the water we drink is purified of bacteria, and our cutlery is shaped from metal refined from ore. Amazing amounts of energy are hidden in the objects all around us.”

Dr Matthew Cowan assembling a call for testing the mixed-gas permeation of new membrane materials.
The warm up: probing the fundamentals of room temperature superconductivity

It’s arguably the ‘holy grail’ of solid-state physics - superconductors that operate at or near room temperature.

“It’s definitely the dream,” says Dr Shen Chong, Associate Investigator at the MacDiarmid Institute and Senior Scientist at the Robinson Research Institute.

“And whoever cracks it will surely get the Nobel Prize.”

Superconductors were first discovered by another Nobel winner, Dutch physicist Kamerlingh Onnes. In 1911 he cooled elemental mercury to very low temperatures and observed that the electrical resistance disappeared. That was at a frosty 4 K (−269 °C).

Since then, low-temperature superconductors, super-chilled with liquid helium, have come to be used to generate high-intensity magnetic fields for magnetic resonance imaging (MRI) scanners in hospitals, experimental nuclear fusion reactors and even the Large Hadron Collider.

“We are looking at ways to modify iron-based superconductors so that they can carry higher electrical currents,” says Dr Chong.

“Ultimately, it is about trying to increase the maximum magnetic field for superconducting magnets while ensuring that the cost is competitive.”

The applications of superconductors that most appeals to him are their use in medical imaging equipment that can ultimately save lives.

“The magnetic field in MRI machines is adequate at the moment, but to get the resolution you need to really look at the issue in detail and perform chemical analysis at the same time, you need a high magnetic field.”

More efficient superconductors able to operate at higher temperatures could reduce the cost and improve the availability of MRI scanners as well as nuclear magnetic resonance (NMR) instruments, which allow the molecular structure of materials to be analysed.

“If we can make wires out of this iron material, it could be cheaper and more efficient than existing high-temperature superconductors,” says Dr Chong, who has been with the Robinson Research Institute for nearly seven years and in 2016 received a Marsden Fund grant to pursue his research on iron-based wires.

Sensors and storage

Dr Chong and MacDiarmid Institute Principal Investigator, Professor Grant Williams, are also exploring using sensors to create magnetic and temperature maps to monitor the health of our power generation and distribution infrastructure.

The pair are seeking to test field-test prototypes that would take advantage of the magnetochromic effect and photoluminescence to spot fluctuations in magnetic fields and temperature variations that indicate equipment failure may be imminent.

“The sensors may be more accurate and safer to use than existing wired magnetic sensors and will be trialed with the Robinson Research Institute’s partners in the electricity sector.”

Yet another project Dr Chong is exploring first opened up in 2008, when iron-based materials were discovered to have superconductivity in ways that could give them advantages over conventional copper-oxide superconductors.

“Storing data in 3D composite sample.”

“We’re working towards the superconductors we’ll need for high-intensity magnetic fields applications.”

DR SHEN CHONG

High-temperature superconductors followed, allowing the temperature to rise to a relatively balmy 77 K (−240.2 °C) the boiling point of the liquid nitrogen (LN2) that keeps them cool. High-temperature superconductors increasingly show promise for real-world uses such as in motors and generators, power storage systems and even electricity lines.

In the labs at the Robinson Research Institute, scientists have developed and (with the company HTS.110 Ltd) commercialised a system for determining the characteristics of superconducting wires.

“What I’m trying to do is pursue new types of superconductors, understand how they work, and optimise their physical properties to make them cheaper.”

Yet in doing so, Dr Chong grapples every day with a troubling trade-off.

Iron as an alternative

With liquid helium selling for around $60 a litre and in increasingly short supply and materials in high-temperature superconductors too delicate for many applications, the effort to discover new superconductors that can operate at higher temperatures is intensifying.

One path Dr Chong is exploring first opened up in 2008, when iron-based materials were discovered to have superconductivity in ways that could give them advantages over conventional copper-oxide superconductors.

“We are looking at ways to modify iron-based superconductors so that they can carry higher electrical currents,” says Dr Chong.

“For now, the search for better superconductors continues.”

Says Dr Chong: “The great thing about being part of the MacDiarmid Institute is the physicists, molecular chemists and crystallographers I get to work with. It is these types of collaborations that will move us towards our goal.”
A year of disrupted travel plans hasn’t stopped PhD candidate and MacDiarmid Institute researcher, Stephanie Lambie, from successfully kick-starting a new collaboration with researchers at an Australian Centre of Excellence.

Lambie collaborated with MacDiarmid Institute Co-Director, Associate Professor Nicola Gaston, and Associate Investigator, Dr Krista Steenbergen, as well as Future Low Energy Electronics Technologies (FLEET) researchers at the University of New South Wales on the research, just published in Nature Nanotechnology.

The MacDiarmid Institute-FLEET team looked at the properties of liquid metals, in this case, bismuth-gallium alloys, which create nanoscale patterns, that could be useful in nanoelectronics, or that could play a role as catalysts to speed up chemical processes using low amounts of energy.

“We designed our calculations around the experiments that were carried out by the researchers at FLEET,” says Lambie, who is completing her doctorate at the University of Auckland.

“A lot of these experimental techniques aren’t designed to look at the subsurface metallic structure. Doing these computational calculations provides an extra level of insight.”

FLEET Chief Investigator, Professor Kourosh Kalantar-Zadeh, explains the need for theoretical insight into pattern formation thus. “We serendipitously observed this deviation from the old metallurgy at the interface of liquid metals, where traces of secondary metals created fascinating patterns. Our colleagues at the MacDiarmid Institute, supported by the joint FLEET-MacDiarmid programme, were able to establish the underlying theory that governed the displacement of the secondary atoms toward the interfacial regions.”

Potential applications of the patterning that these liquid metal alloys can create include nanoelectronics, but perhaps most excitingly, the catalytic conversion of CO2 into useful hydrocarbons for energy storage. Lambie says despite Covid-19 forcing her to shelve plans to visit her collaborators across the Tasman, the team has stayed productive.

“We meet virtually every couple of weeks. I’m still very keen to get over and see them and they are keen to have me.”

Lambie is in her first year as a PhD student but into her fourth year as a MacDiarmid Institute collaborator, having worked with MacDiarmid Institute researchers, Dr Anna Garden and Associate Professor Franck Natali, as part of her master’s degree.

“I like seeing the patterns and what we can figure out from them,” says Lambie of the computational modelling work she undertakes.

“With this liquid metal technology, we aren’t really sure what the potential applications will actually be. But it is cool and exciting and new and I spend a lot of time thinking about it.”

As well as the collaborations with MacDiarmid Institute researchers that have been integral to her studies to date, Lambie, who completed her MSc with Associate Investigator, Dr Anna Garden at Otago, said a highlight had been working with inspiring women in science.

“I’ve worked with lots of amazing women who all know each other through MacDiarmid,” she says.

“MACDIARMID INSTITUTE RESEARCHER STEPHANIE LAMBIE

“In this game, the finer details are just as important as the big scale changes.”

“I’m really grateful to have such awesome role models and mentors.”

Lambie hoped a planned research trip to Berlin would come off in 2021 as the world opened up in the wake of Covid-19. In the meantime, she will continue her work on science that she admits appears obscure to that outside of the field.

“It’s complicated. But in this game, the finer details are just as important as the big scale changes,” she says.

“The biggest discoveries can only happen because other people have spent hours and hours iterating and refining.”

Potential applications of the liquid metal patterning include nano-electronics, but perhaps most excitingly, the catalytic conversion of CO2 into useful hydrocarbons for energy storage.
The quest to unlock the green hydrogen revolution

It holds the promise of virtually emissions-free energy - using electrolysers to split water (H₂O) into hydrogen (H₂) and oxygen (O₂), and using the resulting H₂ to power fuel cells in cars, buses, trucks and trains.

Our own government has recognised the potential of using our extensive renewable energy resources to create hydrogen for local industry and transport and even to become a hydrogen exporter.

“We are talking about a two-dimensional material that is just three atoms thick.”

DR ANNA GARDEN

There’s just one major problem. The catalysts used in the electrolysers that produce the hydrogen currently rely on expensive and rare metals such as platinum to operate efficiently.

“Platinum sits in this Goldilocks zone,” explains MacDiarmid Institute Associate Investigator, Dr Anna Garden, a lecturer in the Department of Chemistry at the University of Otago.

“To catalyse the conversion of protons and electrons into H₂, you need to bind the protons to the surface of the catalyst, which is where the reaction takes place. That forms hydrogen gas and then they leave again,” says Dr Garden.

A catalyst for change

Platinum-based catalysts facilitate that two-step process with great efficiency but fail the economic test to make ‘green hydrogen’ production viable.

Dr Garden and her colleagues have spent the year exploring a potential alternative - molybdenum disulﬁde (MoS₂), a low-cost inorganic compound with properties similar to platinum for hydrogen evolution.

