CHANGE THE WORLD

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

2018 RESEARCH REPORT | KIMIHIA TE MEA NGARO

Produced by Research & Innovation and Student Services and Communications, University of Canterbury.

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Publication printed by Caxton

Key: when you see this symbol, read to find out the real world application of this research – how this work will improve society.

E ngā muka tangata nō ngā hau e whā, nāia te owha o Te Whare Wānanga o Waitaha e rāhiri atu ki a koutou katoa. E mōhiotia whānuitia a UC mō āna mahi rangahau e puta ana i te ao. Ahakoa te hākari a te mahi kua hora e tēnei whare wānanga i te tau nei, kua tīpako noa mātou i ēnei kaupapa rangahau, hai paramanawa mā te hinengaro - arā, ko te rangahau e aro ana ki te oranga tonutanga o te kai.

Nā reira, e ngā ringa whero o ēnei kaupapa rangahau o te whare wānanga nei, he kai kei ā tātou ringa! Tēnā koutou katoa.

Greetings from the University of Canterbury (UC). UC is well known for its research reputation and although this is only a small selection, the excellence and quality of UC's research can be seen through these stories from our activities during the 2018 year, with an emphasis on securing the future of food through food equity, food intelligence and food innovation.

Doctoral student Katie Coluccio

Doctoral student Katie Coluccio is working to understand groundwater seepage of Te Waihora Lake Ellesmere. The lake is a biodiversity hotspot that supports an abundance of fish species and has long served as a key food source for local iwi Ngāi Tahu. Read more on page 45.

Research Report 2018 Theme: This report highlights UC's bold vision working towards securing the future of food and the contribution our researchers are making in the areas of food equity, food intelligence and food innovation.

Research & Innovation

Connecting UC's research with the world

The role of Research & Innovation is to provide services that facilitate and support all stages of research and innovation at the University of Canterbury, from initial funding of the research through to commercialisation of the outcomes, where appropriate. Research & Innovation is the first point of contact for external organisations that are interested in: discussions on how UC resources might help their organisation; assistance in accessing UC expertise and facilities; consulting services and contract research; opportunities to use or commercialise UC's intellectual property and assistance in identifying business or investment opportunities. Please contact us if you are interested in engaging with UC.

Phone: +64 3 364 2688

Email: enquiries@research.canterbury.ac.nz

www.canterbury.ac.nz/research

UC Research Profile

A showcase of UC research

UC Research Profile is a searchable website that showcases UC's research. You can search it for information about individual researchers, the projects they are working on, the research groups they belong to, the specialist equipment that they use, and their affiliations. UC Research Profile provides a comprehensive view of research at UC.

https://researchprofile.canterbury.ac.nz/

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UC

Research 2018

This year's report highlights the breadth of UC's research capability to address 21st century food production and consumption.

It is a great pleasure, as Deputy Vice-Chancellor | Tumu Tuarua, to write the foreword to the University of Canterbury | Te Whare Wānanga o Waitaha Research Report | Kimihia te mea ngaro 2018. This report continues to highlight the evolution of UC's research and demonstrates the excellence and impact of our research. The pillar of research excellence is built around UC having academics who are thought-leaders in their respective fields who provide intellectual leadership, nationally and internationally. The benefit of our research continues to be felt across the spectrum of economic, environmental, and societal impacts, ranging in scale from immediate benefits to Ōtautahi Christchurch and Waitaha Canterbury, through to Aotearoa New Zealand and on a world scale.

In 2018, the Performance Based Research Fund (PBRF) concluded its most recent six-yearly assessment of research quality for the period of 2012 – 2017. Given this period was the most disruptive to UC academics following the Waitaha Canterbury earthquakes (with either temporary or no access to many on-campus research facilities), we are extremely proud to have improved our overall institutional research quality, and in numerous areas be at the forefront of Aotearoa New Zealand tertiary research. The resilience and dedication of our academics has been truly remarkable and impressive.

As we come to the conclusion of the campus rebuild, the University is reflecting on its academic future (including its research) over the next decade – a process being led by our new Vice-Chancellor | Tumu Whakarae,

Professor Cheryl de la Rey. An early initiative of this post-rebuild vision is UC's contribution to the future of food production, both globally and in Aotearoa New Zealand. This encompasses a range of issues including capturing more value, changing consumer choice, increasing sustainability, establishing new policies for mitigating climate change, the complexity of global supply chains, the demand for food traceability, the complexity of trade regulation, creating value from food wastage, producing innovative new foods, and the social and economic inequities of food production and consumption, which underline the fact that 'more of the same' is not going to work. UC will actively seek collaboration nationally and internationally to pursue this research agenda.

UC is bringing to bear its research strengths in this domain under the banner of Kia Tōpū, bringing a 'disruptor' view at the nexus of science, engineering, e-commerce, marketing, law, business, big data and artificial intelligence, and crucially the social sciences where social acceptance and ethics, trends in consumerism, and indigenous and cultural considerations could provide an alternative trajectory for food production and consumption. This research report highlights the underlying breadth of UC's research, from which our Kia Tōpū initiative will evolve with a clear focus around research. The following research stories give insight into exciting new developments already occurring at UC including dealing with food waste, biodegradable coating for food crops to minimise herbicide and pesticide use, understanding protein integrity in food processing, holistic approaches to 'urban farming', the use of algae for high-value food supplements, the application of blockchain technology for food traceability, 'genetic rescue' of mahinga kai to improve freshwater aquaculture success, through to understanding the constraints of water extraction in Waitaha Canterbury, the changing social norms of meat consumption and rise of vegetarianism, and the legal and land policy framework for high-country pastoral farming.

Our UC Council | Te Kaunihera o Te Whare Wānanga o Waitaha recognised internationally ranked excellence and innovation in 2018. Electrical and Computer Engineering Professor Rick Millane was awarded the Research Medal for his outstanding research in macromolecular imaging for structural biology. His research is rooted in developing a new theory and computational algorithms from new x-ray, free-electron lasers to image biomolecular structure. This imaging advance underpins understanding of disease process and pharmaceutical drug design. His recent work is contributing to understanding mis-folded proteins potentially associated with neurogenerative diseases.

Professor Phil Butler, Te Kura Matū |School of Physical and Chemical Sciences, was awarded the Innovation Medal for his outstanding research in the field of medical physics, particularly the development and translation of this technology into 3D colour X-ray imaging which provides multi-coloured 3D images of the human bone structure and chemical constituents (like water, calcium, disease markers) in soft tissues such as fat, muscle and tendons. This technology breakthrough underpins a fast-developing spinout company (MARS Bioimaging) which is selling the first commercial, pre-clinical imaging systems around the world. The first clinical trials for cancer patients are being conducted in Ōtautahi Christchurch in 2019.

Finally, Dr Mitja Remus-Emsermann, Te Kura Pūtaiao Koiora | School of Biological Sciences, was the recipient of the Early and Emerging Career Researcher Award for his research on how bacterial communities develop on plant leaves, which is an exciting development at the intersection of microbiology, ecology and plant science. This research may potentially lead to the prevention of plant pathogen colonisation and disease outbreaks during agriculture production.

Elsewhere, UC researchers continue to be recognised by national and international peers for contributions to their research fields, including Royal Society Te Apārangi fellowships for Professor Jason Tylianakis (Te Kura Pūtaiao Koiora | School of Biological Sciences), and Professor Angus Macfarlane (Te Kura Whakangungu Kaiako | School of Teacher Education), Rutherford Discovery fellowships, and numerous discipline and professional body awards. In particular, UC is proud that Distinguished Professor Geoff Chase was the recipient of the 2018 MacDiarmid Medal for his research on physiological modelling of human metabolism as the basis for treating intensive-care patients in Aotearoa New Zealand and overseas.

2018 was a watershed year for UC – our campus transformation draws to a close, and there is a re-focusing to our core mission of being a

university with teaching and research at its heart. The University bid farewell to Dr Rod Carr as outgoing Vice-Chancellor | Tumu Whakarae, and looked forward to the arrival of our new Vice-Chancellor | Tumu Whakarae, Professor Cheryl de la Rey.

I put forward this report for your reading, and hope you gain an appreciation of the potential at UC to collaboratively research how Aotearoa New Zealand and the world will sustainably and ethically produce and consume food over generational timescales.

Tēnā koutou katoa,

Professor Ian Wright
Deputy Vice-Chancellor | Tumu Tuarua

UC received $40,650,000
in research income in 2018

3114 scholarly outputs
were produced in 2018

Two UC academics were appointed Fellows of the Royal Society Te Apārangi in 2018

We welcome people from many countries

88
countries represented by PhD & Masters students

69
countries represented by academic staff

79 international academics visited UC in 2018 as part of the Erskine Programme. And 23 UC academics were funded to visit and teach at international universities

UC's postgraduate students come from all over the world

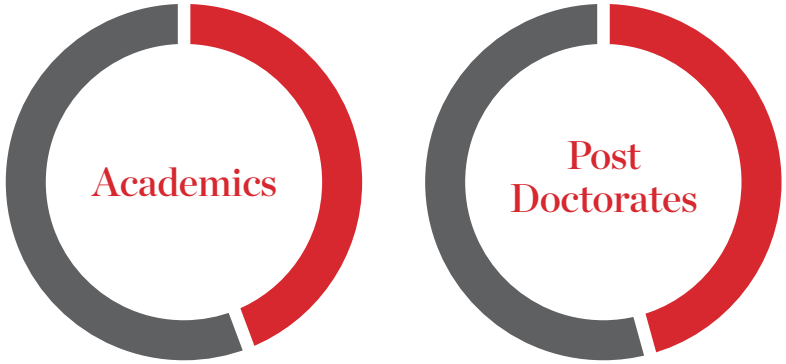
Domestic 63%
International 37%

Domestic 35%
International 65%

Eight visiting Fellows from Cambridge and Oxford Universities

Seven UC research projects received $4million Marsden Funding in 2018.

Gender Split: Academics / Post Doctorates



Females 44%
Males 56%

Females 46%
Males 54%

772.2
Academic staff[1]

53.3
Post-doctoral fellows[2]

Postgraduate degrees completed

169
PhD

245
Masters

Performance-based Research Fund (PBRF):

UC has ranked in the top three in over half of the subject areas within which it submitted.

UC ranked first in New Zealand in:

- ecology, evolution and behaviour
- marketing and tourism
- political science, international relations and public policy
- public health

1. Annualised FTE of academic staff
2. Annualised FTE of post-doctoral staff

Research into kaupapa or plant-based kai and ethics could act as an intermediary between Western intensive animal agricultural practices and vegan ethics.

Ngata Centenary Doctoral Scholar Kirsty Dunn

Kaimangatanga is the word for vegetarian, and is used by both vegans and vegetarians to describe their ethics. Ms Dunn uses the word and "plant-based" purposefully to encompass both.

Kaimangatanga – Māori perspectives on plant-based kai

Gathering together many different perspectives on kaupapa Māori veganism or plant-based kai and ethics is just a starting point for Ngata Centenary Doctoral Scholar Kirsty Dunn, who is also a postgraduate member of UC's New Zealand Centre for Human-Animal Studies.

It is work she hopes will lead to a deeper understanding of kaimangatanga and the broader issues surrounding food sovereignty.

During her MA research studies at UC, Ms Dunn considered representations of Western meat production and consumption in contemporary fiction and the portrayal of concerns about intensive animal agriculture.

For her current research, which began as part of a UC Summer Scholarship in 2016, she has switched her primary focus from Western ideas and perspectives to Māori perspectives on alternative and plant-based diets and how these relate to dominant ideas about kai and associated concepts such as health, cost, production, sustainability and animal welfare.

It is the start of a journey for Ms Dunn, whose iwi are Te Aupōuri and Te Rarawa from Te Tai Tokerau. She is discovering many entry points to kai and its surrounding issues: online searches have revealed a growing community of Māori discussing kaupapa Māori plant-based kai and ethics via social media sites, websites and podcasts.

"In different spaces we exchange recipes, provide tautoko (support) and explore the influences that Māori values, concepts, narratives and experiences have on our approaches to kai and plant-based kai in particular. There has also been some news coverage of Māori plant-based ethics and initiatives including recent coverage of Tūrangawaewae marae in Ngāruawāhia and the incorporation of plant-based kai information into the marae menu."

These may be seen as part of wider initiatives with similar kaupapa (themes, ethics, ideas), such as those centred around healthy kai, food sovereignty and kaitiakitanga.

Different perspectives, common whenu (threads)

Common threads or whenu run through different perspectives of 'kaimangatanga' (veganism or plant-based ethics), which Māori have drawn on in different ways. The following are among the whenu she highlights.

- **Whakapapa** encompasses relationships, connections, origins and layer-making, as well as relationships between people, other species, the environment, ancestors and atua. It is also used in regard to the origins of kai and production processes. Whakapapa informs Ms Dunn's research into both Māori literature and kaimangatanga.
- **Manaakitanga** (or uplifting the mana of others, reciprocal hospitality) is a concept that underpins the provision of more nutritious kai, such as wholefoods, fresh fruit and vegetables, to visitors.
- **Tino rangatiratanga** captures ideas about exercising sovereignty over oneself and making decisions that don't necessarily align with the status quo – in this case, the dominant meat culture in Aotearoa New Zealand. It may also involve drawing on the practices and knowledge of tūpuna (ancestors) and of decolonial diets, namely eating endemic plants species and using plants as rongoā (medicine).
- **Kaitiakitanaga** encompasses guardianship, not only of the environment but also of other species, of mātauranga (knowledge) and of resources for current and future generations. Wrapped up in this thread is the concept of sustainable kai.

Finding common ground

Debate on food in the Western context can become polarised between the rationale supporting intensive animal agricultural practices and vegan ethics.

Ms Dunn suggests that the ethics she is exploring have the potential to act as an intermediary between the two, as well as in discussions about alternative plant-proteins and issues such as genetic modification and lab-grown meat.

"Perspectives from tangata whenua regarding plant-based kai ethics, food sovereignty and decolonial diets based on the principles I identified in my research can provide various avenues for critique: they are particularly valuable because they are in and of this place, this whenua."

'These may be seen as part of wider initiatives with similar kaupapa (themes, ethics, ideas), such as those centred around healthy kai, food sovereignty and kaitiakitanga.'

This research is an ongoing side project for Ms Dunn. Her main PhD research, "'Into the Dark, We Are Moths' – Representing and Reimagining Animals in Māori Writing in English", is being undertaken under the supervision of Senior Lecturer Mr Garrick Cooper (Māori and Indigenous Studies) and Professors Annie Potts (Cultural Studies) and Philip Armstrong (English).

Though born in Tāmaki-makau-rau Auckland and completing her secondary schooling in Southland, Kirsty considers Ōtautahi Christchurch her home town. She completed her BA in English with First Class Honours at UC in 2012 and her MA with Distinction in 2015. She was awarded the prestigious Ngata Centenary Doctoral Scholarship in 2017 for her PhD research and received the Australasian Animal Studies Association award for best postgraduate paper at the association's 2017 conference in Adelaide.

Biodegradable coating to help achieve food security

Associate Professor David Leung's biodegradable coating can help achieve food security in an environmentally friendly and consumer-conscious way.

Biotechnology Associate Professor David Leung, in Te Rāngai Pūtaiao | College of Science, is working on a nontoxic, biodegradable coating to protect edible plants against diseases, pests and environmental hazards, including the effects of climate change.

The research could prove vital in protecting plant food without compromising consumer health. Because the coating is biodegradable, it would also provide an environmentally sustainable solution and avoid the negative impacts of agrochemicals commonly used to protect plants.

In addition to being eco-friendly, the coating is nontoxic, which Associate Professor Leung says is key to protecting the people consuming the end product.

"It is counterproductive to protect plants using toxic methods. Even though you may provide security for a food source, you are still missing the mark if you have contaminated the environment you are growing the plants in during the process and delivering a food product with toxic residues," says Associate Professor Leung.

"It's not just about the quantity of food that we care about; it is also about producing safe food that doesn't harm the surrounding environment."

Non-degradable pesticides, herbicides and biocides can damage the surrounding environment by contaminating soil, water, turf and other vegetation. Although they are effective in killing insects, they can be toxic to a host of other organisms, including humans.

> 'Right now, we have to use these undesirable substances or we simply would not be able to harvest enough food to support the world's needs. This is why we need to have another option – a safer and more sustainable option.'

"There is a demand for environmentally sustainable ways of doing things and, in food production, it is important because we cannot continue using these chemicals without causing major, long-term harm to the planet," Associate Professor Leung says.

"We believe the public, the people consuming the food, will appreciate this option because it is safer and more environmentally friendly."

Producing a safe solution

Associate Professor Leung explains that if toxic chemicals are used to protect crops over a long period, those substances will destroy the surrounding elements, which are critical to supporting the plant's life process. Furthermore, toxic residues can accumulate in the local environment, resulting in long-term damage to the ecosystem.

"Copper sulfate is a classic case. For example, the avocado industry – without copper sulfate, there is no avocado industry."

Avocados are just one example of fruits and vegetables protected using chemicals such as copper sulfate. A variety of agrochemicals is used every day to harvest nearly all of the world's commercial produce.

"Right now, we have to use these undesirable substances or we simply would not be able to harvest enough food to support the world's needs. This is why we need to have another option – a safer and more sustainable option."

Potentially harmful substances are not only used during harvesting but also are applied to protect food being stored and shipped to overseas markets. The coating will also be adaptable to protect foods post-harvesting.

"This biodegradable coating can also be adapted to solve post-harvest challenges, including storage and shipping."

Additionally, a large amount of food around the world is wasted due to improper storage, another problem that the biodegradable coating has the potential to address.

According to the Food and Agriculture Organization of the United Nations, "roughly one third of the food produced in the world for human consumption every year – approximately 1.3 billion tonnes – gets lost or wasted".

Associate Professor Leung agrees. "Food spoilage is a serious problem and this could potentially be used to combat that. This is another real-world impact we are thinking about."

The research began after Associate Professor Leung was awarded a Tech Jumpstart Award grant in 2017, as part of UC's annual competition that helps researchers turn their ideas into commercial reality. The project is funded until October 2019 and, while he has already created a useable solution, Associate Professor Leung hopes to acquire more funding to keep building on his current idea.

Associate Professor Leung is continuing to evolve the coating into one that will have broad use in the agricultural industry. In conjunction with the commercialisation team, Associate Professor Leung is currently working on further improving the coating to make it as appealing to investors as possible, an important step in bringing his work to the public.

"We have already come up with a patentable formulation; however, we are continuing to work on enhancing it to ensure the most effective and impactful product is brought to market."

Associate Professor David Leung

Associate Professor Leung's biodegradable coating can help achieve food security in an environmentally friendly and consumer-conscious way.

Technology to tag and track tiny insects could improve Aotearoa New Zealand's biosecurity, safeguarding sustainable food production and export market access.

From left: Dr Graeme Woodward, Associate Professor Barry Wu, Dr Steve Pawson and doctoral student William Sloane.

Biosecurity boost from trap and track research

Smarter ways to monitor and track pests are being developed and trialled by UC's Wireless Research Centre as part of collaborative work aimed at improving Aotearoa New Zealand's biosecurity. The research could help safeguard sustainable food production, along with export market access.

Attaching a tiny harmonic radar tag to an insect and then tracking it using a swarm of drones may sound far-fetched, but the approach has the potential to deliver a level of cutting-edge tracking accuracy for use in biosecurity that until now has been beyond Aotearoa New Zealand's reach.

It is just one of a number of interdisciplinary research projects in the biosecurity area involving staff and students at UC's Wireless Research Centre. Leading the engineering research at UC is Dr Graeme Woodward, supported by Associate Professor Barry Wu, who is an expert in the field of sensor networks. They are working closely with entomologists from Scion, including Dr Steve Pawson on traps and tracking projects, and with Āta mātai, mātai whetū | AgResearch's Dr Scott Hardwick on trap development. Both Scion and AgResearch are member agencies of a cooperative science collaboration called Better Border Biosecurity (B3), seeking to reduce the number of new plant pests and diseases entering and establishing in Aotearoa New Zealand.