“It’s been known to have some activity that’s useful for this reaction, but it’s not good enough yet,” says Dr Garden. Using computational modelling, she is able to determine what minute changes in the characteristics of MoS₂-based catalysts will mean for the efficiency of the process.

“We are talking about a two-dimensional material that is just three atoms thick. The complicating factor when studying H₂ evolution over MoS₂ is that we are dealing with an electrochemical process. Its surface, the contacting electrolyte and the applied voltage all influence H₂ production rates. This adds complexity,” she says.

The computational models created by Dr Garden and her colleagues offer atomic-scale insights that can inform lab experiments using potential materials for catalysts. Along with MacDiarmid Institute student researchers at the University of Otago, Charlie Ruffman and Calum Gordon, and Professor Egill Skúlason from the University of Iceland, Dr Garden in June published a paper in the Journal of Physical Chemistry looking at the mechanisms for hydrogen evolution using MoS₂ catalysts.

Working through Covid

While the pandemic had disrupted research and the team’s plans to present their findings at the first Commonwealth Chemistry Congress which was to be held this year in Trinidad and Tobago, Dr Garden said a highlight of 2020 had been working with PhD student, Charlie Ruffman.

“He’s really the driving force behind this research and he came through the year astonishingly well,” she says. The MacDiarmid Institute had moved early to support student researchers through lockdown by giving them a three-month extension for their research projects.

Work would continue next year on MoS₂-based catalysts, including modelling the impact of wrapping the materials into nanotube form.

“We are not putting all of our eggs in one basket and these catalysts aren’t any silver bullet, they won’t allow us to completely replace fossil fuels,” Dr Garden says.

“But they could help us create a more sustainable economy if we can get to that financial tipping point where the process of making hydrogen from electrolysis becomes competitive.”

At his lab at the University of Auckland, MacDiarmid Institute Principal Investigator, Associate Professor Geoff Waterhouse, experiments with those 2D materials, testing their performance for hydrogen production.

“The ground-breaking computational work of Dr Garden’s group provides valuable insights and cues about the types of 2D materials we should synthesise for this application.”

His group takes bulk layered materials, then exfoliates these using chemical and electrochemical processes to give ‘2D nanosheets’.

Defects that deliver

While the computational modelling of the Garden group involves the development of 2D photocatalysts for hydrogen generation from water using direct sunlight.

“We could completely eliminate the electrical circuit altogether in H₂ production, simply by placing our semiconductor photocatalyst in water and exposing that system to sunlight," explains Associate Professor Waterhouse.

For both electrocatalytic and photocatalytic H₂ generation, the key challenge is making these technologies efficient and adoptable at scale, thus allowing them to compete with conventional forms of hydrogen production based on fossil fuel feedstocks.

Associate Professor Waterhouse normally spends four months of the year in China working with experts in the design and fabrication of 2D catalysts for hydrogen production, CO₂ reduction and N₂ fixation.

“We’ve lost basically one year of experimental work this year, due to the impact of Covid-19.”

Just another reason to celebrate the emerging synergies between computational and experimental efforts to address CO₂ reduction within the MacDiarmid Institute.
The emerging field of mechanobiology

Wellbeing and medical health is generally seen as the realm of biology rather than physics. But physics—biology collaborations are forging a new field—mechanobiology—a research area key to understanding health and disease.

We’re familiar with the idea of chemical messaging: we know neurotransmitters pass messages to nerves and that hormones travel through blood to signal to cells throughout the body. But it’s less well known that our cells are also constantly reading and reacting to mechanical signals.

MacDiarmid Institute Principal Investigator and Massey University Professor, Bill Williams, says that this is exactly what the new field of mechanobiology studies.

“Cellular mechanobiology looks at the physical structure of cells and their environments and the role that mechanics plays in sensing and actuation.”

We tend to associate ‘mechanics’ as something more on the size scale of our cars, but it’s micro-mechanics that he’s talking about. The ‘extracellular matrix’ surrounding our cells is a protein-based scaffold, an example of which is connective tissue. This matrix can vary in stiffness (much like the difference between fresh or stale bread). It turns out that the stiffness of the matrix has a big effect on the ability of our cells to function healthily and withstand disease. Changes in the stiffness of this matrix are thought to contribute to many types of disease, including cancer.

“Changes in the materials properties of this extracellular matrix, around our cells for example, can be transmitted through the cell membrane and into the cytoplasm where they can impact on gene expression.”

Professor Williams says, mechanobiology is hugely multidisciplinary, encompassing cell biology, bioengineering and biophysics and requires more than one measurement technique.

“If I gave you a slinky and asked you to measure the mechanics of the spring in different ways, all the measurements would report pretty much the same thing. But biological systems are typically spatially heterogeneous and have mechanical properties that vary according to length and time scales. Typically you’re measuring something slightly different when you apply a different technique.”

He says that developing a suite of techniques for the measurement of the mechanical properties of soft biological materials has been a recurrent theme throughout the history of the MacDiarmid Institute and that the Institute is now well positioned with an impressive range of techniques including Optical Tweezers (his own research), AFM (Associate Investigator Dr Jenny Malmatron), Microaspiration (Principal Investigator Associate Professor Geoff Willmott), and Micropillar bending (Principal Investigator Associate Professor Volker Nock) to address challenging problems.

“Cancer tissues, for example, can be up to ten times stiffer than healthy tissues. So for cancer it’s important to measure the cell’s materials properties—and since these are complex, we need to have several techniques up our sleeve.”

A happy research coincidence

He points out that the mechanobiology field is by definition extremely collaborative. One key collaboration came about by chance, from a tea room discussion with Dr Tracy Hale from Massey University’s School of Fundamental Sciences.

“We were chatting over a cup of tea, as you do, and I was talking about how we were working on bringing together several different techniques to measure the physical properties of cells. I mentioned that we were concentrating our efforts on standard cell samples in order to develop the techniques we needed an actual biological problem.”

And it turned out that Dr Hale had managed to produce a line of breast cancer cells lacking in a particular protein (heterochromatin protein 1)—a protein that is found to be expressed less in the most invasive cancer cells. The hypothesis was that the downregulation of the protein affects the mechanics of the cell nucleus in a way that impacts on their ability to migrate through the body.

“She had managed to grow cells like that, along with a control cell line, and was actually looking for biophysical materials scientists to work with.”

But why should we be doing this research here in NZ?

“It’s part of a responsible society that we put tax dollars into science and medicine. And for that we need to be doing these things demonstrably at a world-class level.”

“And yes there are big groups in the States doing this, but there’s lots of competition between those groups. New Zealand is small enough that we can collaborate effectively—this type of collaboration is an example of the strength of a Centre of Research Excellence like the MacDiarmid. Although each of the three techniques we’re using can be done elsewhere, first up, we’re as good as anyone else is, and secondly, unlike them, we’re all working together.”

His MacDiarmid Institute collaborators on the breast cancer cell work include University of Auckland Associate Professor, Geoff Willmott, as well as PhD students, Susav Pradhan and Anikta Gangotra (who has just left NZ for a postdoc in the USA), and Research Assistant, Ayelen Tayagui, from the University of Canterbury. Associate Professor Volker Nock’s lab has recently travelled to Auckland and Palmerston North to investigate the mechanics of fungal like organisms.

Professor Williams says that having already built up collaboration on the different mechanical measurements we can do within the Institute, we can now apply these more generally to other biological systems.

“Volker’s been using his expertise in lab-on-a-chip force measurement to study the forces involved in the protrusion of hyphae of fungi (studying Myrtle Rust and Kaun Dieback).”

“The investment the Institute has already put in developing these techniques, calibrating and understanding them—means we can do exactly the right measurements. And now, with the help of Dr Hale, we can apply these to something else—the breast cancer cells—in fact anything that involves mechanical properties of cells.”

“For now, the MacDiarmid Institute teams have the mechanical properties of breast cancer cells firmly in their headlights, using multiple physics techniques to better understand the biological environments that keep us healthy. We’re as good as anyone else is, and secondly, unlike them, we’re all working together.”
The aim of the visit was to increase connectivity between research centres in Germany and Aotearoa New Zealand, with sustainability broadly the theme of the visit. Along with representatives from some other CoREs, Associate Professor Gaston and Professor Brooker spent the week visiting Clusters of Excellence – very similar research centres, in Germany, to the CoREs – from Bonn, to Cologne, to Aachen, Hamburg, and Berlin. In particular, the delegation visited the Cluster of Excellence in Matter and Light for Quantum Computing (ML4Q), in Bonn; the Fuel Science Centre in Aachen; Advanced Imaging of Matter, in Hamburg; the Max Planck Institute for the Structure and Dynamics of Matter (also in Hamburg); and the Leibniz Institute for Crystal Growth in Berlin, as well as Unifying Systems in Catalysis, at the Technical University in Berlin.