Dr Woodward says harmonic radar technology, being researched in conjunction with Scion, has the advantage of being very target-specific. It also does not require batteries, meaning it could be used to create tiny tags for tracking insects.

> 'Some of the insects we're tracking also have a particular threat to the food industry.'

"It should be possible to create a lightweight tag about one centimetre in length. Once tagged, you could then radar-track the insect using a swarm of four or five unmanned aerial vehicles (UAVs). Building the tag and making it small enough is the number one challenge. The second hurdle involves getting enough range so as not to interfere with the insect's flight behaviour."

Scion postdoctoral scholar Dr Anastasia Lavrenko is undertaking research in this area, with her time split between Scion and UC. She started working with the Wireless Research Centre in June 2018.

Her involvement follows other collaborative research with Scion that involved painting insects with retroreflective paint and tracking them using infrared light. Wireless radio tagging of insects has also been trialled.

These innovative tracking systems are being explored because traditional methods using traps laid down at a distance from a release point can produce ambiguous or patchy results. Better insect tracking could pave the way to a better understanding of what leads to insect infestations, in turn helping reduce Aotearoa New Zealand's reliance on border fumigation of export products such as timber.

"Some of the insects we're tracking also have a particular threat to the food industry," says Dr Woodward.

A separate project with potential biosecurity applications, conducted in conjunction with Scion and Āta mātai, mātai whetū | AgResearch, has involved investigating the potential of low power–wide area network (LP-WAN) technologies to gather field data.

A team of four UC students – with backgrounds spanning electrical engineering, computer science and mechatronics – undertook research in this area for their major final-year engineering project. The goal has been to create and develop effective insect trapping instrumentation.

"They started with computer modelling and design work before building a prototype that could be tested," says Dr Woodward.

Their prototype uses a solar panel and incorporates an innovative trap-clearing process. Two UC engineering students spent the 2018/19 summer break doing further field testing. Plans for more advanced prototypes are in the pipeline.

Traditional insect traps simply catch the bugs and then a field worker has to go out and collect the pot at the bottom of the trap to analyse its contents. Adding instrumentation to traps opens up the potential to remotely check and monitor traps, as often as every 15 minutes.

"You could then start to unlock behaviour patterns and work out what insects are flying around at particular times of day, for example," says Dr Woodward.

Work to develop ways of automatically identifying insects remotely is ongoing. Ultimately, camera or video technology in traps could be used to detect biosecurity threats and generate alerts.

"The trap could sit in a field for weeks on end, sending updates several times an hour."

Other past research projects at UC associated with biosecurity have included remote wireless monitoring of possum traps in conjunction with Manaaki Whenua | Landcare Research, and identifying insects using wing beat frequency.

Change agents – proteins in our food

Proteins have a huge influence on the quality of the food we eat. When food is processed its proteins change structure and, in turn, so too do features such as taste, texture, colour and nutritional value. UC Biochemistry student Hannah McKerchar is seeking a deeper understanding of particular protein changes that could influence the future of food nutrition.

Smashing proteins into little bits, charging them up and sending them flying to an analytical bull's-eye target are tasks that are all in a day's research work for UC doctoral student Hannah McKerchar, who is using mass spectrometry to create protein pandemonium at Āta mātai, mātai whetū | AgResearch.

It is all for a good cause – namely to investigate protein modification during processing. Āta mātai, mātai whetū | AgResearch's suite of mass spectrometers is perfectly matched to Ms McKerchar's research task, which involves pulling apart and analysing tiny and complex proteins in food that change as they are processed. As she explains, mass spectrometry delivers extremely accurate results that enable her to pinpoint minute changes in protein structure.

"I've used milk as a starting point in my research because it's such a fundamental food source and I'm studying a specific type of modification that happens during processing."

Ms McKerchar began her doctorate in February 2016 with a UC Connect Doctoral Scholarship, in collaboration with Āta mātai, mātai whetū AgResearch and with the advisory support of Professor Renwick Dobson. The biological study of proteins and food is a key focus for Dobson's lab, whose research is associated with the Riddet Institute, a Centre of Research Excellence that brings together Aotearoa New Zealand's leading scientists in food and nutrition.

Protein modifications

As Ms McKerchar observes, proteins in food change even when the type of processing used is very simple, such as cooking or heating. You only need to think about how an uncooked croissant compares to the completely different smell, taste and texture of a freshly cooked, puffy croissant. Yet not all protein modifications that take place during processing are necessarily desirable.

Heat and acidic conditions can induce a less-than-desirable protein modification in milk that may affect digestibility and nutritional value. The focus of Ms McKerchar's research is to find out more about this particular change and where it happens during processing.

"It's hard to detect and even harder to map specifically where the protein modification of interest is located but we know that it occurs and not just in milk. As this family of protein modifications is present across different foods and beyond food as well, the research is highly applicable to a range of science fields."

If the 'where' part of the puzzle is solved, the next step would be to build digestion models to find out how this protein modification affects digestive systems. Ultimately, the research could pave the way to improved processing and more nutritious food.

> 'Heat and acidic conditions can induce a less-than-desirable protein modification in milk that may affect digestibility and nutritional value.'

While the potential is exciting, the challenges are considerable. The questions of how cells organise and how they regulate their chemistry of cells already represent an extremely complex research field.

"Yet in a food system, where you have unregulated chemistry going on, it's another order of complexity on top of that again," Professor Dobson says.

The added challenge with food is that it's all treated, or processed, differently.

"The way we treat food is very complicated and varied and that's true even of a product like milk," says Ms McKerchar.

By late 2019, she hopes to be in a position to test a putative diagnostic fragmentation pattern of the modification that she has identified in a simplified model system, and extend this knowledge to milk proteins. In fact, she has already trialled her first models, with plans to test against a protein in cow's milk.

Before enrolling in postgraduate studies in science at UC, Ms McKerchar worked as a litigation lawyer. She had earlier completed a Bachelor of Laws and a Bachelor of Science with First Class Honours in Biochemistry, but curiosity led her back to UC to pursue her fascination with biochemistry.

Other research into proteins and food from UC's Biomolecular Research Centre includes a study of differences between cow and goat milk proteins by postdoctoral Research Fellow Jennifer Crowther; and a new PhD study that Amanda Board is just getting under way with funding from the Riddet Institute.

Doctoral student Hannah McKerchar

Understanding protein modification during processing could lead to improved processing and developing more nutritious food.

In exploring the everyday lives of young people, the aim is to better understand how a new generation can be supported to achieve a low-carbon, equitable future.

Postdoctoral Fellow Kate Prendergast, doctoral student Mehedi Hasan, Dr Sylvia Nissen and Associate Professor Bronwyn Hayward look at and discuss photos taken by 12–24 year olds documenting their day.

Towards sustainable prosperity for children and youth

The Children and Youth in Cities: Lifestyle Evaluations and Sustainability (CYCLES) study, led by UC's Associate Professor Bronwyn Hayward, is exploring everyday lives of young people in seven global cities. The aim is to better understand how a new generation can be supported to achieve a low-carbon, equitable future.

Young people's lives can look very different from each other, depending on where they live in the world. Yet, as UC's Associate Professor Bronwyn Hayward observes, what connects them is urbanisation. By 2050 seven out of 10 young people will live in an urban area. It follows that if the world's young people are to have a more sustainable and prosperous future than the one they currently face, then change has to start in the world's cities.

As the research leader for CYCLES, Associate Professor Hayward identified seven cities, including Ōtautahi Christchurch, and worked to establish international research partnerships to study young people's lives in those places. The study itself is an international collaboration funded through the United Kingdom's Economic and Social Research Council (ESRC), as one of several related projects established by the international Centre for the Understanding of Sustainable Prosperity (CUSP) based at Surrey University and headed by ecological economist Professor Tim Jackson. Associate Professor Hayward is a co-primary investigator of CUSP.

"We're interested in finding out what cities can do to better support quality of life for young people in low-carbon ways and that includes understanding their aspirations and life satisfaction and their energy use across five domains: what they are eating, how they're getting around, how their homes are being heated or cooled, their time use (study, work and leisure activities) and their methods of communication."

> 'At a global level, initial results are highlighting a water crisis in many cities as poor governance combined with environmental change is restricting youth access to clean running water.'

The four-year study is now into its second year, looking at the lives of young people in Ōtautahi Christchurch, Dhaka (Bangladesh), Makhanda (South Africa), Jagdamba Camp, New Delhi (India), Lambeth, London (UK), São Paulo (Brazil) and Yokohama (Japan).

To date, the study has focused on the qualitative picture, building up 'a day in our lives' understanding of what life is like for young people in these cities. This perspective has been gathered through photos and drawings young people have created and through interviews to find out what they value and what they would like to change. A touring exhibition of images associated with the study was featured in London for three months as part of the ESRC Social Science Impact Festival 2018/19 and is due to come to Ōtautahi Christchurch in 2019. Award-winning British–Australian film-maker Amanda Blue is also making short films to go alongside the research and add to its wider public impact.

Initial findings

In Ōtautahi Christchurch, 60 students shared their photographs, thoughts and aspirations in eight focus groups. Initial results indicate that the city's green spaces matter to them and young people value and benefit from public activities – everything from festivals to low-key street activity. Very different food consumption patterns are being observed across the city, ranging from traditional high-meat and high-dairy diets in some communities to food insecurity reported by others. Cold housing also emerged as a big issue across many suburbs locally.

"It was striking how many children and young adults here in Christchurch talked about wearing puffer jackets at home to save on heating costs," Associate Professor Hayward says.

At a global level, initial results are highlighting a water crisis in many cities as poor governance combined with environmental change is restricting young people's access to clean running water in four of the seven cities. Air and noise pollution along with inadequate public transport and physical safety are other issues reported alongside huge educational stress in many cities as young people strive to use education to escape poverty.

Other UC-based researchers involved in the CYCLES project include Postdoctoral Fellow Kate Prendergast, who is leading the next quantitative wave of large-scale survey research globally together with Research Fellow Dr Sylvia Nissen, of Te Whare Wānaka o Aoraki | Lincoln University, who led the focus group study and completed her doctoral research at UC, and PhD researcher Luisa Leo. PhD student Mehedi Hassan, whose background is in urban planning in Bangladesh, is leading the study within CYCLES on children's lives in Dhaka.

"Another great spin-off has been the opportunity to also involve masters and undergraduate students as interviewers and research assistants; this builds their capability for future research. More widely, we are also gaining important insights into new methods for cross-cultural research," says Associate Professor Hayward.

The CYCLES study, due to be completed in 2020, supports a new focus on cities in social sciences globally. For example, the next Intergovernmental Panel on Climate Change Assessment – of which Associate Professor Hayward is a coordinating lead author – will examine cities and infrastructure.

Aotearoa New Zealand algae on pathway to high-value product

Microalgae from southern Aotearoa New Zealand are rich in omega-3 fatty acids that could be tapped for commercial use. Doctoral researchers at UC's Department of Chemical and Process Engineering are investigating this exciting resource as a precursor to further development.

In a biological lab at Manaaki Whenua | Landcare Research, UC PhD student Mehrnoush Tangestani has spent many hours studying a green liquid that bears a remarkable resemblance to ordinary pond water.

In fact, the algae in the samples she's been studying are anything but ordinary. At Manaaki Whenua | Landcare Research, Aotearoa New Zealand's leading algae expert Dr Phil Novis was the first to notice that this particular type – from a Southland wetland that is also a mahinga kai site for Ngāi Tahu – has unusually high levels of eicosapentaenoic acid (EPA), an omega-3 polyunsaturated fatty acid. With Ngāi Tahu alongside as a partner and with funding from the 'Science for Technological Innovation' National Science Challenge, he began researching the algae's special properties. The project is aligned with Vision Mātauranga values: Ngāi Tahu has been closely involved from the outset, with iwi representatives gathering samples from the wetland for testing at the Manaaki Whenua | Landcare Research laboratories in Lincoln.

Since 2016, UC scientists have been a part of the research team too. The goal is to develop the commercial potential of this wetland resource, with possible applications as a vegetarian alternative to fish oil health supplements, or as a feed product for aquaculture.

One of the reasons why this research is so exciting is that while similar algae have been found in Europe, there are very few known sources for this type of EPA omega-3 fatty acid. Fish is currently the main source for commercial production of omega-3s. Yet fish don't actually produce these fatty acids – instead they get it from eating microalgae. From a sustainability perspective alone, growing algae for omega-3 provides a promising alternative to harvesting fish for that purpose.

Ms Tangestani, a microbiologist from Iran, started her PhD in June 2016. Her goal has been to fine-tune how to best grow the algae and maximise EPA production. Glass-sided photo-bioreactors containing the algae have been tested in various ways, using variables such as light, pH and temperature.

Along with Dr Novis, Ms Tangestani's supervisory team includes biochemical engineer Dr Gabriel Visnovsky (previously from UC) and UC Associate Professor Ken Morison, her academic supervisor. Her practical work has been completed at Manaaki Whenua | Landcare Research and she has met weekly with her supervisors.

"One of the key challenges has been to find out why this alga grows EPA. We've worked out it's not for energy storage but instead is being used in cell membranes as part of photosynthesis," Associate Professor Morison says.

'One of the key challenges has been to find out why this alga grows EPA [eicosapentaenoic acid]. We've worked out it's not for energy storage but instead is being used in cell membranes as part of photosynthesis.'

EPA production appears to be somewhat temperature dependent and the key is to get the right mix of nutrients and light. Results from the research are promising, showing EPA comprises up to 40% of the cells' oil and 7% of the total dry matter.

Another UC PhD student studying under Professor Morison's supervision is Daniel Smith, with funding from a UC doctoral scholarship. His focus is on scaling up the production process by using a 50-litre tubular photo-bioreactor to maximise biomass and EPA.

"Earlier in my PhD, I spent a couple of months in Spain with world experts in algae production, who have developed commercial-scale plant. I learnt how to design and build a bioreactor there and then built a similar one here for our lab," Mr Smith says.

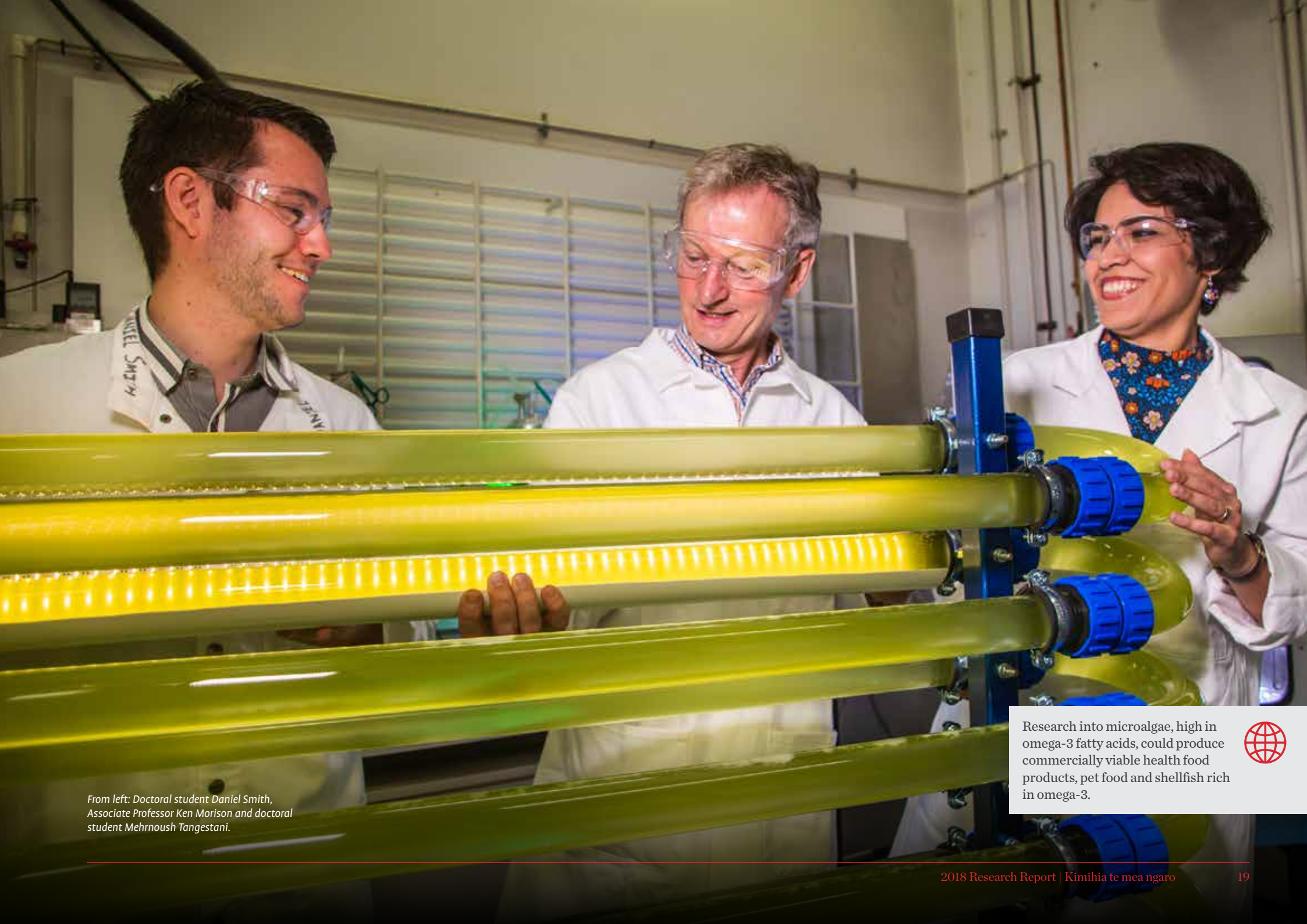
UC master's student Alivia Alfiarty, from Indonesia, has also contributed to this research, with her thesis focused on optimising the algal growth medium.

To date, results are promising though further work will be needed to determine how the algae could be presented as a commercially viable health food product. One option could be to market it in a natural, unprocessed form and as a dry product.

Beyond nutraceuticals, other potential markets include the pet food industry and aquaculture.

"You can feed it to mussels, for example, to produce high-EPA shellfish – it's a very functional and potentially commercially useful application," Ms Tangestani says.

A future avenue of inquiry for the team could be to investigate applications for algae biomass beyond EPA.



From left: Doctoral student Daniel Smith, Associate Professor Ken Morison and doctoral student Mehrnoush Tangestani.

Research into microalgae, high in omega-3 fatty acids, could produce commercially viable health food products, pet food and shellfish rich in omega-3.

Blockchain technology is being explored as a tool to ensure sustainable food production for everyone.

Associate Professor Michaela Balzarova

Blockchain benefits sustainable food production

Adapting new data technologies may lead to fairer food prices for consumers and producers, by increasing transparency.

Associate Professor Michaela Balzarova of Te Rāngai Umanga me te Ture | College of Business and Law is conducting theoretical research into eco-labelling schemes and voluntary environmental systems that businesses adopt to mitigate their environmental and social impacts. She is also exploring alternative schemes and to what extent blockchain technology helps to address sustainability challenges that arise from problems of production and consumption of goods and services.

Using blockchain in future, she suggests, could be a way of ensuring transparency of transactions, gathering more accurate data and eliminating the need for intermediaries. Associate Professor Balzarova believes that once present problems related to trust and a lack of experience with blockchain technology are addressed, using blockchain platform for future transactions could result in reduced prices for consumers and fairer returns for farmers.

For example, Fair Trade labels have been developed to improve the livelihoods of farmers in developing countries. In the case of coffee, the problem with this approach is that products may have gone through as many as 26 intermediaries that may have added no value to the product or service and consumers have no way of knowing if the price they have paid is fair. The transactions are not transparent and are not direct.

Limited benefits to current labelling schemes

Eco-labels were created to address increased consumer demand for environmentally sound and ethical production processes and to provide the consumer with better information about the product, allowing them to make more environmentally friendly purchases. However, literature is inconclusive about the social, economic and environmental effectiveness of eco-labels. In other words, it is not clear whether eco-labels deliver what they promise – that is, creating conditions for indefinite sustainable production and overcoming inequalities within the supply chain – or if they are promoting unsustainable trends in the consumption of goods. Eco-labels are facing challenges in terms of measurability. This is mostly due to a lack of data, inconsistent record-keeping and confidentiality issues, with the result that it is not possible to assess the entire programme's economic, environmental and social impact.