The delegation, which included Education NZ, MBIE and MFAT, also met with several German Members of Parliament. Associate Professor Gaston said that at a very personal level – as someone who was once funded by the DAAD to visit Germany on a research stay during her PhD – it was extremely positive to see the emphasis put by these policy makers on the importance of scientific exchange for the relationship between Aotearoa New Zealand and Germany.

Professor Sally Brooker and Associate Professor Nicola Gaston enjoy lab visits in the Centre of Excellence facilities in Hamburg (left and Bonn right); bottom: the group of delegates included representatives of R&D, Ta Punaha Matatini, the BioProtection Research Centre, as well as MBIE and Berlin Embassy staff.

Internationally connected

Co-Director, Associate Professor Nicola Gaston, and Principal Investigator, Professor Sally Brooker, were invited to join a German Academic Exchange Service-funded delegation to Germany in January 2020.

The German Academic Exchange Service (DAAD) is the largest German support organisation in the field of international academic co-operation, akin in role (although not in scale) to Education Aotearoa New Zealand.

“There is a lot we have in common as scientific communities.”

ASSOCIATE PROFESSOR NICOLA GASTON

Awards 2020

- Chris Bumby, Victoria University of Wellington, Heavy Engineering Research Association (HERA) 2020 Innovation Award
- Jim Johnston, Victoria University of Wellington, Baldini Research Entrepreneur Award - KiwiNet Research Commercialisation Awards 2020, MBIE Supreme Award - KiwiNet Research Commercialisation Awards 2020
- Justin Hodgkins, Victoria University of Wellington, Prize in Industrial and Applied Chemistry – New Zealand Institute of Chemistry (NZIC)
- Duncan McBillany, University of Auckland, New Zealand Institute of Chemistry (NZIC) Fellowship
- Shane Teller, Massey University, Bristol Benjamin-Masder Distinguished Visiting Professor Award – University of Bristol, Bristol, UK
- Geoff Waterhouse, University of Auckland, 2020 Maurice Wilkins Centre Prize for Chemical Science – New Zealand Institute of Chemistry (NZIC)
- 2020 Clarivate Web of Science Highly Cited Researcher List Fellow of the Royal Society of Chemistry (RSC)

Funding successes

2020 Marsden Grants
- Simon Brown, University of Canterbury, “Correlations and randomness: Branilike computation using nanoparticle networks”
- Chris Bumby, Victoria University of Wellington, “Ultra-precise control of magnetic flux quanta in high-Tc superconducting magnets”
- Robin Fulton*, Victoria University of Wellington, “Activating Substrates for Chemical Synthesis with Reactive Alkene Reagents”
- Tilo Söhnel, University of Auckland, “Skyrmion systems: New Opportunities for Information Technologies”
- Jadranka Travas-Sejdic, University of Auckland, “A New Approach to Transparent Organic Electronics”

*contributing as an AI

Royal Society Fellowships
- Nathaniel Davis, Victoria University of Wellington
  (Rutherford Discovery Fellowship), “Pushing the limits on renewable energy technology through hybrid organic/inorganic nanomaterials”
- Charles Unsworth, University of Auckland, (James Cook Research Fellowship), “Understanding how aggressive adult brain cancer talks”

2020 MBIE Funding
- Margaret Brimble, University of Auckland, “Wannas workahiti rongoā paturopi: New Generation Peptide Antibiotics” (Research Programme, Endeavour Fund)
- Ranwick Dobson, University of Canterbury, “Understanding the interactions between plant-based protein and cellular agriculture” (Catalyst Fund)
- Laura Domigan, University of Auckland, “Investigating the interactions between plant proteins and cultured livestock cells” (Catalyst Fund)
- Laura Domigan, University of Auckland, “Crystalin biomaterials” (PreSeed Accelerator Fund)
2020 HRC (Health Research Council) Grants

Michel Nieuwoudt and Cather Simpson University of Auckland

For Charles Hercules Fellowship - “Photonic device for real-time measurement of ischaemic tissue margins in surgery”

2020 NSC (National Science Challenge) Grants

David Barker University of Auckland

“Novel engineered media for sustainable water treatment by biofabricating and valorising waste resources” [Science for Technological Innovation (STI) Spinehead]

Ranviq Dobson University of Canterbury

“Host, Pathogen & Environment targeting Austropuccinia psidii effectors as a novel control strategy” [New Zealand’s Biological Heritage]

Jadranka Travas-Sejdic University of Auckland

“Remote detection of Phytophthora sogatophila” [New Zealand’s Biological Heritage]

2020 Domestic Funding – Other

David Barker University of Auckland

Swarak synthetics contract

David Barker University of Auckland

“Development of Tymal-DNA phosphodiesterase 1 inhibitors for cancer therapy” Cancer Society of NZ Project grant Cancer Research Trust Research Grant

Margaret Brimble University of Auckland

“Design and Synthesis of Sulfonylureas and Nitroaromatic ureas: Diverse Derivatives, as Bioremediation Inhibitors in Ramaitis” Fastfood Greenhouse Gas Research Limited

“Development of Novel Peptidomimetics Against Pediatric Dental Caries” Cure Kids

“Molecular Tools for Methane Mitigation” New Zealand Agricultural Greenhouse Gas Research Centre Innovation Fund 2020

“SARS-CoV-2 Virus Entry Inhibitors” Auckland Medical Research Foundation

James Crowley University of Otago

Donation to support anti-cancer and anti-bacterial drug projects (from P Lane)

Laura Domigan University of Auckland

“Melanosomes from livestock hair as radiation absorbing materials” Bioresource Processing Alliance (BPA) Student Project

Justin Hodgkiss Victoria University of Wellington

“Ultrafast Spectroscopy” KwinNet Tier 2

Aaren Marshall University of Canterbury

Seed investment for Zincovery

Carlo Melandradi University of Otago

“Gold nanoparticles: A novel treatment strategy for oral mucositis” New Zealand Dental Association Research Foundation Grant

“Topical ultrasound contrast agent for oral cancer screening” Lottery Health Research Grant

International Funding

Jack Chen Auckland University of Technology

“Dynamics of structure formation in stimuli-responsive amphiphatic catalysts” [ID 8736]” Australian Centre for Neutron Scattering Neutron 2020.2

“Dynamic formation of a multifunctional catalyst (ID 9379)” Australian Centre for Neutron Scattering Neutron 2021.1

James Crowley University of Otago

“Metallo-supramolecular Cages for Enanta selects Applications” with Dr. David Turner, Monash University

Laura Domigan University of Auckland

“Stabilization of Fortified UH Brevages” Fonterra Cooperative Group Limited funding for a PhD student

Simon Gravilis Victoria University of Wellington

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Catherine Whitby Massey University

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Philanthropic Funding

Viji Sarajeni University of Auckland

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2020 University Internal Funding

Martin Allen University of Canterbury

“Accelerator” PhD Scholarships [x2] for high achieving domestic PhD students working on MacDiarmid-relevant research areas – UC Aho Haere Scholarships

Matthew Gower University of Canterbury

“Operational Process for Allenite/Alumina Separation” UC Aho Haere Scholarship

Petrik Gavrossa Victoria University of Wellington

“Cellular Tissue Model for Magnetic Resonance” Faculty Strategic Research Grant

Simon Gravilis and Ben Rock University of Wellington

“Cystogenic time-resolved MOKE system to measure magnetisation dynamics at GHz-THz” Faculty Strategic Research Grant

Erik Lehes University of Auckland

“Classifying polysulphides made by inverse vulcanisation of functional silanes” Performance Based Research Fund

Ben Mallett University of Auckland

“Understanding novel states in superconductor sandwiches” Mosendt Nanosys

Jenny Malmström University of Auckland

Faculty Research Development Fund

Duncan McGilvray University of Auckland

“Atmospheric plasma jet printing of aerosol materials for tailored surfaces” Faculty Research Development Fund

Volker Niek University of Canterbury

“Gluco-CHIP” Strategic Grant

Viji Sarajeni University of Auckland

“Self-cleaning Antibacterial surface against Catheter-associated Urinary Tract Infections” Auckland Medical Research Foundation

Catherine Whitby Massey University

“Novel liposome vehicles for delivering pain relief to animals” Massey University Research Fund
Chapter 3.

INTO THE MARKET PLACE
Successful research translation relies on networks, connectedness and relationships. 2020 was therefore particularly challenging for NZ’s research commercialisation sector, often labelled an ‘ecosystem’. For most, the forced restrictions provided an opportunity to refocus and R&D was high on the agenda for many. The MacDiarmid Institute’s commercialisation and industry engagement activities went online, a forced adaptation that will serve us well in a reduced-carbon future. We maintained high standards in our own activities – developing IP and spinouts, delivering an online Interface event alongside many industry engagements, and giving our researchers at all levels a step up towards research commercialisation. The cherry on the top for 2020 was provided by our affiliated spinout Zincovery, winners of the C-Prize.

Many of our researchers are making strides into new materials for energy storage. One project approaching the market is the development of an aluminium-ion battery material. Dr Shalini Divya has recently completed her PhD working on new materials to replace lithium-ion batteries and is now forging her path as co-founder of the fresh spinout company, Tasmanion. The company aims to ensure the rapidly increasing global demand for batteries is met with a more sustainable alternative. Aluminium is a more abundant element than lithium and can be more easily recycled, leading to lower lifecycle impacts on our environment.

Like other deep tech opportunities, modern battery development and commercialisation is complex, time-consuming, and needs long-term support. Dr Divya has received MacDiarmid Institute support to take the technology to market and we are pleased to contribute alongside Wellington UniVentures and her academic supervisors (Professors Thomas Naan and Jim Johnston).

The coming year for Tasmanion will include finalising the seed investments and then pursuing technical milestones to develop a better battery prototype.

“The chance to translate my PhD project into a sustainable commercial product is a dream come true.”

Dr Shalini Divya
For Dr Rob Ward and MacDiarmid Institute Principal Investigator, Professor Bill Williams, commercialisation is the end point of a long learning process.

Together with recent engineering graduate Reuben Osborne, the pair are co-founders of White Rabbit which has a vision to provide plug and play scientific equipment for microworld experiments. They are initially focusing on developing easy-to-use reliable parts for microfluidics.

Microfluidics involves manipulation of liquids using micrometer-scale channels, valves, pumps and the like. This fast-growing technological field often goes by the label ‘lab-on-a-chip’, drawing an analogy with miniaturization of electronics in the second half of last century. Microfluidics has wide-ranging potential in areas such as sensing, diagnostics, genomics and proteomics, and even efficient industrial chemistry.

In the lab Dr Ward and Professor Williams found out the hard way that off-the-shelf microfluidics equipment is not easy to use. Turns out they’re not alone and now they are in a position to leverage years of troubleshooting by developing and selling market-leading parts. Their first commercial product, the subject of a filed patent application, is a small ‘Apple-esque’ high-precision syringe pump.

Professor Williams thinks that experimental work to develop new equipment and methodologies is important and often underappreciated. “Research labs generally have cupboards full of gizmos that languish into obscurity, while other labs reinvent the wheel. We want to produce devices that we would have loved to have had available when we started out and that could have saved us many hours and research dollars.”

The MacDiarmid Institute has supported Dr Ward to scope opportunities, develop a commercial plan, and hone commercialisation skills. He says, “MacDiarmid has been a great source of ongoing training, support and advice, and we hope to draw more from their expertise over the coming years as we bring more products to market.”

“White Rabbit was born out of the belief that the scientific community can do better.”

Professor Bill Williams

“Stepping from the lab into the commercial world feels a bit like shifting into a new universe.”

Dr Rob Ward

Pulling microfluidics out of a hat

MacDiarmid Institute affiliated start-ups:

- Number of start-ups and spinouts preparing to raise capital: At least 4
- Number of patent applications by researchers (2020): 10
- Number of patents granted to researchers (2020): 5
- Number of inventions disclosed to TTOs (2019): 6
2020 certainly threw a few curveballs for Aotearoa New Zealand’s research commercialisation ecosystem but true to our collaborative culture, the MacDiarmid Institute still managed to host and share a wide range of Commercial Skill Building and Industry Interface activities.

We would like to thank our many partners who have generously given advice, time and support for our efforts to grow the success of our research entrepreneurs - the likes of KiwiNet, Return on Science, each of our member University Technology Transfer Offices (TTOs), Callaghan Innovation, investors and deep tech entrepreneurs.

Commercialising materials science requires not only leading edge scientific research, but also a diverse team of dedicated, well informed, ambitious founders and contributors along the journey.

A member of the Ligar team working on a natural products project.

### Commercial Skill Building

We aim to ensure that our research community has access to all of the people, skills and support that they need on the challenging journey of deep tech commercialisation. With Covid-19 disrupting in-person activities, we jumped at the chance to initiate an online ‘Commercial Skill Building’ seminar series, in partnership with Auckland UniServices and Return on Science. Beyond the lock downs, we are continuing to host monthly online seminars for research entrepreneurs interested in the intricacies of intellectual property, capital raising, investor dynamics, and accessing support from university technology transfer offices.

### Industry Interface activities

We continue to develop long-term relationships with companies aimed at supporting any research needs they identify over time, while enabling researchers to plan long-term science portfolios that are relevant to these companies. These ‘Interface’ partners get to tap into our regular offerings (Industry Advisory Panels, internships, Commercial Skill Building, job postings and ongoing science outreach), and to advise us of their future focused aspirations.

Our annual Industry Interface event, held within Techweek, was an online event but still managed to draw a highly engaged crowd. Entitled Advanced Materials – Science careers that improve our world, the event featured a range of speakers alongside Zoom break-out room discussions:

- Jono Ring, CEO Zincavery, winner of the 2020 Callaghan C-Prize

- Veronica Harwood-Stevenson, CEO Humble Bee, developing advanced materials using biomimicry (from the nesting material of a solitary bee emerges a new chemical resistant, biodegradable fabric)

- Prof Jadranka Travas-Sejdic, Director of the Polymer Electronics Research Centre at The University of Auckland and a Principal Investigator at the MacDiarmid Institute

- Te Horipo Karaitiana, Ngati Kahungunu, Kurukura Kai Tahu, Kaiti Mamoe, Waitaha, Hawea. CEO Te Awanui Huka Pak

Our commercialisation and industry engagement activities continue to develop our next generation of start-up, commercial and R&D leaders so that our graduates emerge into the market, ready to improve Aotearoa New Zealand’s R&D productivity. We continue to fund industry internships and are confident of the strong contribution our scientists are making (and will make) to local industry (see Into the Future).

### Industry Advisory Panels

With Covid-19 requiring us to move to online formats, we also commenced an online platform for regular engagement between technology companies and our scientists in the form of an Industry Advisory Panel. Each panel session hosts a company that is interested in pursuing research to overcome a technical challenge with commercial relevance. The panel consists of a selection of our materials scientists (chemists, physicists, biologists, engineers) who provide advice on how to approach the company challenge. Companies such as CarbonScape and Ligar (see images) are able to learn about our research capability and facilities, and potentially build partnerships, while our scientists are able to identify new collaborations and gain exposure to industry perspectives and ways of operating.

“Working on hi-tech science for industrial processes, we value the ability to access and consult with knowledgeable specialists in the field of materials science, chemistry and engineering through MacDiarmid.”

HUMPHREY FELTHAM, PRODUCT DEVELOPMENT CHEMIST, LIGAR

“Via the Industry Advisory Panel, CarbonScape was able to connect with a wide range of enthusiastic scientists to further our materials understanding and enhance our product.”

CARBONSCAPE CTO, HEINRICH BADENHORST

CarbonScape has developed a patented technology and process to produce graphite sustainably from renewable feedstock.

Processing including pyrolysis, graphitisation and purification.
Zincovery wins the C-Prize

Zincovery is a University of Canterbury (UC) startup that recycles waste from the galvanizing industry for reuse as valuable raw materials. Associate Investigator and University of Canterbury Associate Professor, Aaron Marshall, and former UC student and MacDiarmid Institute alumnus, Jono Ring, have developed a process which recovers high purity zinc, iron and acid from material that would otherwise become expensive landfill. The team is developing an industry scale demonstration plant before launching in the international market.

Zincovery is an example of the type of high tech sustainability innovation that addresses not only environmental goals, but also Aotearoa New Zealand’s opportunity to be a world leader in exporting sustainable-tech IP. Young entrepreneurs like Jono Ring are also an inspiration to other young people keen to see where science and engineering could lead them. The MacDiarmid Institute congratulates Zincovery on their 2020 achievements, and is proud to have supported the research and professional development underpinning their success.

“Science and entrepreneurship are our best chance to protect our planet’s environment.”

JONO RING, CEO, ZINCOVERY

Alumni Business Scholarships

These scholarships will support the recipients to develop a more comprehensive commercial skillset to wrap around their existing scientific capabilities with the aim of enhancing New Zealand’s deep tech commercial portfolio over time.

Four scholarships have been awarded for study in 2021.

Anna Farquhar

Anna Farquhar completed her PhD at the University of Canterbury and now works as a Senior Scientist in the R&D team at Aeroqal in Auckland as an electrochemist, focusing on electrochemical gas sensors, and ensuring their reliability in monitoring air pollution.

Anna will be starting a Master of Business Development at the University of Auckland in March. She intends to gain skills in business, product management and leadership to help develop New Zealand’s reputation in the global air quality industry.

Stephen Lo

Prior to completing his PhD in Chemistry at the University of Auckland, Stephen Lo had partially completed a Postgraduate Diploma of Bioscience Enterprise. The MacDiarmid Institute Business Scholarship will allow him to complete this programme, which had always been a goal of his.