This is where blockchain technology promises improvements. It provides a novel way of recording data and confidence in peer-to-peer trading transactions. It keeps records of digital asset transactions in a decentralised manner, based on mathematical algorithms and financial incentives.

"We need to focus models on how we can feed everyone on a fair basis, improving comfort and standard of living for everyone on this planet. It's not just an issue of getting rid of intermediaries. We need to encourage users to take ownership of data stored on their behalf and blockchain enables this," says Associate Professor Balzarova.

"Right now, I have been exploring benefits of blockchain technology in sustainable food production theoretically, by looking at what blockchain offers versus experiences with labelling schemes that try to mitigate adverse production impacts. In the field of food production and agriculture, I see a clear overlap of my research interests with UC's Kia Tōpū programme."

Associate Professor Balzarova first discovered blockchain during a short visit to Vienna in 2017. She is returning there in 2019 to join a team of colleagues from the University of Natural Resources and Life Sciences (BOKU) that will assist Grüne Erde GmbH – the first Austrian company certified under Fair Wear Foundation – to set up a system for monitoring and remediating the labour conditions of its suppliers. Furthermore, Associate Professor Balzarova will be presenting the outcomes of her conceptual study at an international conference of the European Academy of Management, EURAM 2019, in Portugal later in the year.

'We need to focus on creating models that can feed everyone on a fair basis, improving comfort and standard of living for everyone on this planet.'

Adding value to food waste

New Zealanders throw away thousands of tonnes of leftover food every year, but an ingenious new solution being engineered at UC aims to turn such waste into valuable chemical components that could be used to make bioplastics.

From household scraps to café leftovers and date-expired supermarket goods, food waste is a big problem in Aotearoa New Zealand. Most of this uneaten food is thrown out and left to rot, but what if something really useful could be done with it instead?

At UC's Department of Chemical and Processing Engineering, Dr Alex Yip is leading research into food waste conversion. He has already undertaken collaborative work to design and develop a catalyst to achieve this outcome with the Hong Kong Polytechnic.

"The ultimate objective is to produce a high-value product from food waste. To date, we have completed a proof of concept showing that it's feasible," Dr Yip says.

Funding is now being sought from Hīkina Whakatutuki | Ministry of Business, Innovation and Employment to fully develop the technique for the Aotearoa New Zealand context, using food waste from retail, restaurant and supermarket sources.

Creating a catalyst

The project's goal is to extract three key chemical components, including polylactic acid (PLA) and the organic compound 5-HMF, from the food waste stream. These could then be used as building blocks to make bioplastics with various properties to suit consumers' needs in a sustainable way.

"At the moment we're designing the catalyst for the process and we're planning to collaborate with Eco Stock in Tāmaki-makau-rau Auckland, which is the biggest food-waste collector in New Zealand," says Dr Yip.

Eco Stock has been recycling surplus food into stock feed at its plant in South Auckland for more than a decade and also supports composting and worm farms as a way of minimising waste. If this innovative project is successful, food waste could wind up having an exciting new use as raw material for valuable bioplastics.

Bioplastics produced from food waste would be 100% recyclable or fully biodegradable. They could be used for products such as biodegradable bin liners.

Sending food waste to rot is still the most common outcome for it in Aotearoa New Zealand. Once in landfill, food waste breaks down and emits gases such as carbon dioxide and a particularly powerful greenhouse gas – methane.

"This waste stream carries opportunity and financial costs. What we're trying to do is add value to that waste by converting it into something useful while at the same time also responding to another environmental problem in Aotearoa New Zealand, which is the plastic waste problem."

> 'The ultimate objective is to produce a high-value product from food waste. To date, we have completed a proof of concept showing that it's feasible.'

The future of food waste

Clearly then, being able to convert food waste into bioplastics would deliver the dual benefit of lowering greenhouse gas emissions while also reducing the amount of non-biodegradable plastics going into the country's landfills.

Currently UC has two PhD students working in the specialised field of catalytic conversion for food waste valorisation. Provided funding is approved, this latest project is on track to start in October 2019 and would also involve researchers at the University of Auckland | Te Whare Wānanga o Tāmaki Makaurau.

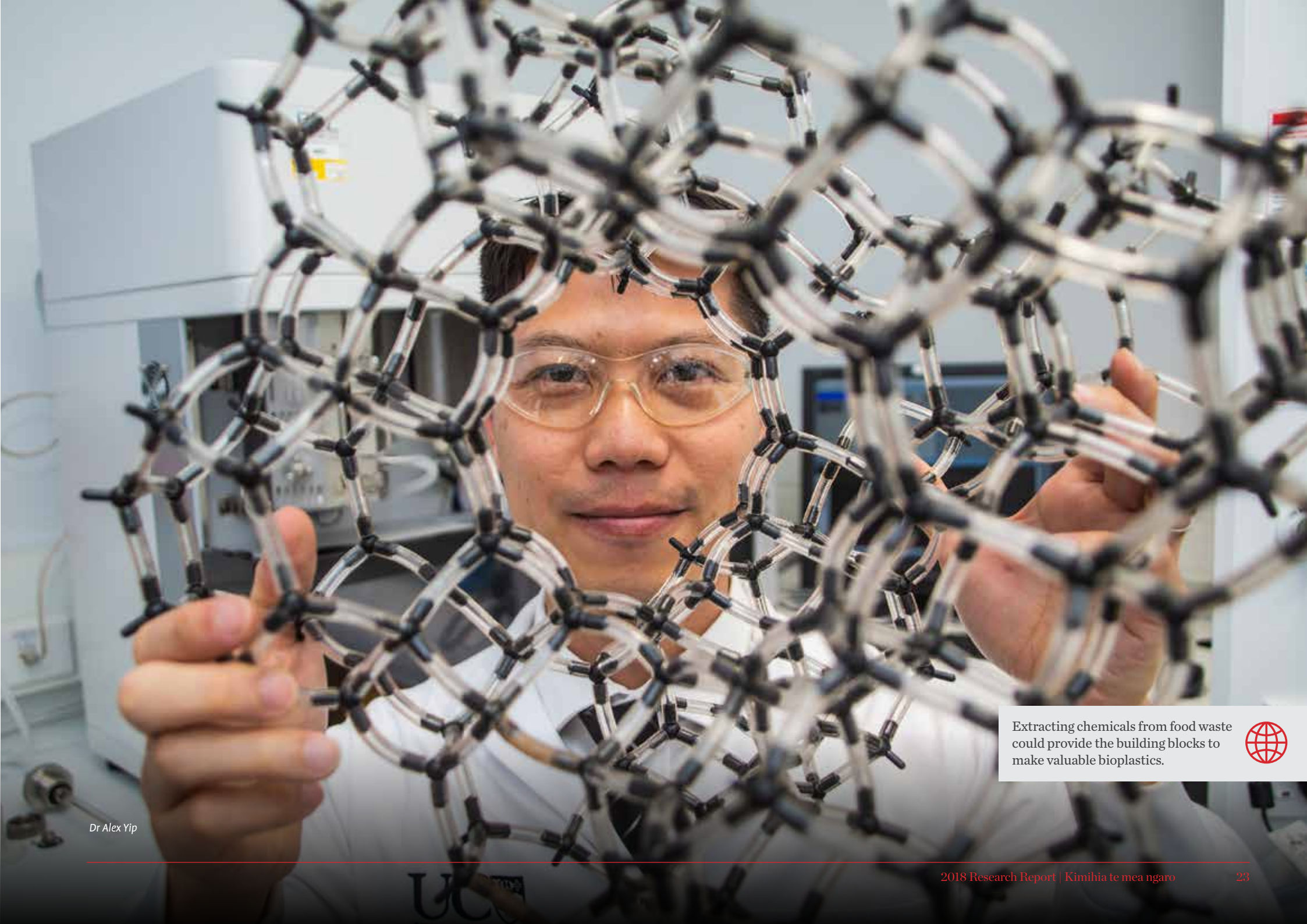
If successful, it would represent a pioneering breakthrough for catalytic conversion of food waste for this particular purpose. The project's first goal would be to prove the concept could work before moving to the pilot phase. Long term, the objective is to scale up the process for commercial application.

"We're convinced that our process with this specific catalyst is very promising," says Dr Yip.

He also notes that Hong Kong research in this field relies on a catalytic process that is less environmentally friendly and has a higher process cost, though the objectives are similar.

Dr Yip's research interests range widely, from design and development of new catalysts with environmental and economic benefits through to the design of advanced nanomaterial. He studied engineering at the University of New South Wales and completed his doctorate at the Hong Kong University of Science and Technology. He was a Postdoctoral Research Fellow at the University of California, Berkeley, in the United States of America.

He has been a senior lecturer at UC's Department of Chemical and Process Engineering for the past three years and is director of Third Professional Year Studies.



Dr Alex Yip

Extracting chemicals from food waste could provide the building blocks to make valuable bioplastics.

A pioneering conservation approach aims to enhance sustainability of species and commercial outcomes for kēkēwai freshwater crayfish.

Doctoral student Aisling Rayne

Securing sustainable kai: a conservation genomics approach

UC scientists, in partnership with primary industry and Te Ngāi Tūāhuriri Rūnanga, mana whenua, are pioneering a conservation genomic approach to enhance commercial, customary and conservation outcomes for a declining mahinga kai species.

UC's Conservation, Systematics and Evolution Research Team (ConSERT) is at the forefront of an interdisciplinary research approach that includes Ernslaw One's aquaculture company KEEWAI and is harnessing diverse expertise for the mutual benefit of conservation and primary industry. Threatened species and species in primary industry face similar challenges associated with small population size, including low genetic diversity and high levels of inbreeding. ConSERT's research shows that collaboration between conservation geneticists and primary industry can lead to better science and, in turn, better conservation and commercial outcomes.

The group co-developed a 'genetic rescue' project, led by UC PhD student Aisling Rayne, to enhance commercial outcomes for kēkēwai freshwater crayfish *(Paranephrops zealandicus)* by increasing short-term productivity and long-term resilience.

From a conservation genomics perspective, resilient populations include those that are able to evolve – or adapt – in response to environmental change. Generally, populations with more genetic variation are better equipped to evolve. Thus, conservation geneticists prioritise the co-development of strategies that seek to minimise the loss of genetic variation over time.

Genetic rescue

The introduction of unrelated individuals into small inbred populations to increase survival and reproduction has potential as a management tool to enhance commercial productivity. Although the approach is gathering widespread interest, the genetic mechanisms underlying genetic rescue remain unclear. To better understand these mechanisms, and to develop broadly applicable best-practice guidelines, Ms Rayne and her colleagues co-designed an innovative genetic rescue experiment.

Mr John Hollows, manager of KEEWAI, has established over 1,800 aquaculture ponds in Ōtākou Otago and Southland forestry blocks, offering an unprecedented opportunity to determine the genetic mechanisms underlying genetic rescue. Many of the ponds at KEEWAI were stocked with small numbers of kēkēwai, each from a single source population. As a result, the productivity of KEEWAI ponds may be compromised due to low genetic diversity and inbreeding.

"These genetic rescue experiments are important for the future of KEEWAI, as this work hasn't been done before," says Mr Hollows.

To date, the research team has performed a genetic rescue experiment using aquaculture ponds previously stocked using wild populations. "Until now, we haven't been able to directly test these questions using established populations. However, the unique set-up at KEEWAI has enabled a replicated experimental design that will translate to clear commercial outcomes and inform conservation management of the species elsewhere," Ms Rayne says.

> 'The unique set-up at KEEWAI has enabled a replicated experimental design that will translate to clear commercial outcomes and inform conservation management of the species elsewhere.'

Genomic data produced in the genetic rescue experiment will be enhanced using a platinum-standard 'reference' kēkēwai genome that is being developed in an aligned project. Ms Rayne explains that until recently, geneticists have been limited to using a handful of 'neutral' genetic markers. However, now tens of thousands of 'neutral' and 'adaptive' genomic markers can be used to measure genetic variation across the genome. Ms Rayne will combine these genomic data with traits of commercial interest to determine whether genetic rescue is attributed to an overall increase in genome-wide diversity or introgression of novel variants at specific genes. The effects of genetic rescue are likely to vary across generations, so the experimental ponds at KEEWAI will be monitored for at least several years.

Resolving the genetic mechanisms underlying genetic rescue will inform the management of aquaculture ponds. For example, if increased productivity in the 'genetically rescued' ponds is due to an overall increase in genome-wide diversity, then any source population that is genetically different can be used for genetic rescue. However, if increased productivity is due to introgression of new variants at specific genes, then only source populations with those variants should be used.

The team will extend the results of its research beyond KEEWAI. For example, in an aligned project with Te Ngāi Tūāhuriri Rūnanga, Ms Rayne and kaitiaki mahinga kai are actively co-developing research to better enable sustainable customary harvest. These actions may include strategies to re-establish or augment existing populations, or to establish new populations in suitable habitat.

Mr Hollows says he is happy to be involved in the project.

"Achieving important outcomes for aquaculture and conservation is our operating plan – we want to farm kēkēwai commercially, but we also want to ensure the species itself is secure moving forward."

Finding balance in the Mekong Basin

Economic development in the Mekong Basin is altering the food-water-energy nexus in the area – and UC researchers are working to find a balance.

For eight years, Professor Tom Cochrane has been conducting research in the Mekong Basin in Southeast Asia. He began by looking at the development of hydropower schemes in the area following intense economic development in the late nineties. Subsequently his focus has been on how this development has altered the food-water-energy nexus and could continue to do so.

"When researching the catchment, we found a very clear link between how energy production was affecting water flow and food productivity down the line, particularly in the Mekong Basin" Professor Cochrane says.

The advancement of hydropower has supported the economic development of countries such as Vietnam, Laos and Thailand since the nineties, but it has also upset a number of natural balances. Before hydropower was developed, the natural water flow of rivers would carry and disperse sediment, which served as a natural fertiliser and supported food production and the water flow. It also varied naturally, creating wet and dry seasons that in turn supported fisheries and crop production.

To support the development of countries in the region, new large hydropower schemes are being proposed and more areas are being turned into productive land, which further upsets the natural ecosystem.

"We start to see a decline in species, and the ecosystem as a whole, as the habitat they usually live in is destroyed. Overall, this is an economic risk," Professor Cochrane says.

As more hydropower dams are constructed to support economic growth, the natural flow of sediment and seasonal water level in the area are altered.

"A lot of people live in this region and depend on the water supply, food resources, protein from fish and aquatic lifestyle. All the development is changing the way people are living, their livelihood, the agriculture, and causing big impacts on their food productivity."

In response to these changes, farmers in the Mekong Basin are constructing levees and stock banks to manage the flow of water through their land and protect the productivity. These initiatives have flow-on effects for neighbours further downstream.

Conservation International, the Mekong River Commission and the governments of Laos, Vietnam, Thailand and Cambodia are working together to develop these areas in a sustainable way, while minimising impact on their neighbours and those further downstream.

Professor Cochrane has led a team of six doctoral and three postdoctoral students over the years, and works in collaboration with the organisations named above and a number of other institutes and university researchers from the United States of America, Vietnam, Cambodia, Thailand and Finland.

"We are providing our skill and knowledge in modelling ecological systems, environment and agriculture, and sharing our understanding of how these development projects affect the local environment. We are also investigating thresholds that will affect the ecology and agriculture of the Mekong in a more permanent way."

> 'We start to see a decline in species, and the ecosystem as a whole, as the habitat they usually live in is destroyed. Overall, this is an economic risk.'

Professor Cochrane and doctorate students from UC have been visiting the Mekong Basin twice a year to take water samples, observe the area and work with local researchers and students.

"It is good to stand back and spend time really understanding what is going on and how all of these things are interrelated," Professor Cochrane says.

More than just being concerned with economic development, the area is facing climate change challenges. Rising sea levels and extensive groundwater pumping for agricultural purposes are slowly causing the Mekong Basin to sink – an issue that has become a focus of Professor Cochrane's research.

"The land in the basin is quite low-lying and some of the modelling conducted on sea-level rise forecasts a number of villages will be under water by the 2060s. However, the villages are only there because of the agriculture and if that is no longer viable, the villages won't remain. It is a very complex situation."

Professor Cochrane is working to find a balance in the food-water-energy nexus of the Mekong Basin so that he can make recommendations to governments and other environmental organisations.

"We aim to be able to provide advice on where to develop hydropower schemes, how to operate them and reduce impact, and how to manage irrigation schemes in the basin and adapt to climate change. This might mean engineering ways to adapt to sea-level change through engineered ways or restoring vegetation buffers and preserving native mangroves.

"There are lots of potential adaptation strategies and that is what we are trying to explore."

Professor Tom Cochrane is exploring adaptive strategies to help areas like the Mekong Basin find the balance between economic advancement and ecological conservation.

Professor Tom Cochrane

A comparative winegrowing study has highlighted a gap in the biosecurity system in one of Aotearoa New Zealand's biggest export industries.

Doctoral researcher Tim Baird

Winegrowing and sustainability in Australia and Aotearoa New Zealand

How cool-climate winegrowing regions are responding to sustainability issues has been put under scrutiny by UC PhD researcher Tim Baird, now a lecturer in tourism and entrepreneurship at Lincoln University. His findings point to unresolved tensions and issues within the industry.

Attitudes and practices of Aotearoa New Zealand winegrowers have been on Tim Baird's research radar for almost a decade now. His interest in this area was first piqued while studying for a master's degree in management and marketing at UC's Te Kura Umanga Business School.

In 2010 he completed a national survey as part of a longitudinal study of wine tourism in Aotearoa New Zealand, which included questions on sustainability. It paved the way to a PhD, starting in March 2013 and now nearing completion.

One key difference he observed in Aotearoa New Zealand's industry-wide sustainability certification programme, compared with other parts of the world, is that winegrowers here must sign up to the programme's sustainability practices in order to be a part of the industry. Similar programmes elsewhere take a voluntary approach. The 2010 survey revealed that some Aotearoa New Zealand winegrowers were unhappy with this mandatory stance and felt they were not getting any economic benefit out of it. As a result, they were starting to question its value.

For his PhD, Tim also turned his attention to the cool-climate winegrowing areas of Tasmania and Western Australia to provide the first internationally comparative data on approaches to sustainable winegrowing.

"We took the template of the New Zealand survey and modified it for Tasmania and Western Australia with the help of Curtin University in Perth. As well, we were able to draw on the New Zealand longitudinal study, including the latest survey in the series done in September 2015. Effectively, it's a supply-side perspective looking at wine producers and what the reality of making wine is like for them," Mr Baird says.

Professor C Michael Hall and Professor Pavel Castka, of UC's Department of Management, Marketing and Entrepreneurship, supervised the research.

Its findings reveal not only conflicting definitions between winegrowers of what actually constitutes sustainability but also, in the Aotearoa New Zealand context, a sense of disengagement from Sustainable Winegrowing New Zealand (SWNZ). Some smaller wineries noted they simply could not afford to sign up to the programme, while others reported feeling short-changed because they never saw anyone from the organisation and were left wondering what the levy was actually for.

"The end result is a group of wineries that regard themselves as penalised in terms of export potential purely by the inflexibility of the sustainability indicators of SWNZ, rather than their preferred strategies. The mandatory nature of the programme for exporters also reinforces the impression that it has been developed as much to reinforce the brand positioning of New Zealand wine, rather than any commitment to actually be 'sustainable'," Mr Baird says.

He has observed an apparent lack of meaningful communication between industry bodies and winegrowers themselves. Some pioneering winegrowers also expressed frustration at being charged to be part of a national programme that they felt simply echoed what they'd already put into action.

In Aotearoa New Zealand, he suggests another issue is that the industry has been somewhat slow off the mark with addressing biosecurity issues associated with wine tourism.

"By way of comparison, in Tasmania they have a really proactive biosecurity system through Wine Tasmania and also have a system of winegrowing programmes that incorporate biosecurity elements. They're very aware that a disease outbreak could wipe out their wine industry."