After the Postgraduate Diploma at the University of Auckland, Stephen intends to go further and also complete the Master of Bioscience Enterprise. He is really looking forward to developing the knowledge and skills required to bring valuable products from scientific research towards the commercial space, an area of work that is particularly exciting to Stephen.

Udbhav Ojha

After completing his PhD in condensed matter and materials physics at Victoria University of Wellington, Udbhav Ojha joined the financial technology services provider firm FNZ where he currently works as a senior analyst developer in the software development team.

The MacDiarmid Institute Business scholarship will enable Udbhav to undertake a Postgraduate Certificate in Business Administration at Victoria University of Wellington to develop skills in business accounting and finance that he plans to incorporate into his work from a fintech product development standpoint.

Davoud Zare

Davoud Zare completed his PhD at Victoria University of Wellington. He is currently working as a research scientist/engineer at the Fonterra Research and Development Centre in Palmerston North. The need for innovation in today’s business environment and his ambition to commercialise academic knowledge motivated him to apply for this scholarship.

Davoud will be undertaking a Postgraduate Certificate in Business Administration with a specialisation in Technology Commercialisation at the University of Auckland to further develop his managerial abilities and business acumen and unify it with his existing scientific skillset.

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Patenting to achieve market access

One of the early considerations on the path to market for materials science is what should be patented and why.

Our researchers are developing a deep pipeline of intellectual property (IP), including some that are best published, some that need to be patented in order to achieve their intended benefit, and some that demand a combined patent and publish strategy.

Our CIE team works closely with our researchers and member Technology Transfer Offices (TTOs) to explore the potential impact of scientific discoveries that could be commercialised. Early consideration of the IP strategy helps researchers plan their research to achieve optimal academic and commercial impact. Through our early ‘seed funding’ rounds we have financially supported five research projects this year to refine their market research or IP strategy and by doing so, increased their speed to market and likelihood of ultimate success. MacDiarmid Institute researchers have submitted ten patent applications in 2020 (see additional detail in following table).

Patenting activity by MacDiarmid Researchers in 2020

<table>
<thead>
<tr>
<th>Patent Applications</th>
<th>(only MacDiarmid Investigators named)</th>
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<tbody>
<tr>
<td>Volker Nock</td>
<td>Microfluidic sealing valve and microfluidic circuit</td>
</tr>
<tr>
<td>Margaret Brimble</td>
<td>Methanogen Inhibitors (1)</td>
</tr>
<tr>
<td>Margaret Brimble</td>
<td>Methanogen Inhibitors (2)</td>
</tr>
<tr>
<td>Rob Ward and Bill Williams</td>
<td>Syringe pump</td>
</tr>
<tr>
<td>Aaron Marshall</td>
<td>Process to extract dissolved metals and recover hydrochloric acid and apparatus thereof</td>
</tr>
<tr>
<td>Simon Brown</td>
<td>Nanoparticle networks</td>
</tr>
<tr>
<td>Simon Brown, Saurabh Bose</td>
<td>Percolating Switching Devices</td>
</tr>
<tr>
<td>Jerome Leveneur, John Kennedy</td>
<td>Ion beam sputtering apparatus and method</td>
</tr>
<tr>
<td>Chris Bumby</td>
<td>A superconducting switch</td>
</tr>
<tr>
<td>Laura Domigan</td>
<td>Biomaterials and Methods Related Thereeto</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Patents Granted</th>
<th>(only MacDiarmid Investigators named)</th>
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<tbody>
<tr>
<td>Marcus Jones</td>
<td>Quantum Dot Light Emitting Devices</td>
</tr>
<tr>
<td>Marcus Jones</td>
<td>Methods and Compositions for Biosensing</td>
</tr>
<tr>
<td>Simon Granville, Eva Anton, Ben Ruck, Frank Natoli, Joe Trodahl</td>
<td>Magnetic materials and devices comprising rare earth nitrides</td>
</tr>
<tr>
<td>Simon Granville, Ben Ruck, Frank Natoli, Joe Trodahl</td>
<td>Doped rare earth nitride materials and devices comprising same</td>
</tr>
<tr>
<td>Eric Le Ru</td>
<td>Spectrometer apparatus for measuring spectra of a liquid sample using an integrating cavity</td>
</tr>
</tbody>
</table>

Affiliated start-ups formed

White Rabbit, led by Dr Rob Ward: microfluidic devices including syringe pump drivers and ultra-high temperature microfluidic chips.
Chapter 4.

INTO THE COMMUNITY
What a huge year 2020 was for everyone, both in Aotearoa New Zealand and around the world. For organisations running educational outreach and engagement programmes, Covid-19 provided enormous challenges but also the proverbial opportunities. We took the chance to redevelop our resources and reconfigured what we do to reach our audiences via an online environment. We ran our annual Regional Lecture Series as online webinars, started a quirky podcast series and supported our students to make animated videos of both their own work and some of our ‘Materials Fact or Fiction’ episodes (our partnership series with RadioNZ Nights). While we were fortunate to be able to run some of our engagement (such as DiscoveryCamp and NanoCamp) in person, our pivot to an online environment added new strings to our bow, and we’ll keep playing new tunes as we move forward.
15 Minutes Smarter

2020 saw the launch of our new podcast - '15 Minutes Smarter', with MacDiarmid Institute alumnus Dr. Jonathan Falconer, and Otago Museum’s Science Engagement Coordinator, Dr. Claire Concannon, taking an irreverent but insightful look into the big important questions in materials science – “What has materials science ever done for the sport of skateboarding?” “What does being smart mean?” and “Is solar power really renewable if the sun is going to run out of hydrogen in 5 billion years?”

“Materials: Fact or Fiction?”

As part of our pivot to online delivery of outreach, we employed several of our students to script and animate short videos on the ‘Materials: Fact or Fiction’ theme, as well as on their own science.

Supporting science communication at The Spinoff

We continued our four-year partnership with award-winning online magazine The Spinoff, supporting high-quality science stories, which became especially crucial during the Covid-19 pandemic.

Covid-19 dominated the news, and the science news. This year, fewer stories on the Science page featured the work of MacDiarmid Institute researchers but these were viewed on average more than 4,600 times for longer than 4 and a half minutes.
Kids who discover the buckyball shape will never see footballs in the same way again.

Our partnership with Otago Museum saw the development of ‘The Future is Nano’ workshops. These were run at the museum during school holidays, demonstrating how nanotechnology can be used to mitigate climate change through better photovoltaics, solar concentrators and metal organic frameworks.

New photovoltaics developed by researchers at the MacDiarmid Institute were also featured in the Otago Museum’s Global Science Show – a Twitter-based collaborative project hosting regular shows to celebrate science communication around the world.

An Otago Museum curated exhibition created in collaboration with the MacDiarmid Institute, Unlocking Curious Minds and the Dodd Walls Centre, is dedicated to helping resolve the gender imbalance that exists in STEM by building relationships between female role models in STEM and young people. A significant aspect of this project is ‘100 women, 100 words… infinite possibilities’, a digital portrait exhibition where people nominate women in their community who make science, technology, engineering and math meaningful to them.

As part of Otago Museum’s Education weekly programme for the Gifted and Talented Education (GATE) group from Anderson’s Bay Primary School, students have been learning about nanotechnology and how it can help combat climate change, including through better photovoltaics, solar concentrators and metal organic frameworks.

Otago Museum this year took our science to sports grounds around Dunedin with its Sideline Science Programme. Our cardboard push-out buckyballs (replicas of nano-sized buckyball structures of 60 carbon atoms), were a huge hit amongst the football players who could take a buckyball to hang from their ceiling at home, along with their end of season trophies. Footballs will never be seen the same way by the kids who discover the power of the buckyball shape, and know that tiny buckyballs are made from 60 carbon atoms.
This year we continued sponsoring the House of Science to provide teachers and children with resources and equipment to teach science with at least one ‘NanoChem’ box at every House of Science branch.

There are 14 copies of our NanoChem kit in circulation and it was booked by schools (for a week at a time) 221 times in 2020 - which is not a bad stat given the interruptions to classroom teaching in 2020.

Following the successful ‘Element of the Week’ slot on RadioNZ Nights (for the Year of the Periodic Table in 2019), we continued our collaboration with RadioNZ, with a new series ‘Materials: Fact or Fiction’, where a MacDiarmid researcher or student discussed whether fictional or sci-fi materials from books or movies could one day be a reality.

From Star Wars, Avatar, Doctor Who, Lord of the Rings, the Marvel Comics and more, 21 of our researchers and students dove into the science behind fictional materials.

“House of Science”

“A great kit that challenged the students’ thinking and extended their knowledge of science.”
GISBORNE INTERMEDIATE

“This year we continued sponsoring the House of Science to provide teachers and children with resources and equipment to teach science with at least one ‘NanoChem’ box at every House of Science branch.

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“RadioNZ Nights’ Materials: Fact or Fiction”

“‘My 5 and 6 year old students absolutely LOVED the nano-chemistry kit!”
WHANGAMARINO PRIMARY

“The students really enjoyed the activities, went home and talked about them.”
KILBIRNIE PRIMARY

“We had some amazing learning out of this kit and my students said this was the best one yet. They absolutely loved it.”
ST PAT’S TAUPO

“‘My 5 and 6 year old students absolutely LOVED the nano-chemistry kit!”
WHANGAMARINO PRIMARY

“The students really enjoyed the activities, went home and talked about them.”
KILBIRNIE PRIMARY

“We had some amazing learning out of this kit and my students said this was the best one yet. They absolutely loved it.”
ST PAT’S TAUPO

From left to right: students making flubber, glow-in-the-dark polymers and crystals, all from the NanoChem kit.
“Coming from a small isolated town, it can tend to be hard to find opportunities for Māori females interested in science. I now realise that the University of Otago could be my future University and even though it is so far from home, the atmosphere and society is there to support students and create a home away from home.”

“A big takeaway is how supported Pasifika students are at Otago University - it really feels like a home away from home.”

“A personal favorite of mine was the micro-robotics.”

“This was mind-boggling - I had no idea that you could use blueberries to make power.”
Chapter 5.

INTO THE FUTURE
Our graduates cite a ‘MacDiarmid difference’ of added soft skill training within the PhD and support for their next steps in their careers, as some of the most valuable aspects of their student experience. This year we continued our funded three-month graduate internships into the government, NGO and industry sectors. Covid-19 also gave us a nudge to look within the Institute for individuals and groups needing better support. This led us to establish a women’s network and to give further impetus to our ongoing wellbeing work.

Internships

Past interns and their hosts repeatedly tell us how valuable the internship experience is in taking the first steps into the world of employment. With the vast technical skills and ability to self-manage a research workload, our graduates are well placed to plug into company R&D projects or government policy making and data analysis.

This year we placed four graduate interns into MacDiarmid-funded or co-funded commercial R&D environments to undertake projects related to sustainability, biotech, market research and commercial R&D.

With Covid-19 disruptions, companies unfortunately had limited capacity to take on new R&D activities, so we anticipate a strong uptake of these internships in 2021. Two of the internships are currently in progress and we are able to advertise positions on an ongoing basis when companies identify a need.

2020 also saw eight of our graduates take up MacDiarmid Institute-funded three-month internships within the government and social enterprise sector. Three joined the Office of the Prime Minister’s Chief Science Advisor (OPMCSA), and three took the opportunity to experience science and energy policy development within government (MBIE Contestable Investments, and Energy Resource Markets); and the Energy Efficiency & Conservation Authority (ECCA). One interned at the Science Media Centre (SMC) and another at Aēkina Foundation. All spoke positively of the opportunity to broaden their understanding of science, energy and science communication in policy, and review current regulatory frameworks via report writing, app design and protocol development in areas of energy resources, nanotechnology and funding processes.

OPMCSA Office
Cherie Tollemache: Covid-19 severity and vitamin D status.
Shinji Kihara: Nanotechnology regulation in Aotearoa New Zealand - comparison with overseas regulations and current developments.

Ministry of Business, Innovation and Employment (MBIE)
Aubrey Dosado: Science through the government lens with Contestable Investments.

Aēkina Foundation
Kannan Ridings: Creating Outlines and a Framework for a Data Strategy.

Energy Efficiency & Conservation Authority (ECCA)
Silvina Pugliese: Thermal energy storage in New Zealand Evidence Insight and Innovation Team.

Science Media Centre (SMC)
Cherie Tollemache: Covid-19 related – improving skills for data journalists (0.3 FTE).

Humble Bee
Ed Cozens: Technical Analyst and Research Support - for developing a chemical resistant material using biomimicry.

LPG Association
Praveen Vadakkedath: Identify process for production of bioLPG or biopropane in New Zealand.

Toha Foundry
Roan Vasdev: Identifying viable low emissions manufacturing and construction materials and processes, focused on low carbon cement and concrete.

Ligar
Maxime Savoie: Removing smoke taint from wine using molecularly imprinted polymers.

‘What I wish I’d known before my internship’

Webinar
We ran a webinar for prospective interns titled ‘What I wish I’d known before my internship’. Dr Kyle Webster, former intern at OPMCSA, and Dr Kannan Ridings, former intern with the Aēkina Foundation, shared their knowledge and tips based on their own experiences. There were lots of great questions and enthusiasm to continue this type of connection between our previous and soon-to-be interns.
INTERN, CHERIE TOLLEMACHE

My internship at OPMCSA involved urgent research and reporting on Covid-19 topics. I looked at testing methods, Covid in animals, Covid and vitamin D status, vaccine development, mental health impacts, and mask use. Being a part of such a fascinating time for science policy and science communication was beyond my expectation.

ED COEENS

Having recently completed my PhD and looking at what direction to pursue a career in, I had a few different thoughts on options. One option that interested me was working within the biotech start up space. My internship with Humble Bee provided me invaluable experience of the workings and challenges associated with such ‘deep tech’ start ups. One of the highlights was that it confirmed to me that this is an area I want to get involved with in the future, something that I was previously uncertain on. It has given me the confidence that this is a career move I would enjoy and that my skills and personality are well suited to deliver what companies like Humble Bee Bio need. The internship has also presented a number of challenges, giving me opportunities for growth while working through them. In particular, I have had the chance to grow my communication skills, particularly within a virtual space, as a portion of the internship had to be completed back within my home country, the UK, as a result of the Coronavirus pandemic.

Humble Bee founder Veronica Harwood-Stevenson reports that “Ed helped prepare information for audiences from patent attorneys, to investors, through to colleagues and commercial partners. His work was of high quality and immediate value.”

“Ed’s deep research and science background meant that he was able to compile and interpret our data and compare it to the literature and our competitors’ data.”

VERONICA HARWOOD-STEVENSON, HUMBLE BEE FOUNDER

ALUMNI ENGAGEMENT

We continue to celebrate the achievements of our alumni – in academia, government and industry.

Dr Lita Lee

Dr Lita Lee completed her PhD in Chemistry at the University of Canterbury under the supervision of MacDiarmid Principal Investigator Professor Alison Downard. In 2019, Dr Lee was awarded a MacDiarmid Institute Alumni Business Scholarship which supported her to complete a Postgraduate Certificate in Commercialisation and Entrepreneurship at the University of Auckland. Her project involved designing an app that reveals a ‘sustainability star rating’ when products are scanned, enabling consumers to make better informed and sustainable purchasing decisions.

Dr Lee is now working as an R&D research scientist at Auckland startup, Mint Innovation, where her focus is to recover copper from e-waste using electrochemistry.

Dr Ankita Gangotra

Engineer turned physicist Dr Ankita Gangotra graduated from the University of Auckland in 2020 with a physics PhD supervised by Principal Investigator Associate Professor Geoff Willmott. Dr Gangotra was one of the MacDiarmid’s first funded interns, exploring equity, diversity and inclusion policy options for Aotearoa New Zealand, based at the Office of the Prime Minister’s Chief Science Advisor. She then went on to Measurement Scientist roles at start-up company Taha under Professor Shaun Hendy, and with Calm the Farm, working with local farmers to develop science policy and measure environmental impact. She is now based in Washington DC as a Postdoctoral Fellow at Georgetown University Walsh School of Foreign Service and Department of Physics, researching low carbon construction materials from a science and policy perspective.

Covid-19 and the post-PhD workforce

Covid-19 presented a massive disruption to the academic workforce, particularly for PhD students and early career researchers, who face uncertainty about their future career prospects inside academia and options outside the university walls. To give some insight to our students and recent alumni, we arranged a joint webinar with our Australian partners FLEET, about career and post-PhD job market insights in our current pandemic times. The webinar was presented by Dr Inger Mewburn, Director of Researcher Development at The Australian National University.
As a key part of our pivot during Covid-19, we set up a Women in MacDiarmid Institute/MESA Network.

The idea was to immediately support female and gender minority/non-binary students and early career researchers through lockdown. The Network started as a social hour once a week via Zoom during Aotearoa New Zealand’s Covid Level 4 lockdown. The Network provided a safe space for eligible members of the MacDiarmid Institute to connect via discussion of their research, experiences regarding being a gender minority in STEM and to informally present their research. The Network includes MacDiarmid Institute investigators, students, early career researchers and professional staff members. As the Network has grown, we have been able to host workshops around leadership, including strengths-based development and EQ facilitated by Associate Investigator, Dr Emilia Nowak, from Massey University. We also hosted an Institute-wide webinar with guest speaker, Catherine Fox, titled, ‘Stop Fixing Women’, which provided great foundational knowledge about building fairer workplaces.