Last year, Mr Baird and his supervisors had a paper based on this research published in the journal *Sustainability* under the title 'New Zealand Winegrowers' Attitudes and Behaviours towards Wine Tourism and Sustainable Winegrowing'.

> 'The programme reinforces the impression that it has been developed as much to reinforce the brand positioning of Aotearoa New Zealand wine, rather than any commitment to actually be 'sustainable'.'

"There will be more papers coming out in due course. I hope that New Zealand's national body looks at all of this, because they do seem to be on a somewhat different page to the wineries themselves," Mr Baird says.

Another important thread in the research is social justice as an aspect of sustainability. In both Tasmania and Western Australia, the surveyed groups placed a high value on social justice and migrant workers' rights whereas Aotearoa New Zealand winegrowers were somewhat less committed on that issue.

Increasing ryegrass harvests for Aotearoa New Zealand livestock

Altering genes that cause seed shattering in ryegrass could dramatically curtail harvest loss and, in turn, produce considerable economic benefits.

Experts consider ryegrass to be the most valuable plant species in Aotearoa New Zealand. In 2012, it had an estimated $14.5 billion impact on the country's GDP, primarily because it is highly valued as fodder for the livestock industry.

Ryegrass is difficult to harvest, because the plant is developmentally programmed to shed its seed, an abscission event known as seed shattering, during harvesting. As a result, up to 50% of the seed yield may be lost.

Compared with cereal crops, perennial ryegrass is less domesticated, having been actively bred for fewer than 100 years. Due to its short breeding cycle, it has kept its seed-shattering trait.

Professor Paula Jameson in Te Rāngai Pūtaiao College of Science is leading a team to tackle the seed-shattering problem by studying the genes that cause seed shattering in certain grass species, like perennial ryegrass, and the genes that prevent seed shatter in other crops, such as rice and sorghum.

"The yields can vary really significantly and for ryegrass, for instance, the seed falls off. If you are thinking of your main domesticated cereals, like wheat, barley and maize, the seed doesn't fall off because over 10,000 years of domestication retaining the seed has been selected for," says Professor Jameson.

"What we did in this project is look at non-shattering genes in other cereals and use that genetic information to go and look in perennial ryegrass for those genes, which we found. There are many commonalities across all the grasses' genetic makeup."

Isolation and gene editing

Samples of plant material were studied at the UC glasshouses and in field plots in Waitaha Canterbury. Some of the plants for the study were also grown and analysed at Yantai University in China.

"We carried out a comparative genomics approach to isolate these genes in perennial ryegrass. We also conducted morphological and histological analysis of the abscission process in this species."

Results of the study were published in January 2019, outlining the isolated putative seed-shattering genes of perennial ryegrass. By identifying these genes in their research, Professor Jameson and her team have opened the door for plant breeders to develop reduced shattering lines of ryegrass.

"We were able to provide useful information on the genetic mechanism of seed shattering in perennial ryegrass, which can be used to provide targets for functional analysis," says Professor Jameson.

"The idea now would be to go in and use gene editing to mutate a specific gene in the way that it has been mutated in cereals and see what happens. Ideally, that is where this work is headed in the future."

The findings have the potential to dramatically lower the cost of perennial ryegrass seed, and in turn fodder, which means a significant expenditure reduction for farmers using the grass.

"Ryegrass is the most valuable plant to New Zealand because it underpins the entirety of the grazing system. If you think about the meat industry, the milk industry, all of the animals that graze on ryegrass, all of them are reliant on ryegrass seed that has been grown in New Zealand."

Ryegrass, sometimes referred to as *Lolium*, is a genus of tufted grasses in the bluegrass sub-family used as the principal grazing grass in Aotearoa New Zealand, where over 10 million kilograms of certified seed are produced each year. The soil and climate in this country are ideal for harvesting ryegrass seed.

It is the most common grass found on farms throughout Aotearoa New Zealand. The main advantage of the plant is its ability to keep growing over a long period. The grass also recovers well in wet winters, which is crucial in areas like Te Waipounamu South Island.

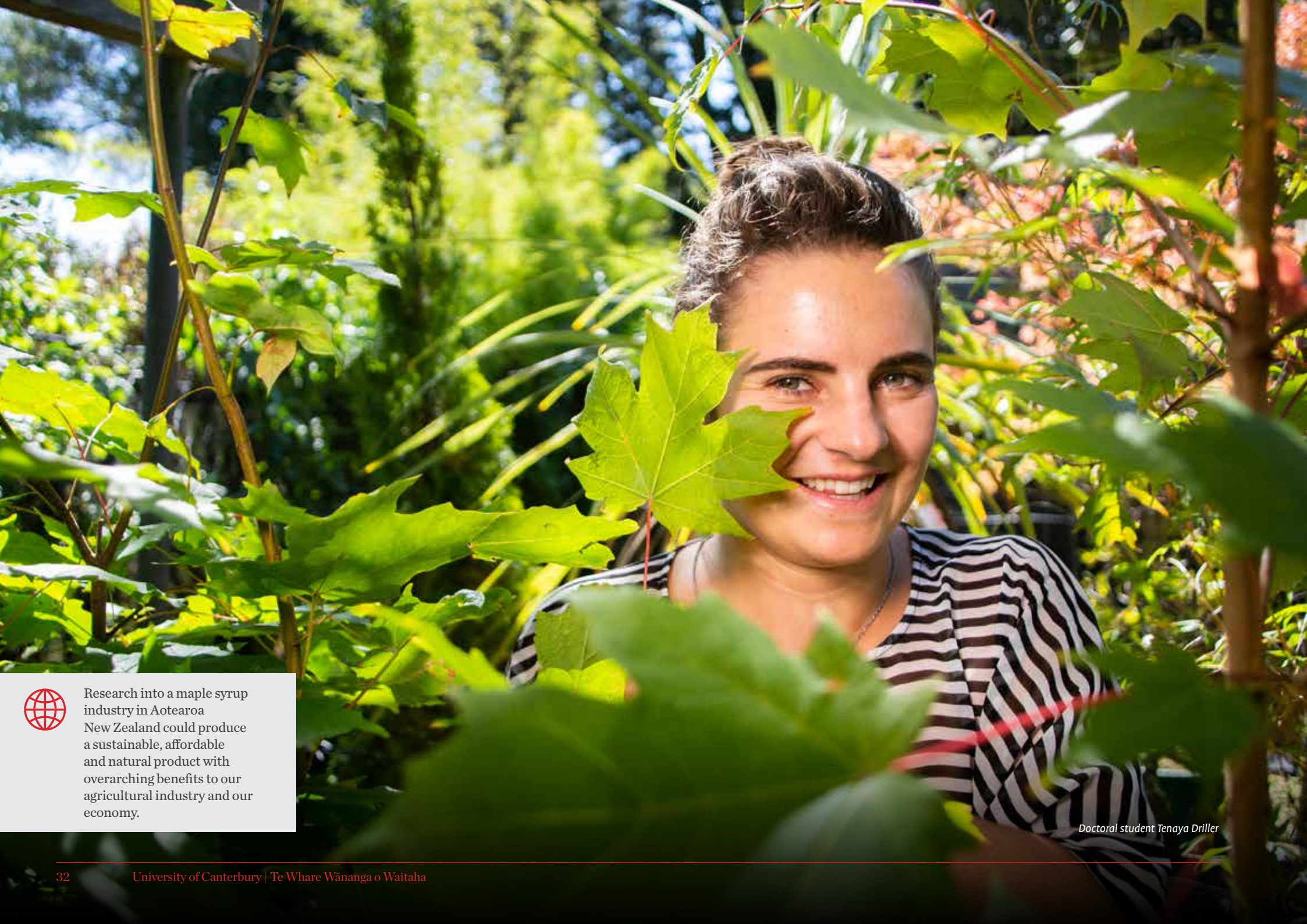
Ryegrass is also used in other parts of the world, including Asia, North Africa, Australia, South America, the United States of America and Canada.

The team working on the research included Dr Zeyu Fu, who received a PhD scholarship from the New Zealand Foundation for Arable Research, and Professor Jiancheng Song from Yantai University, who was previously a senior research fellow with Professor Jameson at UC.

'Ryegrass is the most valuable plant to New Zealand because it underpins the entirety of the grazing system. If you think about the meat industry, the milk industry, all of the animals that graze on ryegrass, all of them are reliant on ryegrass seed that has been grown in New Zealand.'

Professor Paula Jameson

Altering genes that cause seed shattering in ryegrass could dramatically curtail harvest loss and, in turn, produce considerable economic benefits.



Research into a maple syrup industry in Aotearoa New Zealand could produce a sustainable, affordable and natural product with overarching benefits to our agricultural industry and our economy.

Doctoral student Tenaya Driller

Tapping northern nectar in Aotearoa New Zealand

A family connection has seen UC doctoral student Tenaya Driller travel to the other side of the world to research the viability of maple syrup production outside of North America.

Ms Driller grew up watching her grandparents tap maple trees in the New England state of Vermont, so when she was considering her options for postgraduate study, maple syrup production was the immediate standout among a proposed list of doctoral subjects.

"I quickly latched onto that – I love maple syrup, I love trees and, of course, there was a family connection," Ms Driller says.

Through her research, Ms Driller hopes to better understand the process of sap exudation in maple trees by using a wide range of enhanced imaging techniques, and then use her findings to assess the viability of maple syrup production within Aotearoa New Zealand.

Traditionally maple trees are left to mature for 20 to 30 years before holes are drilled into the trunk and tapped, allowing the sap to drip out. But first, the weather must be just right.

Throughout winter the tree will freeze to a temperature of –23˚ Celsius (–10˚ Fahrenheit) before warming in spring and exuding the sap that will become maple syrup.

Because of the combination of the time required for trees to reach maturity and the great volume of sap necessary to produce syrup (43 litres of sap makes just one litre of syrup), genuine maple syrup is an expensive product unlikely to be found in the pantries of Aotearoa New Zealand.

But new research out of North America has demonstrated a way to produce sap from smaller, younger trees by removing the top and using a vacuum rather than a tap to remove the sap.

> 'Smaller, locally grown trees should exude sap as they do in North America but without requiring such frigid weather, and without the decades-long wait required for mature trees.'

It's this process Ms Driller believes could prove maple syrup production is viable in Aotearoa New Zealand.

"Smaller, locally grown trees should exude sap as they do in North America but without requiring such frigid weather, and without the decades-long wait required for mature trees."

Building on work accomplished by undergraduate research and honours projects, the UC research team considered seven environmental factors when determining the best location for a local experiment: minimum and maximum daily temperatures, sunshine hours, annual rainfall, soil moisture, soil temperature and soil type.

With those criteria, using a geographical system and weather stations around the country, they overlaid maps and found inland of Whakatū Nelson was one of the regions that ticked all the boxes. Having a maple syrup producer already established within the region was an exciting added bonus for the research team.

That the grower was able to produce syrup with bigger trees in the Tasman climate was further encouragement for Ms Driller's project – a positive sign that using smaller trees could be successful.

Nature's golden sweetener

What would the local production of a distinctly North American product mean for New Zealanders? A sustainable, affordable and natural product with overarching benefits to Aotearoa New Zealand's agricultural industry and our economy.

Maple syrup is harvested in the spring, unlike most other domestic agriculture products. This is a bonus for both local growers and seasonal workers, as maple trees can be grown alongside other crops, which could allow two or more harvests from one plot of land.

The trees are also not picky as to where they are grown and can be planted in rocky or steep terrain previously thought unfit for agriculture.

The success of this experiment could have run-on effects for a variety of other produce that growers had previously assumed couldn't grow in the Aotearoa New Zealand climate.

Over 70% of all maple syrup is currently produced in Canada and exported around the world. The benefit of a local product for everyday New Zealanders would be the more accessible price and the potential export to our closest neighbours.

Australians are the fourth-largest importer of Canadian maple syrup globally and, given our proximity, the Aotearoa New Zealand production of a high-quality, natural product at a lower price would be certain to make an impact.

For Ms Driller, the potential is limitless.

"I've really enjoyed being a part of establishing a potential maple syrup industry within Aotearoa New Zealand, to find out what's actually working and why. I'm excited to see what comes of our research."

Ms Driller acknowledges the support and assistance of her senior supervisor, Associate Professor Matthew Watson, co-supervisor Associate Professor Daniel Holland and the PhD scholarship of Te Rāngai Pūkaha | College of Engineering.

Food preservatives and household products driving antibiotic resistance

Active ingredients in food preservatives and household products have been linked to an increasing resistance of bacteria to antibiotics.

Professor Jack Heinemann from Te Kura Pūtaiao Koiora | School of Biological Sciences is looking at the social issue behind antibiotic resistance and how the social environments we create lead to antibiotic resistance.

"I'm not studying human medicine; what I want to know is why our options for some of the most wonderful chemistries ever invented are running out."

The chemistries behind antibiotics are amazing for their relatively low toxicity to people and relatively high toxicity to bacteria. Professor Heinemann believes one of the issues that has led bacteria to resist antibiotics so rapidly is the commercial component of drug manufacture.

"We allowed these global non-renewable resources to be turned into market-driven, private-wealth forces where companies aim to sell as much of the product as they can during the life of the patent."

Adaptable bacteria

Bacteria have an incredible ability to change which genes they express in different environments. They can turn on a set of genes specifically when toxins are present to make themselves less likely to be killed. If the concentration of a toxin is not high enough to kill the bacteria, it has a chance to adapt, even to develop an immunity to that level and type of toxin.

"This creates a population of physiologically adapted bacteria. From that population, there is a much larger possibility of mutation and the bacteria might acquire a gene from somewhere else that further increases their resistance," says Professor Heinemann.

> 'What I want to know is why our options for some of the most wonderful chemistries ever invented are running out.'

Preservatives in our food, emulsifiers, surfactants in herbicides and household kitchen cleaners are toxic to bacteria. Sub-lethal exposures to these can act like a vaccine to antibiotics. In combination, they are generally lifting the tolerance of bacteria to our antibiotics. It is called minimum inhibitory concentration (MIC) creep and adaptation is rapid.

"We have simultaneously exposed bacteria to off-the-shelf herbicides and what should have been lethal concentrations of antibiotic. The herbicide made the bacteria resistant to the antibiotic before the antibiotic could kill them," says Professor Heinemann.

One way of describing this process might be that it is an unstoppable cycle. The products we use in food production and preservation, agriculture and household products are aimed at protecting our food, along with its longevity, production and environments, but they are in turn building the resistance of bacteria to antibiotics and reducing their effectiveness.

Focus on the environment

The three main ways people are exposed to herbicides are ingestion (such as of food), contact (such as with pet fur) and inhalation (such as of spray drift). Our environment plays a large part in how we, and our bacteria, are exposed. Ingestion exposure in people is thought to be relatively low, but can be high in livestock and pets. If we live on a farm, then we might be exposed to bacteria from the livestock; equally city dwellers might be exposed to bacteria from pet faeces.

"My focus is the environment and where the resistance is coming from in these bacteria that eventually colonise us. I liken it to a match around gasoline: it's not the cause of the resistance but it lowers the barrier to igniting the gasoline," says Professor Heinemann.

Maximum residue limits apply to food and produce, reducing the level of ingestion for people. For livestock, however, farmers are free to spray paddocks and graze livestock simultaneously, creating a very different environment for those living and working rurally.

Professor Heinemann's research has moved out of the lab and into the environment. He is using water samples from the Ōtākaro Avon River in Hagley Park (urban environment) and Silver Stream (rural environment) to study and compare the antibiotic resistance and adaptation of *E. coli* in the two different environments.

"Long term, I want to restore the effectiveness of our antibiotics by understanding the ecology of resistance and how big the problem is.

"Step one is to acknowledge we are not going to control bacterial resistance simply by controlling antibiotics. What we need is to understand the combination of chemicals we are exposed to every day in our environment that is increasing antibiotic resistance."

Professor Jack Heinemann and Sophie van Hameslveld watch on as Dr Brigitta Kurenbach takes water samples.

By understanding the effects of chemical combinations used in food production, preservation, agriculture and household products on bacteria, Professor Heinemann hopes to restore the effectiveness of antibiotics.

Research into society's 'meat culture' reveals an increase in awareness of the consequences of food production and consumption.

Professor Annie Potts

Scrutinising meat culture in Aotearoa New Zealand

More New Zealanders than ever are switching to plant-based diets. Researchers at UC's New Zealand Centre for Human-Animal Studies (NZCHAS) are exploring changing food beliefs and practices and themes of food justice and sustainability.

'Meat culture' has been an important subject of study at NZCHAS for more than a decade, involving researchers from UC and associates from throughout Aotearoa New Zealand. It is a theme that encompasses food justice and sustainability, along with 'carnism' (the ideological assumptions, values and practices attached to meat-eating) and its opposite, veganism. A 2007 nationwide survey on ethical consumption in Aotearoa New Zealand, conducted by Professor Annie Potts and Mandala White, first established the theme within NZCHAS.

It has since produced a number of cultural histories on sheep and sheep farming (Professor Philip Armstrong, NZCHAS and Cultural Studies); chickens and global intensive chicken farming (Professor Potts, NZCHAS and Cultural Studies); and animal agriculture and the rise of vegetarianism and veganism (which Professors Potts, Armstrong and Brown explored in their landmark bicultural text, *A New Zealand Book of Beasts: Animals in Our Culture, History and Everyday Life*). Aotearoa New Zealand's farming practices and associated animal welfare and environmental impacts have also been examined (Dr Alison Loveridge, NZCHAS and Sociology). In 2016 Professor Potts edited *Meat Culture*, a book containing contributions from leading international scholars.

A PhD programme in Human-Animal Studies, established by NZCHAS, is attracting high-calibre candidates from within Aotearoa New Zealand and around the world.

"I am over the moon, particularly at the enthusiasm of the postgraduate students coming through," says Professor Potts, who is co-director of NZCHAS.

These students are driving much of the innovative new research on meat culture. For example, PhD student Brad Rea is examining masculinity, primitivism and carnism in futuristic novels, while PhD scholar Kirsty Dunn has won an international award for her research on Māori plant-based food ethics. Political Science MA student Eilish Espiner is investigating interspecies sustainability and how plant-based foods can alleviate global poverty and improve health, while Marketing PhD scholar Samantha White is researching the consumption and promotion of meat substitutes.

Factors driving research interest on meat culture – and a rapidly increasing demand for plant-based meat, dairy and egg substitutes – include concern about the suffering and slaughter of other species farmed for consumption, along with environmental and sustainability issues. According to a 2009 United Nations report, global agribusiness accounts for 18% of the world's greenhouse gas emissions. It is also recognised that beef production consumes vastly more water than plant food crops like root vegetables, pulses and grains.

"In 2016 I was invited to speak at a public forum and workshop on interspecies sustainability, funded by Sydney University. As a result of this workshop, we published an article called 'A Sustainable Campus: The Sydney Declaration on Interspecies Sustainability' in *Animal Studies Journal*," says Professor Potts.

> 'Consumer preferences and awareness of the consequences of food production are increasingly creating a need for new products.'

This article urges universities to actively promote plant-based diets, include interspecies ethics as part of social justice commitments and recognise animal agriculture as a key contributor to climate change.

Social justice and human rights issues are undoubtedly driving change too. In the spotlight of late, for example, has been Aotearoa New Zealand's controversial import of phosphate for farm fertiliser from Morocco, taken from disputed territory in Western Sahara.

Coupled with these issues comes mounting research into the health costs of eating meat. A recent article in medical journal *The Lancet* reports that "the health-related costs directly attributable to the consumption of red and processed meat will be US$285 billion in 2020 or 0.3% of worldwide gross GDP".

In her own work, Professor Potts has closely examined ideas and expectations about 'kiwi manliness' and how these create difficulties for men who want to move to plant-based diets or who are already vegetarian or vegan.

"I'm heartened to read in studies that it is actually young men who are increasingly opting for plant-based diets in contemporary Aotearoa."

In turn, consumer preferences and awareness of the consequences of food production are increasingly creating a need for new products.

"High-protein plant-based alternative non-GMO [genetically modified organism] meats, such as Aotearoa New Zealand's own Sunfed Chicken-free Chicken, will make an impact on those who care about their own health, the environment and animals' wellbeing, but want to continue to enjoy the taste of meat."

Editorial. (2018). "We need to talk about meat". The Lancet, 392(10161: 2237).

Spreading the load on fisheries through balanced harvesting

A more balanced approach to harvesting fish could slow down fisheries-induced evolution and result in other conservation benefits, according to collaborative research from UC's School of Mathematics and Statistics.

A sixth-floor office at UC's Erskine building may seem a world away from the rolling deck of a working trawler, yet research that Professor Michael Plank is undertaking there has potentially far-reaching implications for how fish stocks could be managed in the future.

The mathematical biologist has been studying what would happen if fisheries were managed using a balanced harvesting approach. Mathematical models he has tested suggest that this alternative, balanced approach would better serve biodiversity than current approaches. Balanced harvesting requires a broad understanding of how species interact and how a whole ecosystem functions. Its goal is to try to keep a natural balance in that system rather than, for example, fishing for set volumes of target species of a particular size.

"The idea of balanced harvesting is to spread the load as widely as possible across the ecosystem ... I first began looking into this in 2012 after hearing a talk on the subject by Professor Richard Law, of the University of York, who was here on a visit at that time. I then became interested in modelling various scenarios to see what they would look like," says Professor Plank.

The two researchers have since worked on a number of collaborative projects to compare the balanced harvesting approach with current fishing practices and test the respective ecosystem impacts. Sources of funding have included Te Pūtea Rangahau a Marsden Marsden Fund and Te Pūnaha Matatini, a New Zealand Centre of Research Excellence.

In their latest joint paper, published in the journal *Fish and Fisheries* in June 2018, Professors Plank and Law focused on fisheries-induced evolution. The test method involved coupling an ecological model of marine size-spectrum dynamics to an adaptive dynamics model of life history evolution.

"The idea that drives this type of modelling is simple: you are tracking biomass around an ecosystem in which there are predators and prey, big fish and small fish. You can then study the consequences of both predation and fishing and track the loss of biomass out of the ecosystem using different variables," says Professor Plank.

The research findings indicate that balanced harvesting would have spin-offs for conservation of aquatic ecosystems. It would also lend weight to the argument that big, old fish should be protected for both ecological and evolutionary reasons.

"When you target larger fish, it induces evolutionary pressure that leads to a reduction in the size of that fish species over time. We compared balanced harvesting with current fishing strategies and found that balanced harvesting can mitigate that impact by reducing the number of large fish being caught," says Professor Plank.

> 'When you target larger fish, it induces evolutionary pressure that leads to a reduction in the size of that fish species over time.'

In essence, balanced harvesting would likely have a lower evolutionary impact because the overall distribution of mortality in the fishery would stay relatively close to what would happen naturally.

Population dynamics underpin the mathematical modelling approach used. While these models are essentially theoretical, the work is grounded in empirical data on how fish interact and grow. Perfectly balanced harvesting of an ecosystem is probably unachievable, but the findings of Professors Plank and Law suggest that seeking a better balance could yield more sustainable results in the long term than is currently achieved. The research lays the groundwork for constructive discussion on fisheries management and how practices could potentially change in future.

Since 2015, Professor Plank has held the role of principal investigator with Te Pūnaha Matatini. Hosted by Te Whare Wānanga o Tāmaki Makaurau | University of Auckland, it brings together experts from the academic research community, industry and government. As principal investigator, Professor Plank is tasked with steering research projects that build a better understanding of Aotearoa New Zealand's environment. Linking into his research on balanced harvesting, he has also been exploring the evolutionary history of the country's fish species.

"I've done some work with anthropologists through Te Pūnaha Matatini, looking at New Zealand archaeological records on fish that have been found here and trying to get more of a long-term perspective on how fishing activities have changed over the years."

Finding a balanced approach to harvesting fish could slow down fisheries-induced evolution and result in conservation benefits.

Professor Michael Plank

Research into land use in the Mackenzie Basin has led the government to scrap land review and instead to focus on sustainable farming and the protection of landscape values.

Dr Ann Brower

Land policy research leads to dramatic law change, protecting over a million hectares

Dr Ann Brower is pleased to see the carve-up of the high country of Te Waipounamu South Island has been halted and that the government will now bring the Land Act 1948 into the 21st century to consider environmental, cultural and economic impacts.

Why did the carve-up of the high country of Te Waipounamu South Island fail to adequately protect land with high ecological value? That is the question Senior Lecturer Dr Ann Brower of Te Rāngai Pūtaiao | College of Science sought to answer through her ongoing research on the high country 'tenure review' process in special places like the Mackenzie Basin. Her work is highly regarded in Aotearoa New Zealand.

In 2018, Dr Brower was awarded the Critic & Conscience of Society Award, which aims to encourage the academic staff at Aotearoa New Zealand universities to provide the public with independent, expert commentary on issues affecting the community and future generations. The award recognised Brower's work with the previous government for evidence-based reforms of the Building Act, culminating in the ministerially titled 'Brower Amendment' to the Building Act 2016. Though the new government's announced changes to the Land Act will not be named after Brower, her research has been central in the government's stated reasons for changing the law.

The tenure review of Te Waipounamu South Island high country is a land reform that has been quietly transforming key regions like the Mackenzie Basin since 1992. The law affected 10% of Aotearoa New Zealand's land mass (20% of Te Waipounamu South Island), or one-fifth of the mainland.

"Everything about owning, selling and buying land is controversial. Everything about land is close to people's hearts. Plus, it's 10% of New Zealand. Anything that affects that much of the country is a big deal," says Dr Brower.

Impacting our agricultural industry prior to the tenure review, the land was primarily used for pastoral purposes (extensive sheep farming dispersed with beef); however, after the land privatisation in tenure review, the area is now being used for a variety of interests, including grape growing for wine production, deer ranching, residential subdivisions and golf courses. The change in ownership has reduced the availability of agricultural land in the Mackenzie.

According to Dr Brower, these shifts in some of Aotearoa New Zealand's key food industries have had negative consequences for the agricultural industry.

"Where you once saw sprawling lands of sheep pasture, mixed in with some cow, now you see irrigators and residential subdivisions. So the Mackenzie and its landscapes have been profoundly shaped by land ownership and that will have food implications for New Zealand for a long time," says Dr Brower.

According to Toitū te whenua | Land Information New Zealand, tenure review was "a voluntary process that gives pastoral lessees an opportunity to buy some of their leasehold land. The rest of the land returns to Crown ownership, usually for conservation purposes".

> 'The controversial land carve-up of high country stations was only 'half-heartedly' protecting landscapes and biodiversity.'

However, Dr Brower believes this process was not being properly followed in the Mackenzie, home to famed sites like Lakes Tekapo and Pūkaki and The Dark Sky Reserve. Her research found that improper application of the law was having a dramatic impact on one of Aotearoa New Zealand's most renowned parts of the country.

In a research paper, Dr Brower and John Page of Australia's Southern Cross University reported their findings that under the tenure review process, important landscapes and threatened habitat went into private ownership, often with limited protection.

"The controversial land carve-up of high country stations was only 'half-heartedly' protecting landscapes and biodiversity. In fact, the more rare and threatened the ecological values of the land, the more likely it was to be freeholded," Dr Brower says.

"What these maps show is that the land that offered the most biodiversity was being freeholded and the land that offered the least ecosystem services was more likely to be put into conservation."

Dr Brower also notes that while large areas of land were at least somewhat protected under tenure review, either by Te Papa Atawhai Department of Conservation management or through covenants on at least 5%, or 3,033 hectares, of private land, many of the region's most sensitive and ecologically important areas were being sold to private entities with little oversight.

Update: The coalition government announced on 14 February 2019 that it is scrapping tenure review altogether, and that new management of Crown-owned pastoral land will be developed focusing more on sustainable farming and the protection of those landscape values that remain in the high country.

UC prepares and exhorts our students to 'Change the World'. Through her contributions to the Land Act and the Building Act, this UC environmental scientist is teaching by example.

Scion assists innovative biosecurity and biodiversity research

UC doctoral student Carol Bedoya is helping advance new concepts and tools aimed at protecting and preserving Aotearoa New Zealand's precious natural environment, with support from Scion.

Doctoral student in Te Kura Pūtaiao Koiora School of Biological Sciences, Carol Bedoya is receiving scholarship assistance through Scion to conduct research into insect detection at our borders.

A Crown Research Institute (CRI), Scion specialises in research, science and technology development for the forestry and wood sectors. It has worked closely with UC to support valuable doctorate research for over 20 years.

Listening for unwanted insects

Mr Bedoya is investigating proof-of-concept tools for acoustic detection to stop unwanted pest insects entering Aotearoa New Zealand. Effective acoustic tools could make it easier to detect insect infestations hiding inside cargo containers or timber shipments in future.

Biosecurity collaboration

Of particular interest to Hīkina Whakatutuki Ministry of Business, Innovation and Employment (MBIE) has been the facilitation of mutual research interests identified between Aotearoa New Zealand and the United States Department of Homeland Security. Detection of unwanted insect species is an area of mutual interest.

"We structured Carol's project so it would be of particular benefit to biosecurity agencies and researchers in New Zealand by identifying potentially invasive insect species in the US that we didn't want coming here," says Dr Eckehard Brockerhoff, who is a forest ecologist and entomologist with Scion and an Adjunct Associate Professor at UC's Te Kura Pūtaiao Koiora | School of Biological Sciences.

Originally from Colombia, Mr Bedoya studied electronic engineering before completing a Master's degree in signal processing and bioacoustics. He has travelled to the US several times for his doctorate project, working collaboratively with researchers from the US Department of Agriculture, US Forest Service, and Northern Arizona University.

Much of the research has involved studying the behaviour of tiny bark beetles inside trees and honing prototype acoustic detection methods.

"Until now, there has been very limited activity in the area of acoustic insect detection in New Zealand and no previous research has addressed the use of acoustic detection for pathway risk management in the border biosecurity context," says Mr Bedoya.

> 'Until now, there has been very limited activity in the area of acoustic insect detection in New Zealand.'

Mr Bedoya is co-supervised by animal behaviour and physiology expert, Associate Professor Ximena Nelson from Te Kura Pūtaiao Koiora School of Biological Sciences, and electrical and computer engineer Associate Professor Michael Hayes, from Te Rāngai Pūkaha | College of Engineering.

"Bioacoustics is an interdisciplinary area involving several seemingly unconnected topics such as animal behaviour, signal processing, zoology and acoustics, therefore having a supervisory team from different disciplines has been immensely beneficial to my research. The advice I have received from their different perspectives outside my area of expertise has undeniably made me a better scientist and improved the quality of my research. I could not have asked for a better supervisory team," Mr Bedoya says.

Close connection yields outstanding results

The close connection between Scion and UC goes back many years. Until recently, Scion was co-located with the University and shared a building with Te Kura Ngahere | School of Forestry.

"Our collaboration with the University of Canterbury gives us the ability to think a little more broadly and go beyond the more applied research context. What Carol is doing is not well developed in New Zealand. He is the perfect person to do this research as he had worked in a similar area for his Master's. He has been outstanding and has achieved much more than we could have ever wished for," says Dr Brockerhoff.

Research on biosecurity and ecosystem services can protect and preserve natural environments.

Doctoral student Carol Bedoya

Better understanding of how groundwater seepage affects Te Waihora is crucial to helping organisations working to improve the lake's water quality.

Doctoral student Katie Coluccio

Analysing groundwater seepage into Te Waihora Lake Ellesmere

Better understanding of how groundwater seepage affects Te Waihora Lake Ellesmere is crucial to helping organisations working to improve the lake's water quality.

Te Waihora Lake Ellesmere is a coastal lagoon in Waitaha Canterbury with significant cultural, ecological, social, recreational and economic values. However, over the past several decades, water quality in the lagoon has seriously declined.

Doctoral student Katie Coluccio of Te Rāngai Pūtaiao | College of Science is investigating groundwater seeping into the lakebed of Te Waihora in an effort to determine how much groundwater is entering the lake, where the water is coming from and how its chemistry affects water quality in the lake.

It has been nearly 30 years since extensive research was conducted on this component of the lake's water balance, which makes Ms Coluccio's work that much more important.

"There has only been a limited amount of work done on this issue and that was in the early nineties, but this is critically important to how the lake is managed and for understanding some of the lake's water quality issues," Ms Coluccio explains.

Improving water quality

Many organisations are involved in the complex task of improving the lake's water quality and Ms Coluccio's research could provide them with many insights they could use in this work.

"Is it shallow groundwater? Is it deep groundwater? Deeper groundwater suggests that it is older, while shallower indicates younger groundwater, which may indicate poorer water quality due to adverse effects of land use, such as higher nitrate levels," says Ms Coluccio.

"Understanding where groundwater comes from can help us locate the source and figure out if we need to better protect that source and better address any pollution that may be occurring there."

The lake has long served as a key food source for local iwi Ngāi Tahu, and it remains central to many of the rūnanga of the area as a place of cultural significance. The traditional name for the lake was Te Kete Ika a Rākaihautū, meaning 'food basket of Rākaihautū'.

Today, Te Waihora is used for commercial and recreational fishing, while the surrounds are popular for recreational hunting, tramping and biking.

Te Waihora, while referred to as a lake, is actually a shallow coastal lagoon. Situated one hour's drive south of Ōtautahi Christchurch, it is Aotearoa New Zealand's fifth largest 'lake' (by area only).

A biodiversity hotspot, the brackish lagoon supports an abundance of fish species and rare waterfowl. It is also a key migratory stopping point for many of the region's birds.

"Broadly, I hope my work will help us better understand these types of coastal features, as well as similar coastal lagoons internationally. Because of their unique makeup, they tend to have a significant degree of ecological and cultural importance, including their role as an important local food source," says Ms Coluccio.

Eight months through the project, the PhD candidate is looking forward to executing the initial stages of her data collection in 2019, using a small plane to gather thermal and multispectral imaging, as well as mapping the chemistry (such as salinity, temperature and radon concentrations) of the lake by boat. These data will help her locate places where groundwater is entering the lakebed.

"Ideally, the thermal imaging will reveal the cold patches where groundwater is coming in, which will help me determine where in the lake I need to collect samples," says Ms Coluccio.

"For the survey by boat, I will measure specific parameters that are often used to differentiate between ground and surface water in places where they mix. For example, radon is present at some level in nearly all groundwater, but once it is exposed to air (such as in a lake), the radon levels quickly drop. That difference in concentrations can help me determine where groundwater is entering the lake.

> 'Broadly, I hope my work will help us better understand these types of coastal features, as well as similar coastal lagoons internationally.'

"This will give me a broad idea of what is happening across the lake, and then I can hone in on the spots of interest and do further analysis by calculating the amount of seepage across the lake, while analysing water quality such as nitrate levels in the groundwater."

Te Kaunihera Taiao ki Waitaha | Environment Canterbury (ECan) and the New Zealand Hydrological Society are providing funding support for the project. In addition, Ms Coluccio is supported in her PhD research by a Te Rāngai Pūtaiao | College of Science Doctoral Scholarship. She is working with a team of supervisors: Dr Leanne Morgan from the Waterways Centre at UC, Dr Marwan Katurji from the Geography Department at UC and Dr Fouad Alkhaier at ECan.

"A lot of effort is being made by many different groups to improve the state of the lake. I hope my research feeds better understanding and improved management of this important and unique coastal feature."

Community capacity – searching for hope in Mataura

Changes in food production have been shown to affect community capacity in the small town of Mataura, Aotearoa New Zealand.

In the late eighties and early nineties, food production in Aotearoa New Zealand began to change. As dairy farming emerged and the economy became increasingly dependent on it, people began shifting away from traditional sheep farming. Fewer sheep were being sent to the slaughterhouse and, consequently, mutton-chains began to close, affecting rural communities.

Nestled in lower Te Waipounamu South Island, Mataura is a small town of approximately 1,500 residents. When the mutton-chain at the local freezing works, a refrigerated slaughterhouse where meat is processed, was shut down, 225 workers' jobs were affected.

For health researcher Dr Sarah Lovell, a senior lecturer in Te Rāngai Ako me te Hauora | College of Education, Health and Human Development, the changes created a rare opportunity. It was her chance to observe the impact on local residents of removing an industry that had been a major employer and contributor to the local economy for decades.

"We were interested in how community capacity was affected over time. We were already in the area, and then to find out that the freezing works were about to downsize, it created a really interesting opportunity to see the effect economic setbacks had on that community capacity," Dr Lovell says.

Community capacity

Community capacity building is grounded in the belief that the skills, resources and networks of a community will enable members to identify and act on problems independently. Towns with strong community capacity are believed to be more resilient in the face of setbacks.

> 'Our findings from Mataura suggest that a small town's perceptions of community capacity may be much more sensitive to change than previously recognised.'

"When people are well connected and can use their own resources, they can solve all sorts of problems without relying on government or other sources," Dr Lovell says.

"We surveyed randomly identified people from the town and compared these findings with survey results from people living in similar-sized towns. We wanted to know whether the changes in community capacity we were seeing in Mataura were isolated to this town."

Studying the experience of community members as Mataura transformed economically from a dynamic manufacturing economy to become dependent on nearby towns for employment has yielded some fascinating insights on economic decline and its direct impact on the short-term resilience of the community.

"There is this belief that community capacity is somewhat separate to economic setbacks; however, we very much disproved that theory, at least in the short term," Dr Lovell says.

This is not all a bad news story for Mataura. Despite its economic challenges, the town was boosted by government funding for a community development worker, local governance was supported by the establishment of a community board, and the rejuvenated marae was a social hub. These social development initiatives did not protect the town from further industry withdrawal but they did enable a strategy to minimise the social impact on the town.

"Our findings suggest that towns recovering from economic setbacks may require additional outside support and that reductions in community capacity may have a personal cost for affected residents."

The closure of sheep processing facilities at the Mataura freezing works led to job transfers, retirement or unemployment for most of the self-described 'Muttonheads' who worked on the mutton-chain and participated in the qualitative aspect of Dr Lovell's study.

These workers narrated a life structured around shift work that provided them with a sense of purpose, routine and social connection. Biographical interviews highlighted the personal implications of economic decline as jobs were lost, social networks were eroded and a once-vibrant main street was replaced with empty storefronts.

"Our findings from Mataura suggest that a small town's perceptions of community capacity may be much more sensitive to economic change than previously recognised," Dr Lovell says.

"Competition from offshore is driving change in food production and manufacturing. This research clearly shows we need to think about the impact these industries have on community capacity, especially in rural towns, and what this change might mean for its residents."

Dr Lovell is planning to go back to Mataura in 2019 to reassess the five-year impact of this shift in food production and analyse whether the short-term effects she observed will have long-term consequences for Mataura.

Dr Sarah Lovell

Observation of major shifts in food production are shown to have a profound impact on community capacity.

Distinguished Professor David Schiel
Photo supplied by Distinguished Professor Schiel

Experimental reef structures are being used as part of a long-term study that will assess the growth, survival and sustainability of pāua fishing in Kaikōura.

Studying pāua production on the earthquake coast

The 2016 Kaikōura earthquake greatly disrupted marine habitats, resulting in mass mortality and habitat loss of valuable and culturally significant pāua.

In November 2016, 130 kilometres of productive coastline of Te Waipounamu South Island was propelled upwards by a 7.8 magnitude earthquake. The shoreline was lifted up to six metres within two minutes and many marine habitats and resident organisms were left high and dry.

Tidal zones and rocky habitats were redistributed, and the marine life that survived was pushed upwards into a different light and wave environment. One prominent casualty was the region's pāua, which died in their thousands after they were left exposed. Cultural, recreational and commercial fisheries for pāua were subsequently closed, at a high financial cost to the Kaikōura district.

Marine ecologist Distinguished Professor David Schiel and his team in Te Rāngai Pūtaiao College of Science are studying the effects of the Kaikōura earthquake and recovery of the marine ecosystem, including the pāua population.

"Pāua can withstand some emersion at low tide but must have water lapping over them. They don't have the biochemical mechanisms that allow them to compensate for severe heat and dehydration, so when they are stranded they reach a stage where they cannot recover," explains Distinguished Professor Schiel.