In August 2020, we were fortunate enough to finally be able to host an in-person meetup, with Network members gathering in person at each of the five universities, and streaming in via Zoom. Our week-long writing bootcamp for PhD students and postdoctoral researchers, in December 2020, was also facilitated by Dr Nowak. Our ambition is for this Network to grow and be self-sufficient so that all female, gender minority and non-binary MacDiarmid Institute members have a safe space for support and targeted development.

"Every postgraduate student would benefit from taking the time to attend a workshop on strengths."

"I really enjoyed it and it was nice to meet a group of lovely women from within the MacDiarmid and across Aotearoa New Zealand."

Now in its 10th year, the MacDiarmid Emerging Scientists Association (MESA) runs networking and training for all MacDiarmid Institute students and postdoctoral researchers.

In 2020, the MESA executive was Edordals Goll, (Chair), Sam Brooke (Secretary), Sriram Sundaresan (Treasurer), Tarek Kollnitz (Social Media Representative), David Uhrig, Charlie Ruffman, Aljo Anand, Benjamin Westberry, Colfin Casey-Stevens, Tane Butler, Tehreema Nawaz, Hellen Nalumaga, Liam Carroll, Stephanie Lambe, Geoffrey Weal, Luca Bondi, and Sashikumar Ramamirtham.

From the MESA Chair

This year we celebrated MESA’s 10th anniversary. Unfortunately, 2020 was a very difficult year mainly due to the global pandemic of Covid19. Nonetheless, our MESA committee managed to keep up the great work done in the last decade by organising multiple events. In particular, we started the year with one of the largest committees to date, showing how participation in and engagement with MESA has increased significantly throughout the years.

Our annual welcome events were not affected by Covid19 since they took place at the beginning of the year. This was the perfect opportunity for new students to meet other MESA members through fun activities, such as bowling and go-karting and around a table for dinner. The lockdown significantly changed our mid-year plans. We managed to redirect part of the MESA international travel scholarship budget towards domestic events. We organised our first fully online MESA workshop, ‘Science from the Supermarket’, designed to help MacDiarmid researchers develop outreach skills that they could then use with young students and children. We also launched, during lockdown, a series of weekly social gatherings over Zoom to keep up the morale of the students.

Webinars also became the norm throughout the year. In particular, we organised a webinar with Australian researchers, Dr Inger Mewburn, about graduating during a pandemic and what the job market will look like.

We also managed to arrange an MESA 3-Minute Thesis competition, partially online. (at the time Auckland went back into Level 3) where students at each MacDiarmid partner university connected via Zoom to each other. The competition was a great success with more than 20 contestants.

In addition, this year we focused on developing coding skills for our students through a series of Python workshops in different centres (Massey, Otago, and Auckland).

Finally, the biggest event of the year was our annual Bootcamp 2020 which took place in Te Anau at the end of November. This was our largest Bootcamp to date with around 50 participants. The theme this year was ‘Postgraduation pathways – where to next?’ We had many speakers from industry, academia and the government sector. The feedback from the attendees and the speakers was very positive.

Wellbeing has been firmly in our sights for some time, and 2020 brought it even more sharply into focus. Covid-19 disrupted many of our student and new graduate cohort, so much of our response this year has been to support our people through ongoing disruption and uncertainty.

Students and postdoctoral researchers attending the student-initiated Wellbeing Workshop in 2019 had identified five priorities for the Institute to act on. One of these was to: ‘Survey and develop, with all members of the MacDiarmid Institute, best practice supervision guidelines for our investigators.’ We have drawn upon exit interviews with our graduating students and postdoctoral researchers, and also those exit interviews with graduates who participated in government and industry internships. The surveys, conducted online and in person, sought to understand the MacDiarmid Institute postgraduate student and early career researcher experience. Feedback will be implemented as part of our new CoRE contract.

From this, we pulled together a formal Wellbeing Report to better understand the wellbeing challenges identified that impact on the capacity of students, researchers and others to be well in all areas of their lives. Throughout 2020, and especially in light of Covid-19 with lockdowns and the shift to working remotely, we have been able to implement some initiatives. This includes further equity, diversity, and inclusion by way of financial support for PhD students and Research Assistants, the organisation of online workshops and webinars for upskilling, and the development of the MacDiarmid Institute/MESA Women’s Network.

The Wellbeing Report and all wellbeing initiatives undertaken have demonstrated to us that our people want to strengthen the sense of belonging for everyone in the Institute, now and into the future.

Wellbeing was the big topic of the year. Not only did we have the ongoing disruption and uncertainty, but we also had to deal with the pandemic and all that that brings. But despite the challenges, we were able to support our people and make some headway in this area.

In the constant habit of working on our weaknesses, we often forget about our strengths.

“I now see that I bring unique strengths to a team.”

STRENGTHS DEVELOPMENT WORKSHOP PARTICIPANT

"I now see that I bring unique strengths to a team."

Women in the MacDiarmid Institute

Wellbeing

MacDiarmid Institute

MESA 2020

Women in the
MacDiarmid Institute

“Every postgraduate student would benefit from taking the time to attend a workshop on strengths.”

“During the year we have..."
Chapter 6.

INTO THE METRICS
### Financials

**CoRE funding**  
2019: 6,664,067  
2020: 6,664,067

**Surplus carried forward**  
2019: 2,182,948  
2020: 1,699,129

**Other funding (mainly interest income)**  
2019: 222,892  
2020: 70,590

**Total revenue**  
2019: 9,069,907  
2020: 8,433,786

#### Salaries and salary related costs

<table>
<thead>
<tr>
<th>Category</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director and Principal Investigators</td>
<td>814,090</td>
<td>1,216,070</td>
</tr>
<tr>
<td>Post-Doctoral Fellows</td>
<td>705,597</td>
<td>386,683</td>
</tr>
<tr>
<td>Research / Technical Assistants</td>
<td>222,852</td>
<td>89,802</td>
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<tr>
<td>Others</td>
<td>467,620</td>
<td>386,617</td>
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<tr>
<td><strong>Total salaries and salary related costs</strong></td>
<td>2,210,159</td>
<td>2,079,172</td>
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</tbody>
</table>

#### Other costs

<table>
<thead>
<tr>
<th>Category</th>
<th>2019</th>
<th>2020</th>
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</thead>
<tbody>
<tr>
<td>Overheads</td>
<td>2,407,636</td>
<td>1,969,133</td>
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<tr>
<td>Project Costs</td>
<td>2,789,634</td>
<td>3,241,519</td>
</tr>
<tr>
<td>Travel</td>
<td>462,915</td>
<td>92,158</td>
</tr>
<tr>
<td>Postgraduate Students</td>
<td>1,199,563</td>
<td>1,051,805</td>
</tr>
<tr>
<td><strong>Total other costs</strong></td>
<td>6,859,748</td>
<td>6,354,615</td>
</tr>
<tr>
<td><strong>Total expenditure</strong></td>
<td>9,069,907</td>
<td>8,433,786</td>
</tr>
</tbody>
</table>

**Net surplus / (Deficit)**  
2019: —  
2020: —

### At a glance

**Headcounts by category**

<table>
<thead>
<tr>
<th>Category</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emeritus Investigators</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Principal Investigators</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Stakeholder Relations Partner Iwi</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Associate Investigators</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Postdoctoral Researchers</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>579</td>
<td></td>
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</tbody>
</table>

**Peer reviewed research outputs by type**

<table>
<thead>
<tr>
<th>Type</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal articles</td>
<td></td>
<td>392</td>
</tr>
<tr>
<td>Book chapters</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Conference papers</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Books</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>419</td>
</tr>
</tbody>
</table>
A simultaneous optical and electrical in-vitro neuronal recording system to evaluate microscale electrophysiology.

BioMagn 18, e237790 (2020)

A versatile technique for measuring frozen product adhesion strength: Application to stainless steel freeze-rack interaction.

Journal of Food Engineering 271, 109772 (2020)

Ab initio Molecular Dynamics Investigation of Bixi2Et Compounds.

Inorganic Chemistry 59, 24334225 (2020)

Absorption spectra, defect site distribution and opsonisation excitation spectra of Co2/SF2/ 2-isothiocyanate nanoparticles.

Journal of Alloys and Compounds 834 (2020)

AC loss calculation on a 6.5kN 25kV HTS Traction Transformer with Hybrid Winding Structure.


Accessing a long-lived SIC state in a Ruthenium@Phospholipid Complex with Attached Aromatic Groups.

Inorganic Chemistry 59, 16896-16975 (2020)

An investigation into the effect of ribosomal protein S15 phosphorylation on its intermolecular interactions by using phosphomimetic mutants.

Chemical Communications 56, 7837-7860 (2020)

An Optimized Fold Network Morphology Enables High Efficiency and Ambient Stable Polymer Solar Cells.

Advanced Science 7, 2001986 (2020)

Analytical method for fast converging lattice complexes with crown ether and cryptand.


Analytical ultracentrifugation: still the gold standard that offers multiple solutions.