During such a massive disruption, pāua can be affected in many ways, ranging from being quickly killed by heat stress or burial from cliff falls, to sub-lethal effects such as compromised reproduction.

"Two problems were that many adult and juvenile pāua died from massive landslips along the coastline, and their rocky habitats were buried in many places during the earthquake and in subsequent rain events that washed sediment into the coastal zone.

"In one region, 24% of the habitat for commercially fished pāua populations was destroyed."

Distinguished Professor Schiel's team focused on the recruitment stage – the time when pāua larvae settle from the plankton into shallow-water habitats. These juveniles will enter the 'fishable' population in about six years.

"We did extensive surveys for juvenile habitats, what was in them, what remained. We were particularly interested in seeing if any juvenile pāua were produced in the years following the earthquake and how the event might affect the future fishery," Distinguished Professor Schiel says.

"We found peak recruitment of juveniles in May through July of 2017 and 2018, which we knew must have come from spawning events after the earthquake, so it appeared that recruitment was not compromised, at least in remaining juvenile habitat."

After two years of coastal surveys conducted by Shawn Gerrity and Tommaso Alestra, Distinguished Professor Schiel is pleased with the results and believes the juveniles are not suffering from sub-lethal effects. However, some unanswered questions remain.

"We've had two good recruitment years, but we haven't yet been able to determine what that means for the fishery. We haven't fully quantified how much juvenile habitat remains or has been replaced by new habitat. We are attempting that now with more field sampling, aided by drone imagery."

> 'In one region, 24% of the habitat for commercially fished pāua populations was destroyed.'

The team is also working to compare growth and survival of wild juvenile pāua with those grown in land-based hatcheries and then outplanted to the coast, a common practice of Aotearoa New Zealand's pāua industry.

Experimental reef structures were installed in key locations to provide optimal habitat for wild pāua, and used as platforms for seeding of hatchery juveniles. A long-term study will assess growth and survival.

"Juvenile pāua live under small rocks in very shallow water for up to three years, when they reach about 90 millimetres in total length, and then they wander out and move offshore to live in open habitats as adults. Early indications are that both wild and hatchery-reared pāua are growing and surviving well, but time will tell how this will eventually translate into a sustainable fishery," says Distinguished Professor Schiel.

These surveys and experiments are no easy task. The team waded through the shallow ocean for weeks assessing habitats, and they individually tagged thousands of small pāua. He heaped praise on his team members for their diligent efforts.

Pāua fishing has still not been reopened in Kaikōura. Distinguished Professor Schiel hopes his team's research will help policy makers reach informed decisions about how to manage the region's stressed pāua populations. This research has also been of great interest to local communities along the coast, especially around Kaikōura where the University has a long-standing commitment to marine research.

"One of my primary goals is to be able to provide communities and management agencies with the data and knowledge to make the best decisions for the sustainable use and governance of the area's marine ecosystems and wildlife."

Exploring the offshore extent of groundwater in Ōtautahi Christchurch

How far do the groundwater aquifers of Ōtautahi Christchurch extend offshore beneath the sea? UC researchers are on a mission to find out how sustainable our freshwater is.

Dr Leanne Morgan of Te Rāngai Pūtaiao | College of Science and doctorate candidate Carlos Rosado are working to answer this question about the unique Ōtautahi Christchurch water system. From there, they can determine what their findings mean for the freshwater supply in Ōtautahi Christchurch and other coastal cities around the world that have access to offshore fresh groundwater.

"In order for us to secure a sustainable water source for years to come, we need to know how far offshore fresh groundwater in the Christchurch aquifers extends," Dr Morgan says.

The region's current drinking water source is groundwater, pumped by more than 150 wells across the city. The area relies completely on this resource not only for drinking, but for all other daily water uses, and it also feeds surface waterways throughout the city.

Coastal aquifers are an important source of freshwater in Ōtautahi Christchurch, as in many other locations around the world. However, increasingly dense human occupation of coastal zones, climate change and excessive groundwater pumping are causing what is termed a 'coastal groundwater squeeze', whereby groundwater is threatened from onshore contamination, as well as seawater intrusion.

Seawater intrusion is the inland encroachment of seawater into fresh coastal aquifers. It is most commonly caused by excessive groundwater pumping and is one of the world's leading causes of groundwater contamination.

A recent publication by Dr Morgan and colleagues from Flinders University has shown that at many locations globally, offshore fresh groundwater is increasing coastal groundwater extraction. That is, fresh groundwater being extracted from onshore wells is actually being drawn in from aquifers beneath the sea, often without people realising this. At these locations, offshore aquifers are delaying the impacts of seawater intrusion, but for how long? Ōtautahi Christchurch was highlighted as one of the locations where this might be occurring.

"Despite widespread potential for offshore fresh groundwater, coastal groundwater investigations are traditionally based on the availability of fresh groundwater landward of the shoreline. The contribution of offshore groundwater to onshore pumping and regional-scale water budgets is rarely considered," Dr Morgan says.

Dr Morgan's research aims to explore knowledge gaps surrounding Ōtautahi Christchurch's coastal aquifers.

"We know the groundwater quality is generally very good in deeper aquifers below Christchurch city, but will this continue to be the case in the context of climate change and increasing groundwater extraction?"

As part of the research, Mr Rosado will drag a probe along the seabed off Ōtautahi Christchurch, measuring several parameters in the water, including electrical conductivity, temperature and depth.

Mr Rosado's goal is to develop a big picture of the system.

"The aim of the survey is to try to detect freshwater springs in the seabed. If groundwater discharge is detected offshore, this can give us some indication of where the saltwater–freshwater interface is located to build a picture of the system," Mr Rosado says.

As senior lecturer in groundwater at UC, Dr Morgan has been researching and teaching in the areas of coast hydrogeology, groundwater modelling, groundwater – surface water interaction and water resources management for over eight years.

'Despite widespread potential for offshore fresh groundwater, coastal groundwater investigations are traditionally based on the availability of fresh groundwater landward of the shoreline.'

Dr Leanne Morgan and doctoral candidate Carlos Rosado

The amount of water in Ōtautahi Christchurch's extensive groundwater aquifers is unknown. The answer is key to understanding the future of freshwater sustainability in the region.

Professor Keith Alexander is part of a team researching ways to keep Aotearoa New Zealand at the forefront of shellfish farming and ensure shellfish supply into the future.

Doctoral student Sam Godsiff (left) and Professor Keith Alexander

Leading the world in shellfish farming innovation

Aotearoa New Zealand is a world leader in shellfish farming and Professor Keith Alexander is part of a team researching ways to keep the country at the forefront.

Mussel and shellfish farming is a billion-dollar industry and is crucial to meeting the world's food demand in the 21st century. It is also an important part of Aotearoa New Zealand's history and, more importantly, its future.

This is why Professor Keith Alexander in Te Rāngai Pūkaha | College of Engineering and PhD student Sam Godsiff are working with Cawthron Institute to study methods to improve the efficiency of mussel and other shellfish farming in the open ocean.

Cawthron Institute is Aotearoa New Zealand's largest independent science organisation specialising in aquaculture, biosecurity, marine, freshwater and analytical research. Cawthron is leading the programme, headed by Kevin Heasman and funded by the Hīkina Whakatutuki Ministry of Business, Innovation and Employment, to advance open ocean shellfish aquaculture.

For centuries, people around the world have farmed mussels and shellfish in sheltered sites inshore, using long lines anchored to the seabed and kept afloat by a series of buoys that dangle droppers, or ropes, into the water. For mussel farming, the droppers are seeded with spat (baby mussels), which are then on-grown to harvest. Other types of shellfish such as oysters are also farmed using mesh bags or trays.

The challenge is that consented inshore sheltered water for farming is very difficult to get, yet the world's seafood demand continues to increase. Finding innovative ways to facilitate efficient and sustainable aquaculture in the open ocean is therefore becoming an ever-growing need.

Professor Alexander says harvesting offshore also presents a number of specific challenges.

"These include boat traffic and larger waves, which might cause the mussels to get knocked off the dropper ropes because of the greater movement of the buoys at the water surface. So, the big issue is, if you are going to farm shellfish out in the ocean, how can you do it efficiently and sustainably?"

While the team is not at liberty to discuss some of the solutions it is looking into, Professor Alexander says there are a variety of ways to improve on the current high-maintenance technology, which is primarily surface-based but static.

"The project team are asking questions like, 'Can you put the farming systems below the surface?' This is one of the main ideas that has been floating around for a while. But then how do you access them for maintenance and harvesting? How do you know if the spat ropes below the surface are getting overloaded? Then, what do you do about it?"

One of the key issues is the ability to monitor the farms to ensure they are not being overloaded and that farmers don't miss the optimal window for harvesting. With the new system being offshore, and potentially below the surface, finding an efficient method for keeping tabs on the farming system is more difficult.

> 'Modern information and technology can revolutionise shellfish farming by making it more efficient.'

"If you are harvesting offshore, the system is obviously not close by, so you would have to take a boat out to the farm, but it can't be just any boat. It would have to be a fairly large boat and one with the capability to travel 8 to 15 kilometres offshore in conditions that can be pretty rough," says Professor Alexander.

But with these challenges comes opportunity. Cawthron Institute, with the help of Professor Alexander and his team, could discover a technology and process that are more economical than the current way of growing and harvesting mussels and shellfish, therefore ensuring the security of seafood supply in future.

Professor Alexander believes modern information and technology can revolutionise shellfish farming by making it more efficient.

UC PhD student Sam Godsiff has been integral to the project because of his family history. He grew up farming mussels in Aotearoa New Zealand with his father and has provided crucial insight into the intricacies of the current process.

"He brings a lot of background and hands-on experience to the table that some of us don't have," says Professor Alexander.

The team at UC is an integral part of the Cawthron-led project, which also includes scientists based offshore. There is significant international interest from Europe, the United States of America and China, as this new technology could also facilitate their own production of species. Some of the team designs that Professor Alexander and Mr Godsiff contributed to are now in the process of being produced for trials.

Exploring the holistic benefits of urban farming

Farming and gardening projects are taking root in cities around the world, as urban communities increasingly pursue sustainable food production goals. In Ōtautahi Christchurch, UC geographer Dr Kelly Dombroski has been co-leading a qualitative study of urban farm enterprise Cultivate. It turns out that growing fresh produce in the city can also help transform young people's lives.

Post-quake Ōtautahi Christchurch has presented a landscape marked by both challenge and change. The impact of having so many vacant sites in the city after buildings were demolished was counteracted by an upsurge in innovative uses being found for these areas, with some private land turned into temporary 'commons'.

While investigating this transitional shift in city land use, UC Senior Lecturer Dr Dombroski and Wellington-based researcher Dr Gradon Diprose came across the work of Cultivate and were immediately impressed with what they saw. They found the surplus that Cultivate's urban farm activity generated was being used to support social workers and to accommodate youth interns, so as to care for young people's mental health and wellbeing.

"What excited us was how they were combining mental health and social work by being there alongside young people, working with their hands, in a way that allowed youth to open up and talk about their problems without having to sit in a counsellor's office," says Dr Dombroski.

"It was great that one of the social workers was also a trained chef who could take vegetables from the field and cook them up for lunch. He said some of the young people had hardly ever eaten vegetables before, so we could see there were these wider educational and nutritional benefits going on too."

Clearly, Cultivate was creating an impact beyond the obvious gains one might expect from an enterprise committed to turning green waste into fresh produce.

In 2017, the two researchers secured funding through National Science Challenge 11, 'Building Better Homes, Towns and Cities', for a 12-month project on Cultivate's transformative influence. Also collaborating on the project as associate investigators were UC Associate Professor David Conradson and Dr Stephen Healy, of the University of Western Sydney. UC PhD graduate Dr Alison Watkins worked as research assistant for the project, which got under way in November 2017.

The research challenge was to come up with a way of mapping all the various social and environmental outcomes of Cultivate's activities. Dr Healy had proposed a qualitative assessment tool called the Community Economies Return on Investment (CEROI) with colleagues, which the team decided to adapt, develop and apply with Cultivate as an action research project.

"Our project focused on the social and environmental benefits associated with working outdoors and in caring teams of people ... What came out of this was how caring for people in this context arose through experiences of growing food, eating food and learning about food. You cannot put a dollar value on that kind of return on investment," says Dr Dombroski.

> 'What came out of this was how caring for people in this context arose through experiences of growing food, eating food and learning about food.'

The project methodology used was both practical and observational. Dr Dombroski joined the gardening roster at Cultivate for a semester to contribute to the farm, observe it working and get to know people there. Interview questions for staff and interns were then developed in a collaborative way with the organisation's founders. The project fieldwork included three workshops for Cultivate staff, interns, and urban designers and planners respectively, led by different project members according to their expertise. The team is now working on a final report.

"We want our research to be useful to Cultivate, so plan to turn our final report into a video that can be shared via social media," says Dr Dombroski.

Interestingly, the project has highlighted the difficulties of trying to use CEROI as a 'one size fits all' assessment tool. Instead, the research team ended up developing an adaptive methodology that other organisations could potentially apply to create their own CEROI tool.

The next step is to seek funding to test this methodology in a variety of different organisations in Ōtautahi Christchurch and beyond. The ultimate goal is to create a toolkit that organisations can then use for conducting their own qualitative assessments.

Doctors Dombroski, Diprose and Healy are members of the Community Economies Collective, regularly collaborating in action research work that seeks to bring about more sustainable and equitable forms of development, based on new thinking about economies and politics.

Dr Kelly Dombroski and some of the Cultivate team

The growing of fresh sustainable produce in urban communities is helping to transform young people's lives at the same time.

Advanced spray technology will reduce the volume of pesticide used by half on crops by controlling optimal coverage.

Dr Scott Post of Lincoln Agritech (left) and UC Associate Professor of Electrical Engineering Paul Gaynor.

Waitaha Canterbury researchers join forces on electrostatically enhanced agricultural spray

New research by a team of Waitaha Canterbury scientists and engineers aims to reduce the use of pesticides by harnessing electrostatic technology to deliver agricultural sprays more accurately.

The vision is to develop equipment that automatically adapts to varying plant distances and leaf distributions, and electrostatically charges drops to enhance deposition on fruit and leaves, resulting in better coverage of fruit with less polluting spray drift.

"In this project we are developing the science required to create a smart, electrostatically enhanced agricultural sprayer that can sense the crop canopy location and apply agrichemicals to achieve near-optimal coverage, while minimising chemical wastage and loss to the environment," says Associate Professor Paul Gaynor of Te Rāngai Pūkaha | College of Engineering.

Part of the National Science Challenge 'Science for Technological Innovation', this project focuses on sprayers for high-value row crops – such as potatoes, grapes, apples and kiwifruit – in Aotearoa New Zealand and overseas. They offer broader applications in spraying paints and coatings, as well as active coatings in a wide range of industrial sectors.

"The addition of electrostatic charge enables us to do some really dynamic spray direction and deposit control," says Associate Professor Gaynor.

"We will develop a control system that solves the inverse problem of how to change the initial conditions of the drops generated in an electrostatic spray to provide close to complete coverage of the target surfaces."

Aotearoa New Zealand will see many benefits, including new export revenues through sales of equipment based on the technology and savings to growers in lower chemical costs, along with reduced crop losses due to pests. Additional economic benefits will grow as the technology is adapted to a wider range of crops, the researchers say. Their goal is to reduce the amount of pesticides used by at least 50%, with an associated decrease in off-target pesticide losses to soil, water and air providing environmental benefit to the country.

Researchers share expertise and resources

The research team, made up of people working in several disciplines, including a range of UC experts and students, is led by Dr Scott Post of Lincoln Agritech (Lincoln Agritech Ltd is a wholly owned subsidiary of Te Whare Wānaka o Aoraki Lincoln University). Dr Post says the different UC departments and the Precision Agriculture group at Lincoln Agritech have had "great synergy" on this project.

UC's Electrical and Computer Engineering (ECE) and Mechanical Engineering (ME) departments provided resources and expertise for controller design, electrical measurements and computational fluid dynamics (CFD) simulations of charged spray-drop trajectories in electric fields. UC's Te Kura Matū | School of Physics and Chemical Sciences provided measurements of the electrical properties of plants, as well as invaluable insights into the functioning of complex systems. Lincoln Agritech provided access to Te Whare Wānaka o Aoraki | Lincoln University's vineyard and greenhouse, experience with agricultural spraying, additional spray analysis techniques, and connections with horticulture and viticulture industries in Aotearoa New Zealand.

"We have had several UC students working on this project, including postgraduates in both ECE and ME, a final-year project team that included students from ECE, ME and Physics, and a summer student from Mechatronics Engineering who worked at Lincoln Agritech over the summer," Dr Post says.

"The geographical proximity of the two institutions has also been of benefit, as we are able to take equipment developed in the engineering workshops at UC over to Lincoln Agritech for field testing, and back to UC for further refinement easily."

'The goal is to reduce the amount of pesticides used by at least 50%, with an associated decrease in off-target pesticide losses to soil, water and air providing environmental benefit to the country.'

World-leading electrical engineer receives UC Research Medal 2018

For his industry-leading contribution to the development of new theory and computational algorithms for imaging structures of biological macromolecules using x-ray diffraction, Professor Rick Millane has been awarded the 2018 UC Research Medal.

From UC's Department of Electrical and Computer Engineering within Te Rāngai Pūkaha College of Engineering, Professor Rick Millane is recognised as a global leader in the development of methods for macromolecular imaging for structural biology.

Chair of the selection committee, Tumu Tuarua Deputy Vice-Chancellor Professor Ian Wright, who awarded the medal at the Chancellor's Dinner last November, says Professor Millane is broadly recognised as an outstanding researcher, educator and educational leader.

"His skills are diverse and his work is interdisciplinary – in addition to his work in biomolecular imaging, he has applied his skills in image reconstruction and diffraction theory to medical imaging (optical diffusion imaging and magnetic resonance imaging), diffraction by disordered and geometrically frustrated materials, image analysis problems in biology, vision science, geology and atmospheric science, and aspects of visual perception."

A world of possibility

After finishing near the top of his class at Wellington College, Professor Millane went on to UC where he earned his BE (Electrical) (First Class Hons) in 1975 and received his PhD in Electrical Engineering in 1981.

His initial attraction to engineering, he believes, was born from its almost limitless potential.

"I was interested in mathematics and physics when all of a sudden, I realised you could use mathematics to describe the world."

Over the past three decades Professor Millane has been instrumental in developing new theory and computational algorithms for imaging the structures of biological macromolecules using x-ray diffraction.

His important contributions in his field of research include an influential paper that connected phase problems in crystallography and optics. The paper recognised the potential of these connections, before the technology had been developed. Although published in 1990, the paper continues to be highly cited by other researchers and academics.

Professor Millane's work has had particular impact in the application of new x-ray, free-electron lasers to study the structures of biological molecules. Structural biologists use his methods to help understand disease processes and for drug design. His most recent work contributed toward our understanding of the structures of amyloids, the misfolded protein aggregates implicated in neurodegenerative diseases such as Alzheimer's and Parkinson's.

Making a global impact

As a world-class academic, researcher and UC graduate, Professor Millane has showcased the University on the global stage. His work at Purdue University in the United States of America, where he worked for 20 years completing foundation work in x-ray fibre diffraction analysis and phase retrieval, was supported by the US National Science Foundation. He continued to build on this work following his return to UC, resulting in three Marsden grants and a James Cook Research Fellowship.

Professor Millane was also awarded the Royal Society of New Zealand TK Sidey Medal in 2016 for his "wide ranging and fundamental work in x-ray diffraction imaging, diffraction theory, and optical diffusion imaging, and their application in biology and medicine".

In 2017 Professor Millane was elected a Fellow of Te Apārangi | Royal Society, which recognised his international distinction in research and scholarship for advancing science, technology and the humanities.

Earlier that same year Professor Millane, alongside a team of international colleagues, received a three-year grant worth NZ$2 million from the Human Frontier Science Program to develop a novel method for imaging individual biomolecules with atomic resolution.

> 'I was interested in mathematics and physics when all of a sudden, I realised you could use mathematics to describe the world.'

He is a Fellow of the Optical Society, the International Society for Optics and Photonics and Engineering New Zealand.

Professor Millane is leading a highly regarded UC research group in computational imaging, and has directed 21 doctoral students and 12 postdoctoral fellows.

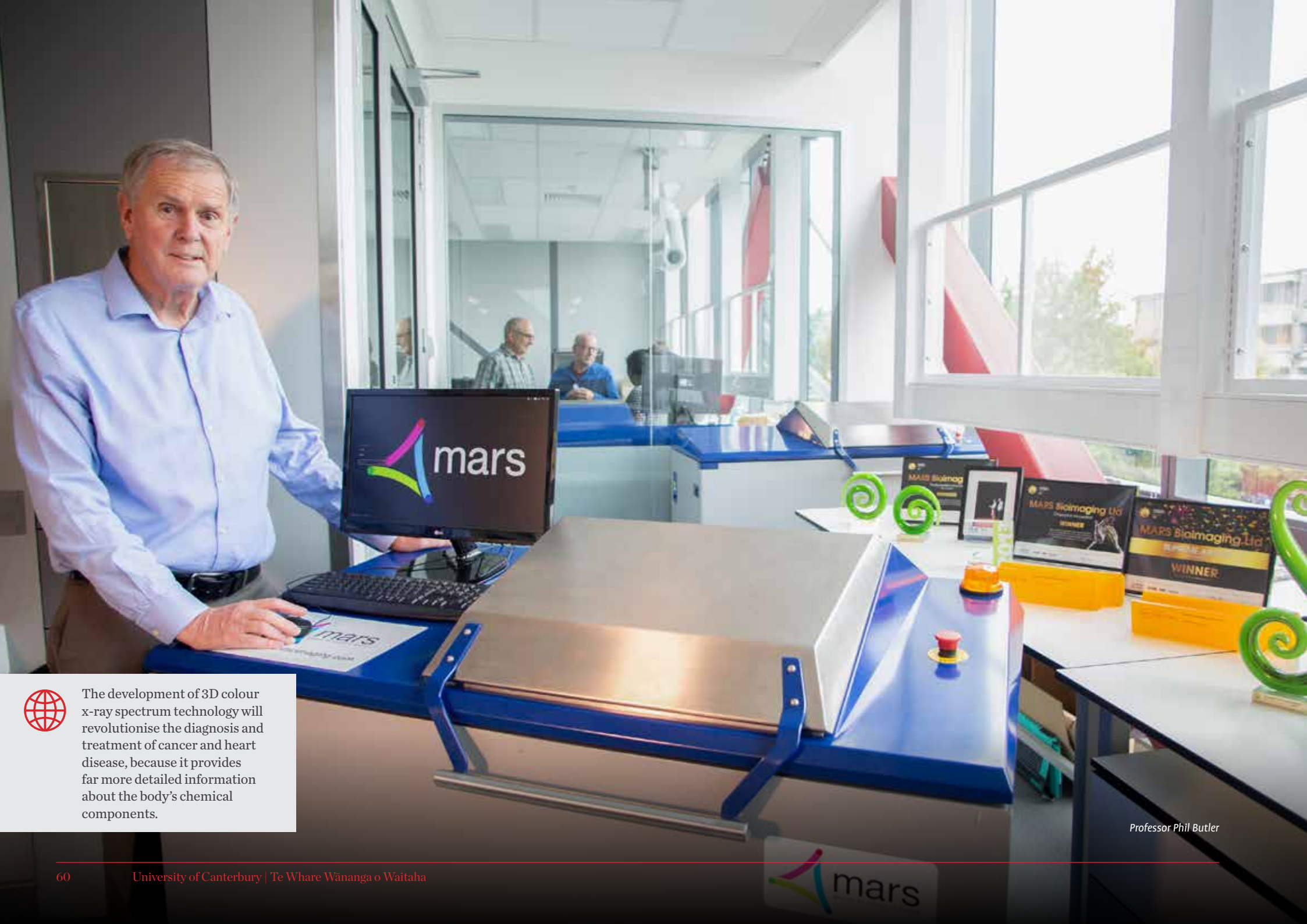
The UC Research Medal is awarded by Te Kaunihera o Te Whare Wānanga o Waitaha University Council for excellence demonstrated through a sustained record of research of the highest quality or through research of outstanding merit produced over a more limited timeframe.

Te Tumu Kaunihera | Chancellor Dr John Wood believes Professor Millane is a fitting recipient.

"Professor Millane is an internationally acclaimed researcher whose work has had a wide impact, and of whom the University can be proud, both as an academic and a graduate of UC."

Professor Rick Millane

Professor Millane's work has had particular impact in the application of new x-ray, free-electron lasers to study the structures of biological molecules. Structural biologists use his methods to help understand disease processes and for drug design.



The development of 3D colour x-ray spectrum technology will revolutionise the diagnosis and treatment of cancer and heart disease, because it provides far more detailed information about the body's chemical components.

Professor Phil Butler

Internationally respected Physics professor awarded 2018 UC Innovation Medal

Medical and Theoretical Physics Professor Phil Butler, in Te Rāngai Pūtaiao | College of Science, received the 2018 UC Innovation Medal in recognition of his standing as a world leader in the development and commercialisation of medical imaging and laser-based medical treatment.

The UC Innovation Medal is awarded by Te Kaunihera o Te Whare Wānanga o Waitaha UC Council for the proactive transformation of academic knowledge and ideas into a commercial product or system that is adopted by the wider community. It is the highest award the University can bestow on an outstanding innovator.

Professor Butler has spent a large part of his adult life on the UC campus, beginning as an undergraduate student before progressing to postgraduate, master's and doctoral studies. He believes strongly in the research and innovation originating from the Waitaha Canterbury region.

Since graduating, Professor Butler has been teaching the next generation of physicists and innovators, and has accumulated over 800 research publications. He has also founded three not-for-profit businesses and two commercial companies, Medical Laser Developments Ltd and MARS Bioimaging Ltd.

For a time at Medical Laser Developments Ltd, Professor Butler was its CEO and a director. The company's commercialisation of the laser treatment technology for treating haemangiomas (port-wine stains) is an achievement he is particularly proud of.

"When the opportunity to work with the laser treatment of port-wine stains arose, I thought it looked like an interesting problem I would be able to apply some physics and math to, especially in ensuring the right pulse length of the laser," he explains.

In addition to treating more than 2,000 patients affected by port-wine stains, the technology has been on-sold to medical professionals, ensuring the treatment will remain available to a wider pool of patients for years to come.

After founding MARS Bioimaging Ltd in 2007, Professor Butler became its CEO and board chair. The company is currently selling the first commercial, pre-clinical, spectral computed tomography (CT) scanners developed for biomedical research to the United States of America and Europe, with clinical trials under way in Ōtautahi Christchurch.

"An invention doesn't stop at the completion of a research paper; you have got to take it to the people so the invention can be used," Professor Butler says.

The MARS scanner is one of Professor Butler's more recent innovations, developed in collaboration with his son, Professor Anthony Butler.

Producing images with significantly improved diagnostic information, the MARS scanner also measures the x-ray spectrum to produce colour images instead of black-and-white, and shows different components of body parts such as fat, water, calcium, and disease markers. With features such as these, it is widely considered to be a breakthrough in x-ray imaging.

The scanner has the potential to revolutionise medical imaging both locally and globally, particularly in diagnosing and treating cancer and heart disease, because it provides far more detailed information about the body's chemical components. The key difference? The ability to distinguish among the various features of the images it captures.

The full capability of this innovation is still being discovered as clinicians gain access to the new imaging technology, but the team is confident that the MARS scanner will have profound impacts on medical imaging. The addition of colour and CT allows for the identification of molecular (biochemical) information, as well as anatomic information in a single scan.

"Three hundred million CTs are taken per year currently – that's roughly 300 million people that could be affected by what our MARS team are doing," Professor Butler says.

"One of the things I've always enjoyed is solving problems and, while it may sound counterintuitive, knowing there are problems to solve is something that continues to inspire me."

'An invention doesn't stop at the completion of a research paper; you have got to take it to the people so the invention can be used.'

$4 million to study space junk, lava, glaciers and quake stories

Several UC academics were awarded 2018 Te Apārangi | Royal Society Marsden Funding to lead research in diverse topics, from identifying space debris to understanding lava flow and analysing melting glaciers, to studying quake stories and how they evolve.

Tumu Tuarua | Deputy Vice-Chancellor Professor Ian Wright says he continues to be inspired by UC's Marsden Fund successes across a range of humanities and science, technology, engineering and mathematics (STEM) subjects, and the exceptional ability of the established and emerging researchers at UC.

2018 UC Marsden – funded research

Are genes all that matter? Dr Laurie McLay, Health Sciences (Fast-Start $300,000)

The prevalence of sleep problems in children with rare genetic neurodevelopmental disorders (RGND), such as Rett, Williams, and Prader-Willi syndromes, far exceeds that observed in typically developing children. These problems profoundly affect children's daytime functioning, and parent and child wellbeing. Without effective treatment, they are unlikely to abate. This study will investigate the role of environmental and learnt (through parent–child interaction) contributors toward sleep problems in children with RGND; the effectiveness of behaviourally based interventions; the short- and long-term maintenance of treatment effects; the role of pre-treatment salivary melatonin levels in response to treatment; and the collateral benefits of effective sleep treatment for family wellbeing.

"Kōrero mai. Tell us your earthquake story" Professor Paul Millar, Humanities and Creative Arts, ($859,000)

There are no major longitudinal, interdisciplinary studies of retelling of disaster narratives from a cohort of similarly affected participants. This gap will be addressed by re-recording a representative subset of the 720 participants who in 2012 gave their earthquake stories to UC QuakeBox – a recording studio in a shipping container that moved around Ōtautahi Christchurch. The resulting large longitudinal data set will provide an unprecedented resource for analysis by the multidisciplinary team. Studying the retold stories will offer insight into how retellings of dramatic experiences years later crystallise narrative structure. Narratives will significantly advance understanding of factors that influence resilience and rejuvenation within Māori whānau and communities.

Cracking under pressure Dr Heather Purdie, Geography (Fast-Start $300,000)

Investigating the impact of seasonally exposed crevasses on glacial melting in Aotearoa New Zealand's Southern Alps will increase understanding of the response of glaciers to climate change. Crevasses in a glacier's surface change the way the glacier interacts with wind and sun, leading to an increase in the rate of melting. Dr Purdie will compare melt rates of crevassed and uncrevassed regions of the same glacier. She will use a drone equipped with an infrared camera to map the shape of the surface of Haupapa Tasman Glacier. High-tech weather stations erected on the glacier will provide detailed measurements of heat exchange between the crevasses and snow surface, and the overlying atmosphere. The results will help scientists develop better models to predict the health of high mountain glaciers and to more accurately estimate glacial response to a warming climate.

Indirect measurement of lava rheology Associate Professor Mathieu Sellier, Mechanical Engineering, ($917,000)

The ongoing volcanic eruptions in Hawaii are a reminder for Aotearoa New Zealand that lava flows are a threat to many inhabited areas. Understanding the rheology of lava is critical to predicting its flow path and inform hazard management plans. Aerial imaging of lava flows provides a rich set of information at the surface that contains a hidden signature of the rheology. Associate Professor Sellier's project proposes to develop new techniques to unravel this rheological signature and enable the remote identification of the lava rheology from observed free surface flow measurements in-situ and in real time.

High-resolution satellite imaging Dr Steve Weddell, Electrical & Computer Engineering ($849,000)

Due to the proliferation of low Earth-orbiting objects, a method is required to find and characterise space debris and satellites. Imaging through the Earth's atmosphere results in small, distorted objects. One way of reducing distortion caused by turbulence on 2D images and 1D light curves is to use artificial (laser) point source beacons, moving them to track a fast Earth-orbiting object. An alternative, natural approach is to use faint background stars as point sources over a wide field-of-view to estimate localised aberrations. This project will investigate the best method of satellite imaging.

The geometry underlying rank-metric codes Dr Geertrui Van de Voorde, Mathematics and Statistics (Fast-Start $300,000)

For over 30 years, the only optimal rank-metric codes known were Gabidulin codes until John Sheekey recently constructed a new family of optimal rank-metric codes (MRD codes). He showed that, for certain parameters, MRD codes could be constructed using an object known from finite geometry, called a linear set. In recent work, Dr Van de Voorde pinpoints the geometric condition under which a linear set gives rise to an MRD code and proves this for all admissible parameters. In this project, the team exploits the connection between rank-metric codes and linear sets to tackle several interrelated questions from coding theory and finite geometry.

Hearing algebraic curves Professor Felipe Voloch, Mathematics and Statistics ($551,000)

Can you tell the shape of a drum from the sounds it makes? Professor Voloch's project will develop methods to tell apart the important mathematical objects called algebraic curves from information that corresponds to their sound. These methods of telling curves apart will yield a fast algorithm to factor polynomials over finite fields. Efficient factoring of polynomials is an essential tool in applications for error-correcting codes, cryptography and random number generation.

Microbiologist recognised with emerging career researcher award

Research into how bacterial communities assemble on plant leaves has won emerging career researcher Dr Mitja Remus-Emsermann a prestigious UC research award.

Microbiologist Dr Mitja Remus-Emsermann from Te Kura Pūtaiao Koiora | School of Biological Sciences was awarded UC's Early and Emerging Career Researcher Award for 2018.

"I am very happy and humbled to receive this award. It is a great recognition of my work and hopefully a good sign for the years of research ahead of me," he says.

Dr Remus-Emsermann's research aims at understanding how bacterial communities assemble on plant leaves and which factors drive the spatial structure of bacterial communities. It bridges the disciplines of microbiology, ecology and plant sciences.

"We are mainly interested in how bacteria grow on plant leaves, which growth pattern they exhibit and how they interact with other species that share the leaf with them."

This research has important implications for life sciences generally and could provide critical information for future approaches to protecting our agricultural interests locally and globally.

"By understanding how bacteria organise themselves on plants, we will be able to better prevent plant pathogen colonisations and disease outbreaks in agricultural environments," he says.

Using genes originally isolated from fluorescent jellyfish and corals, Dr Remus-Emsermann enables bacteria to 'glow' in different colours. By combining those bacteria with special microscopy techniques, he is able to follow individual bacteria and learn about their behaviour.

Innovative in his work, Dr Remus-Emsermann is using plastic slides that mimic, in intricate detail, the surface of a leaf and produce a controlled environment.

"By using leaf mimics, we are able to study bacterial interaction without interference of the plant. This helps us to understand what part the plant plays in the selecting of bacteria on leaves compared to what the bacteria are doing to each other."

Dr Remus-Emsermann is a senior lecturer in Te Kura Pūtaiao Koiora | School of Biological Sciences and an associate investigator at the Biomolecular Interaction Centre. He is recognised as an expert in this field and is a regular reviewer for high-impact journals.

Dr Mitja Remus-Emsermann

Understanding how bacteria organise themselves on plants will help to prevent plant pathogen colonisations and disease outbreaks in agricultural environments.

College of Arts
Te Rāngai Toi Tangata

Professor Paul Millar
Deputy Pro-Vice-Chancellor, College of Arts
Amorangi Tuarua Toi Tangata

Te Rāngai Toi Tangata | College of Arts researchers combine expertise in traditional areas with cross-disciplinary collaboration, innovative problem solving and a desire to address pressing social and cultural issues. Among our strong communicators is Associate Professor Bronwyn Hayward who, as a lead author on the Intergovernmental Panel on Climate Change, calls for swift action to reduce emissions. Our $1.2 million of Marsden Funding related to earthquake impact and response emphasises an ongoing commitment to post-disaster research.

Our research centres make a difference: Te Kāhui Roro Reo | New Zealand Institute of Language, Brain & Behaviour continues unearthing the foundations of human language; the National Centre for Research on Europe advises on the implications of Brexit for EU–New Zealand relations; the Macmillan Brown Centre for Pacific Studies assesses the impacts of geopolitics and climate change on Pacific societies and cultures; and the Arts Digital Lab supports projects like History's digitisation of UC's Medieval scroll and Associate Professor Donald Matheson's MBIE-funded app for preserving residential red zone stories. Research breadth is evident in our 2018 awards shared across all three schools: Dr Cindy Zeiher (Language, Social and Political Sciences) won the Early Career Researcher award for her study of the place of the subject within contemporary systems; Professor Philip Armstrong (Humanities and Creative Arts) won Excellence in Research for leadership in the area of Human Animal Studies. Mr Garrick Cooper (Aotahi—School of Māori and Indigenous Studies) won Teaching Excellence for a pedagogy drawing on research into practices of 'decoloniality' in Aotearoa. Fine Arts academics exhibited prominently and Mr Aaron Beehre won major design awards in Australia and Aotearoa New Zealand. UC's Arts Centre location was a hothouse for creating and performing new music, and for the Teece Museum and Classics Department finding innovative ways to link to our past.

With expertise in biculturalism, indigenous studies, ethics, equity, communication, futures, policy and critical thinking, Te Rāngai Toi Tangata College of Arts offers research-informed advice on major social and cultural issues to decision makers intent on achieving the best outcomes for all people. To learn if our expertise can benefit you, please contact paul.millar@canterbury.ac.nz

College of Business and Law
Te Rāngai Umanga me te Ture

Professor Sonia Mazey
Pro-Vice-Chancellor, College of Business and Law
Amorangi Umanga me te Ture

Increased disciplinary and interdisciplinary national and international collaboration is prominent across all areas of Te Rāngai Umanga me te Ture | College of Business and Law research activities.

The UC Business School is developing areas of strategic research activity alongside more traditional, discipline-based research. Developing research areas include Māori and Pacific research; public sector; sustainability; individual, organizational, and regional resilience; social marketing and alternative consumption; tourism marketing; and entrepreneurship and innovation. Bob Reed (Economics) ran a workshop on replication issues, which attracted international interest. Girish Prayag (Marketing) led a research project on perceptions of tourism sustainability and sustainable business practices funded by the New Zealand Tourism Industry Association. This research was undertaken with ChristchurchNZ, reflecting the School's strong research networks within the Ōtautahi Canterbury region. Ronán Feehily (Accounting) was the 2018 recipient of the UC Business School Early Career Researcher Award. His work was cited by the UN Commission on International Trade Law Regional Head for Asia and the Pacific as a major contribution to the advancement of rule-based commerce and to the promotion of multilateral trade and investment laws.

The government funded Centre for Entrepreneurship Founder Incubator, Xstart, established in 2018, hosts 13 businesses in the Ōtautahi Canterbury region.

The School of Law has an increasing research focus on highly topical interdisciplinary concerns including disaster management, freshwater resource management, oceans governance, human rights and indigenous peoples, gender and welfare law, international trade law, artificial intelligence, refugee law, and cross-border cooperation against crime. Annick Masselot's report, *Family leave: enforcement of the protection against dismissal and unfavourable treatment* has had a direct impact in the EU's new Work Life Balance Directive. Other highlights include Elizabeth McDonald's award from the Borrin Foundation for her project, *Reforming trial process in adult acquaintance rape cases*, John Hopkin's QuakeCore grant on *Addressing Wellington Multi-Story Buildings?* and Robin Palmer's lead in the Law Foundation funded *Forensic Brainwave Analysis Project 2018–2019*. Publication highlights included Lynne Taylor's co-edited *Corporate Law in New Zealand*, Elisabeth Macdonald's co-edited *Mahoney on Evidence*, and Todd, Barber and Finn's *The Law of Contract in New Zealand*.

College of Education, Health and Human Development *Te Rāngai Ako me te Hauora*

Professor Letitia Fickel
Acting Pro-Vice-Chancellor, College of Education, Health and Human Development
Amorangi Ako me te Hauora

Te Rāngai Ako me te Hauora | College of Education, Health and Human Development is committed to multidisciplinary research aimed at informing and enhancing social, educational and health outcomes for children, families and communities in Aotearoa New Zealand, in the Asia–Pacific and internationally. Our research is strongly linked with our teaching to ensure students are well prepared to meet future workforce needs and contribute to the wellbeing of their communities and society.

Our education researchers match interdisciplinary strengths with contemporary and leading-edge theoretical and methodological approaches, including the use of Kaupapa Māori methodology and Vision Mātauranga principles, to address education and social issues. Key areas of research include teacher education, Treaty-based teaching and learning, work-based learning, community engagement, equity and social inclusion, and leadership.