Dental Materials 36, 1096-1107 (2020)

Antiprofector Activity and Associated DNA Interactions of β-2-glucosyl-2-cysteinylglucosyl derivatives from 2-butyldithiophosphoric acid.

Organometallics 39, 1468-1455 (2020)

Applications of advanced signal processing and machine learning in the real-time hypnic-hypnagogic electromyograms.

Neural Regration Research 15, 222-231 (2020)

Atomic Scale Dynamics Drive Braubile Reactions in Paraffin Husk Nanomaterials.

Nano Letters 20, 3933-3942 (2020)

Backscattered acoustic phonons as ultrasonic probes in metal-oxide superlattices.


Biodetachable Poly(ethylene adipate-co-polyethylene terephthalate) composites reinforced with bio-based nanotubes: Preparation, enhanced mechanical and thermal properties.

Journal of Applied Polymer Science 137 (2020)

Capsule robot for gut microbiota sampling using shape memory alloy spring.


Catalytic synthesis of copper oleate composites as solar radiative films.

Nanotechnology 31, 504002 (2020)

Cellulose acetate electropatrons encapsulating linden honey essential oil as active agent with potent and sustainable antimicrobial activity.

Frontiers in Polymers 157, 104769 (2020)

Characterization of p-toluidine m-phenylphosphonic acid nanotubes using small angle scattering.


Characterization of personal solar photovoltaic radiation exposure using detrended fluctuation analysis.

Environmental Research 182, 109769 (2020)

Chiral two-dimensional p wave superfluid from s-wave pairing in the Bose-Einstein-condensate regime.

Physical Review A 101, 031613 (2020)

Chromium (III) adsorption and reduction by humic acid coated iron-doped magnetic porous carbon.

Powder Technology 360, 55-64 (2020)

Clay@Pp on Lipoic to Generate Antimicrobial Lipopolysaccharides.

Chemosphere 117, 5759-5765 (2020)

Cocrystallization of Kanamycin with amino acids improves porosity.

Pharmaceutics 12, 1-19 (2020)

Cocystallization of Kanamycin with amino acids improves solubility.

Pharmaceutics 12, 1-19 (2020)

Coxing therapeutic structures in the catalytically driven growth of rock salt Gdn.

Materials Research Express 7, 66404 (2020)

Collinear orbital antiferromagnetic order and magnetoelectricity in spin-2dimensional intermetallic paramagnets, ferromagnets, and antiferromagnets.

Physical Review Research 2, 043060 (2020)

Combining catalysis and replication.

Nature Chemistry 12, 585-587 (2020)

Comparative Molecular Dynamics Simulations Provide Insight into Antifungal Interactions: A Case Study Using the Enzyme Lipi-Diacylglycerol Acyltransferase (Dagl).

Frontiers in Molecular Biosciences 7 (2020)

Comparative Microscopy.


Corrosion inhibition of the Conventional Fatty Acids of Pyruvate Kreeze in the Gas Phase and in Solution.


Comparison of fruit traits for Chinese cherry cultivars.

Acta Horticulturae 1281, 81 (2020)
Additional scholarly works are briefly summarized here:

- **Materials Science and Engineering B: Solid State Materials for Advanced Technologies**

- **ChemBioChem**

- **International Journal of Modern Physics B**

- **J. Phys. Chem. C**

- **Soft Matter**

- **Environmental Science and Pollution Research**

- **Journal of the Royal Society of New Zealand**

- **International Journal of Modern Physics E**

- **Journal of Molecular Catalysis A: Chemical**

- **Journal of Molecular Catalysis B: Environmental**

- **ACS Catalysis**

- **ChemBioChem**
MacDiarmid Institute
2020 Annual Report
Into the Metrics

Sporle, A.
Waterhouse G.I.N.

Auguié, B.
Hume, P. A.
Hodgkiss, J. M.
Hill, M. R.

Liu, S., Wen, B., Jiang, X., Waterhouse, G. & Kammermeier, M.

Nitta, J.
Zülicke, U.

C.
Gordon, K.

Walker, C., Fotuhi Piraghaj, S. & Bhugra, V. S., Chong, Williams, G. V. M. & Kilmartin, P. A.

Travas-Escot, J. F., Leibl, P. & Kuznetsov, A.


Rai, A., Probs, M. B., Hardjy, G., Gross, K. Schmid, T. & Morris, D. J. L.

Jelley, R. E., Deed, R. C., Zhang, T.

G. I. N.

Simpson, Ashforth, S. A., Oosterbeek, R. N., Bodley, O. T., Ruck, B., Garden, A. & Kruger, P. E.

Kruger, P. E.

Huber, D. L., Muhler, M., Gooding, J. J., Ru, E. C.

Singh, S. & Preston, D.

Extending Azene-Triazole Synthesis to Azole-Bridged, Extended Longevity of the Spin Helix in Low-Dopant Crystals.

Perovskite Nanocrystals.

Light Harvesting Synthetic Protein (Maquette)


Femtosecond Lasers for High-Precision Temperature Ammonia Synthesis.

Facile Dissociation of Molecular Nitrogen Using Nanoflakes: Towards a Multi-Stage, Temperature-Dependent Ammonia Synthesis.

Facile synthesis of Gel-1 like nanowires.

Field of view of kinetic electrodialysis of biomass.

Facile degradation of microplastics using bacterial protoplasts.

Facile degradation of microplastics using bacterial protoplasts.

Facile Degradation of Microplastics Using Bacterial Protoplasts.

Facile Degradation of Microplastics Using Bacterial Protoplasts.


It has been shown that... 

The title of the article is: **Highly Efficient Photoelectrocatalytic Reduction Strategy as Efficient Oxygen Reduction Electro catalysts.**


The journal is: **Chemical Science.**

The year and volume is: (2020) 13, 135-158 (2020)

---

The title of the article is: **Peroxide Catalyzed by Nickel Single-Atom Catalysts with Tetradentate N2O2 Coordination.**


The journal is: **Chemical Communications.**

The year and volume is: (2020) 13, 11767-11771 (2020)

---

The title of the article is: **Greenish-yellow emitting Ca9MgLi(PO4)7:Dy3+ phosphors - Photoluminescence and thermal stability.**


The journal is: **Journal of Luminescence.**

The year and volume is: (2020) 135-158 (2020)

---

The title of the article is: **Fluorometric determination of mercury(II) in waters using spectroscopic and computational methods.**


The journal is: **Analytical Methods.**

The year and volume is: (2020) 12, 3781-3787 (2020)

---

The title of the article is: **Methylene Blue Photo-Oxidation with Remarkable Activity for Aqueous Organic Compounds.**


The journal is: **Applied Catalysis A: General.**

The year and volume is: (2020) 682-693 (2020)

---

The title of the article is: **Electrochemistry of Inertial Capillary Uptake of Drops.**


The journal is: **Journal of Luminescence.**

The year and volume is: (2020) 135-158 (2020)

---

The title of the article is: **Fluorination Position: A Study of the Optoelectronic Properties of Two Regioisomers of 5-[2-(4-Fluorophenyl)ethynyl]-1,3,4-oxadiazole.**


The journal is: **Journal of Luminescence.**

The year and volume is: (2020) 135-158 (2020)

---

The title of the article is: **Highly efficient photothermal heating: Yia distorted wedgefs in barium quantum dot.**


The journal is: **Journal of Materials Chemistry B 8, 9831-9847 (2020)***
**AUTHORS** | **TITLE** | **JOURNAL**
--- | --- | ---
Kumar, V. B. & Leitao, E. M.
Properties and applications of polysilanes.
Applied Organometallic Chemistry 34 (2020)
MacDiarmid Institute
2020 Annual Report
Into the Metrics


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Cho, I., Zhao, L., Mapley, J. I., Shahshahan, S., Wagner, G., Gordon, G. C., Iwai, P. C., Kimura, M., Mori, S. & Mazo, A. Significant effect of Electronic Coupling on Electron Transfer between Surface-bonded Pyrroliodines and Cu2O@Co(O)

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Keynote & invited speaker addresses

Margaret Brimble  
Keynote talk at the Teachers Professional Development Symposium. November 2020, Teina, New Zealand

Carlo Melandretti  
Plenary lecture at the 32nd Australian Collidal and Surface Science Student Conference. January 2020, Churchill, Geppel, Australia

Jadranka travas-sejdic  
Keynote talk at the 14th Annual International Electromaterials Science Symposium. 5-7 February 2020, Canberra, Australia

Catherine Whibey  
Keynote talk at the 17th Australasian Collidal Science Symposium. 17-18 September 2020, online

Martin (Bill) Williams  
Invited lecture at the Northern Lights Food Masterclass. 31 August 2020, Sweden (online)

Keynote talk at the Teachers Professional Development Symposium. November 2020, Nelson, New Zealand

Keynote talk at the School of Chemical Sciences, University of Auckland, Innovation Showcase. November 2020, Auckland, New Zealand