Our health sciences researchers engage in multidisciplinary research focused on individual and population health needs and physical wellbeing and activity over the life course. Of specific interest are the determinants of public health and health loss or disability, and the design of innovative strategies to improve health delivery and health outcomes. Areas of strength include mental health (counselling, child and family psychology), public health, epidemiology, health inequalities, healthcare design and delivery, service evaluation, Māori health, environmental health, sport science, physical activity, coaching and sport education.

In 2018 we launched the UC Child Well-being Research Institute to enhance the learning success and healthy wellbeing of children through multidisciplinary, strengths-based research. We also host the UC Community Engagement Hub aimed at advancing the teaching and scholarship of engagement. This complements our existing research hubs and labs in teacher learning and practice, e-learning, education policy, language and literacy, inclusive and special education, sport, epidemiology and Māori research. College researchers have demonstrated success with funded research, such as National Science Challenges, Marsden, Teaching and Learning Research Initiative, Health Research Council, United Nations Educational, Social and Cultural Organization (UNESCO), the Ministry of Business, Innovation and Employment (MBIE) and private foundations.

College of Engineering *Te Rāngai Pūkaha*

Professor Jan Evans-Freeman
Pro-Vice-Chancellor, College of Engineering
Amorangi Pūkaha

The research capabilities of Te Rāngai Pūkaha | College of Engineering are diverse in their scope and scale. The topics likewise range from large structures like bridges and roads to microscopic structures formed by nanotechnology, and all research is supported by both theory and practical experiments. Our research has real-world impact and societal benefit – including by developing safer buildings, making new advances in medical technology and imaging, conducting research into big data, forest engineering and modelling biodiverse lineages. In 2018 we added to this broad portfolio with the opening of a new School of Product Design and will be enrolling our first research students in this school in 2019.

One of the research highlights in 2018 was an award for a spin coating technique in Mechanical Engineering that can be adapted to curved surfaces and could open up a range of commercialisation options. In addition, significant research funding was obtained in the areas of indirect measurement of lava rheology, high-resolution satellite imaging without artificial beacons, the geometry underlying rank-metric codes and hearing algebraic curves, and factoring polynomials. Researchers gained Earthquake Commission funding to examine critical questions about earthquakes in Aotearoa New Zealand; another group is investigating how to make launching rockets faster and cheaper by modelling the movement of fuel in a rocket.

In 2018 we commissioned our new Structural Engineering Laboratory, in which we have one of the largest strong walls in Aotearoa New Zealand, and are able to test full-size building components for their reactions to prolonged stress, shaking and twisting. Another achievement was to open the Fire Laboratory, which is one of only two in the southern hemisphere. Both research laboratories also open up new possibilities in teaching. Final-year student engineering projects are also an excellent introduction to research, with many being carried out in conjunction with industry partners.

We are always interested in new projects. Engaging with us can take a range of forms, from emailing the College office to speaking with departments directly or talking to our new college relationship and engagement manager.

College of Science *Te Rāngai Pūtaiao*

Professor Wendy Lawson
Pro-Vice-Chancellor, College of Science
Amorangi Pūtaiao

The year 2018 was another exciting and productive one for research in Te Rāngai Pūtaiao College of Science. A particular feature of our ongoing success is the continued increase in the external research funding – reaching a total of $15.9 million in external revenue income in 2018, an increase of 26% on 2017.

We continue to diversify our portfolio of interdisciplinary research teams and interdisciplinary research projects. We were thrilled to have Prime Minister Rt Hon Jacinda Ardern formally open the new Ernest Rutherford laboratory facility in February 2018. Since then, the building has amply demonstrated the extent to which design creates and fosters an environment for interdisciplinarity, in terms of both the technical spaces and the arrangement of 'social spaces' where people – staff, students and visitors – can converse about what they are doing and how they might collaborate.

Three of our leading interdisciplinary researchers have been recognised in various ways in 2018. The winner of our College of Science Emerging Researcher Award was Dr Phoebe McCrae, who works on swallowing disorders as part of the interdisciplinary teams hosted at the Rose Centre. Professor Simon Kingham was appointed to the role of Minister of Transport Chief Science Advisor; his long-standing work on the geography of health and transport epitomises an interdisciplinary approach to exploring research-based solutions to our societal challenges such as sustainable transport and urban planning. Professor Phil Butler, of Te Kura Matū | School of Physical and Chemical Sciences, was awarded the UC Innovation Medal, in recognition of his work leading interdisciplinary teams in the commercialisation of new colour x-ray technology.

Overall, 2018 reflected ongoing progress in our aspiration to conduct impactful interdisciplinary research that is excellent and world leading. If you would like to discuss ways we may be able to work with you and your group or organisation to address a research-related problem, please do not hesitate to contact me at wendy.lawson@canterbury.ac.nz

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Research Institutes and Centres

Biomolecular Interaction Centre (BIC)

The Biomolecular Interaction Centre (BIC) is a national research institute dedicated to understanding and engineering biomolecular interactions, which is central to a range of fundamental sciences and engineering applications.

The centre was founded in 2007 at UC. It has a unique blend of researchers from across Science and Engineering, and partners with several Aotearoa New Zealand Crown research institutes and universities, as well as with Callaghan Innovation.

Its nine principal investigators are based at three Aotearoa New Zealand universities, and more than 35 associate investigators work nationally and internationally. These investigators are supported by experienced postdoctoral fellows and a large number of postgraduate students researching biomolecular interactions. Our flagship projects include engineering biotechnology, evolving and engineering biomolecules and chemical biology. BIC supports a dynamic research environment for both staff and students, and researchers are well placed to explore commercial applications of their science.

www.canterbury.ac.nz/bic

Electric Power Engineering Centre (EPECentre)

The Electric Power Engineering Centre (EPECentre) is Aotearoa New Zealand's Centre of Excellence for electric power engineering, established in 2002 as a joint initiative between the electricity industry and UC. Linking the electricity industry and academia, it has three core areas of operation: research and innovation, industry academia collaboration, and education. The centre has over 30 industry partners through the Power Engineering Excellence Trust (PEET) and ongoing research projects, as well as a network of over 700 industry and research contacts – both local and international.

The EPECentre employs high-calibre researchers, engineers and support staff in management, technical and educational roles to achieve its objectives. It is funded by the Aotearoa New Zealand electricity industry via PEET, research funders (government and industry) and consultancy work. The EPECentre's vision is to carry out electric power research that is of national significance and internationally recognised, and to produce a sustainable stream of high-calibre electric power engineering graduates who move from university to industry and research each year.

www.epecentre.ac.nz

Gateway Antarctica

Gateway Antarctica is a centre for Antarctic studies and research at UC.

The purpose of Gateway Antarctica is to contribute to increased understanding and more effective management of the Antarctic and the Southern Ocean. It achieves this as a focal point and a catalyst for Antarctic scholarship, attracting national and international participation in collaborative research, analysis, learning and networking.

www.canterbury.ac.nz/science/schools-and-departments/antarctica

Toi Hangarau | Geospatial Research Institute (GRI)

Te Toi Hangarau | Geospatial Research Institute (GRI) is a multidisciplinary research centre dedicated to outward-facing, collaborative geospatial research and innovation. Its mission is to provide a national centre of gravity for geospatial research that gives Aotearoa New Zealand the foundation it needs to fully realise the benefits of spatial information technology. It aims to substantially increase geospatial research output and be deeply involved in connecting this research to the outside world through commercialisation, social and educational research, as well as outreach programmes.

www.geospatial.ac.nz

Hangarau Tangata, Tangata Hangarau | Human Interface Technology Laboratory (HIT Lab NZ)

The Human Interface Technology Laboratory New Zealand (HIT Lab NZ) is a dynamic human-computer interface research centre hosted at UC. It is focused on supporting people in performing real-world tasks by applying advanced interface technology.

The HIT Lab NZ is revolutionising the way people interact with computers by creating cutting-edge interfaces to:

- enhance human capabilities
- compensate for human limitations
- assist people to better perform tasks at work and in their daily lives.

The HIT Lab NZ's multidisciplinary approach to research and education facilitates an entrepreneurial environment, which in turn fosters a wealth of innovative ideas, leading to an improved economic climate in Aotearoa New Zealand. Currently, HIT Lab NZ is working on a range of projects in collaboration with industry, academia and government partners from around the world.

www.hitlabnz.org

Macmillan Brown Centre for Pacific Studies

With a world-class research profile, the Macmillan Brown Centre for Pacific Studies is the leading institution for Pacific research in Aotearoa New Zealand. The research scholars (PhD and MA) come from countries around the world and the focus of research revolves around Pacific-related themes as well as Asian and global issues. The centre has led a number of major regional and global projects and continues to be at the forefront of innovative research on the Pacific Island region in collaboration with national, regional and international partners. The centre founded and hosts *Pacific Dynamics: Journal of Interdisciplinary Research* as well as the new Global Interdisciplinary Research and Innovation Hub on the Pacific, which facilitates research and innovation on a range of interdisciplinary issues on Pacific societies such as climate change, political change, cultural transformation, ethnic relations, education, development, history, sociology, anthropology, environmental studies, corporate innovation, conflict and peace building, gender issues and identity.

www.canterbury.ac.nz/mbc

National Centre for Research on Europe (NCRE)

The National Centre for Research on Europe (NCRE) is Aotearoa New Zealand's premier European Union (EU) tertiary-level think-tank. It undertakes both academic and outreach activities, involving a variety of public diplomacy roles and mechanisms.

Since 2006 the NCRE has managed the EU Centres Network of New Zealand, incorporating all eight of the country's universities. It has also established formal links with similar EU centres in the Asia–Pacific region, including: RMIT, Melbourne; the Australian National University, Canberra; Waseda, Tokyo; Korea University, Seoul; University of Malaya, Kuala Lumpur; Sichuan University, Chengdu; and Tsinghua University, Beijing.

As a designated Jean Monnet Centre of Excellence, it also involves Fudan University, Shanghai; Chulalongkorn University, Bangkok; and the University of Kent, Canterbury, UK.

The NCRE offers incoming and outgoing internships – most notably with the European Parliament and the Asia–Europe Foundation – and has a range of teaching and exchange programmes with other EU studies programmes in our region.

The main focus of the NCRE is on the European Union's impact on the Asia–Pacific region, with special emphasis on foreign policy, media perceptions, development policy, trade and regional integration.

www.canterbury.ac.nz/ncre/research

Te Kāhui Roro Reo | New Zealand Institute of Language, Brain and Behaviour (NZILBB)

Te Kāhui Roro Reo | New Zealand Institute of Language, Brain and Behaviour (NZILBB) is a multidisciplinary centre dedicated to the study of human language. Coming from a wide range of disciplines, its researchers forge connections across linguistics, speech production and perception, language acquisition, language disorders, social cognition, memory, brain imaging, cognitive science, bilingual education and interface technologies. This highly interdisciplinary team is working together toward a truly unified understanding of how language is acquired, produced and understood in its social and physical contexts.

www.canterbury.ac.nz/nzilbb

Kā Waimaero | Ngāi Tahu Research Centre (NTRC)

Kā Waimaero | Ngāi Tahu Research Centre (NTRC) was established in August 2011 as a joint initiative between Ngāi Tahu and UC. Its purpose is to be a leader in indigenous scholarship and to provide a centre for the intellectual capital and development of Ngāi Tahu, the principal iwi of Te Waipounamu South Island. NTRC's focus is on issues of importance to Ngāi Tahu, and in recent years has provided research and advocacy on economic development, water and tribal government while building strong relationships with leading international universities.

www.canterbury.ac.nz/ntrc

Te Hiranga Rū | QuakeCoRE: New Zealand Centre for Earthquake Resilience

Te Hiranga Rū | QuakeCoRE is a national Centre of Research Excellence (CoRE) of earthquake resilience researchers. It leverages strengths across the country and internationally, working collaboratively on integrated multidisciplinary programmes of world-class research. Its aim is to support the development of an earthquake-resilient Aotearoa New Zealand where thriving communities have the capacity to recover rapidly after major earthquakes through mitigation and pre-disaster preparation.

www.quakecore.nz

Spatial Engineering Research Centre (SERC)

The Spatial Engineering Research Centre (SERC) addresses the engineering problems of modern-day navigation and remote-sensing geo-referenced data collection. Investigations into the linkages between positioning and data collection are the fundamental baseline for many geospatial sciences, and finding new ways to navigate in environments starved of the Global Navigation Satellite System (GNSS) is essential for complete geographic data coverage. The SERC team is a multidisciplinary force specialising in wireless systems, global navigation satellite systems, computer machine vision and inertial navigation. SERC supports geospatial science research in conjunction with industry, Crown research institutes, other universities and UC students. SERC has provided commercial remote-sensing services to large and small companies.

Among its many areas of work, SERC has been involved in photogrammetry using unmanned aerial vehicles (UAVs). Another UAV activity involves administering a 100-square-kilometre UAV flight test site approved for beyond visual line of sight (BVLOS) flights.

In addition to its own postgraduate engineering students, SERC has been contributing to the teaching of the Master of Geographic Information Science programme. SERC, in close collaboration with the Wireless Research Centre, has started active research in the areas of autonomous vehicles, Internet of Things and terrestrial sensors for satellite communication.

www.canterbury.ac.nz/serc

Te Pokapū Rū | UC Quake Centre (UCQC)

Te Pokapū Rū | UC Quake Centre (UCQC) is a dynamic partnership between the engineering industry and UC. It has developed strong collaborations with the University of Auckland Te Whare Wānanga o Tāmaki Makaurau and other partners, including the learned societies, architects, local government, consultancies, large asset owners, the construction sector and overseas institutions, to provide world-class knowledge and research on and solutions to seismic issues.

UCQC focuses on training and fostering expertise, supporting and encouraging the best professional practices, and keeping individuals and groups informed about ongoing work and research within the sector. Other key areas of work are to identify the levels of risk facing communities and look at ways to provide innovative and commercially viable solutions in response to those risks.

UCQC is committed to using the unique events in Ōtautahi Christchurch's recent seismic history to inform its research and recommendations for the future and, ultimately, providing proven solutions that help make individuals, businesses, governments and communities more resilient to future earthquakes.

www.quakecentre.co.nz

Waterways Centre for Freshwater Management

A joint venture between UC and Lincoln University | Te Whare Wānaka o Aoraki, the Waterways Centre for Freshwater Management is a focal point for improving knowledge-driven water resource management in Aotearoa New Zealand. The centre offers undergraduate courses and postgraduate degrees in water resource management, to serve the ever-increasing demand for graduates in this field.

A strong connection is maintained with private sector and water research organisations to ensure the skills, knowledge and awareness conveyed in the classroom are relevant to the whole water sector. The centre also acts as first point of contact for external groups seeking research expertise and community or professional development education in the field.

The centre is an example of strong cooperation between two universities in Aotearoa New Zealand, leading to better education outcomes for the country.

www.waterways.ac.nz

Wireless Research Centre (WRC)

The Wireless Research Centre (WRC) is responsible for driving research and innovation within the field of wireless communication at UC. WRC's purpose is to secure the continuing presence of a strong and successful industry knowledge base in wireless communications in Aotearoa New Zealand. Its key goals are to assist Aotearoa New Zealand industry by de-risking the early stages of product development in the wireless space and by providing innovative wireless solutions for niche applications tailored to the specific needs of industry partners.

WRC plays a key role in keeping Aotearoa New Zealand expertise at the forefront of international telecommunications research and development, as measured by the graduation of high-calibre students, economic impact, publications and patents. The centre has extensive knowledge and experience working with emerging wireless standards, including the 4G and 5G cellular (mobile phone) family of standards, low power wide area (LPWA) standards, and local area and personal-area networks. Specific technologies of expertise include multiantenna systems (MIMO), error control coding, diversity systems, relaying, scheduling and the application of combinations of wireless and geospatial technologies such as indoor logistics and intelligent transport systems.

WRC, in close collaboration with the Spatial Engineering Research Centre, has started active research in the areas of autonomous vehicles, smart cities, sensors for intelligent transportation and Internet of Things.

www.canterbury.ac.nz/wrc

Child Well-being Research Institute

The Child Well-being Research Institute aims to advance high-quality, multidisciplinary research to enhance the learning success and healthy wellbeing of children and young people. Our focus is holistic, including research related to infants, children and adolescents within the context of their whānau and community. Committed to leading and developing a strengths-based discourse around child development, health and wellbeing, the institute collaborates with partner organisations and communities of interest.

The institute embraces the principles of Vision Mātauranga and builds on the learnings from the National Science Challenge 'A Better Start' to encourage innovation and make a meaningful impact from our research endeavours.

The institute also aims to develop emerging researchers and foster interdisciplinary research, working in constructive and collaborative ways to build teams for research bids and project work. The skills and knowledge of staff in the institute are harnessed to ensure digital technology is at the leading edge in terms of project design and execution, and their research outputs are disseminated to community members, policy funders and global audiences.

www.canterbury.ac.nz/childwellbeing

UC7

UC is a truly holistic place of learning, made up of seven outstanding dimensions that will prepare you to change the world.

1 UC Academic

Did you know UC is ranked in the top 3% of universities worldwide? Founded over 140 years ago, our legacy of celebrated graduates has shaped the world we live in today. Here, you'll learn from passionate lecturers in over 100 programmes of study. You'll have a chance to be part of groundbreaking research at our research centres and field stations. Best of all, you'll graduate with an excellent academic qualification under your belt.

Sophie

'It makes your learning much more real when you suddenly see bacteria change colour or grow on a new medium. It makes the theory click into place and the academic experience becomes way more interesting.'

2 UC Community

The city of Ōtautahi Christchurch is a growing hotbed of opportunity. Developments and initiatives are popping up at a rapid pace and our graduates are perfectly poised to access these opportunities. Over the last few years our students have earned an international reputation for their community involvement. Get involved by joining the Student Volunteer Army or connect with a range of local organisations — Ōtautahi Christchurch is a great place to be!

Jack

'There's lots of amazing stuff to do in the Christchurch community, I'm really excited about helping give students a voice.'

3 UC Bicultural

At UC we are committed to biculturalism. That's a good thing for Aotearoa New Zealand, and a good thing for you too. As part of this commitment we work with Ngāi Tahu, the tangata whenua in our region. At UC you'll gain bicultural perspectives and experience in your courses of study through engaging with course content, ideas and activities in your chosen subjects. You can also take specific courses on Māori language, culture, art, and Te Tiriti o Waitangi.

Abby

'I really want to see Te Reo Māori being valued as the official language that it is, and I want to inspire future tamariki to speak te reo.'

4 UC Global

Come to UC and get ready to see the world. We have exchange agreements with over 50 universities worldwide in North America, Europe, Asia and Australia. We also bring the world to UC. Our unique Erskine Fellowship programme brings 75 international academics each year to teach at UC. We don't just promise a global perspective, we deliver a global experience.

Keegan

'I really wanted to experience a culture that's totally diverse from our own. Landing in a city of 26 million people was amazing.'

5 UC Active

From the sea to the mountains and everything in between, UC is on the doorstep of a massive outdoor 'playground'. Grab your snowboard/surfboard/mountain bike/trail shoes and give it a go. On campus you'll have your choice of high-end accommodation and all the amenities of a fully equipped student village. At its heart, UC features a thriving student association plus over 130 student-led clubs covering every interest under the sun!

Amy

'I love that I can go skiing in winter and to the beach in summer. There are so many cool things you can do around here.'

6 UC Enterprise

Get switched on, get hands on. Over 35% of our courses will get you out into the workplace or the community. The result? When it comes to interview time, you'll have the kind of real experience employers are looking for. Budding entrepreneurs will have the chance to shine with entré, UC Innovators and the UC Hatchery, which are dedicated to supporting innovation and student start-up ventures. At UC you'll create connections that count.

Manny

'As part of the entré exec I got to meet a whole lot of people. I realised that top executives aren't that scary, they actually want to help!'

7 UC Support

What are your strengths? Your interests? Your learning style? At UC you'll have a dedicated support system to help you find your way and make the most of uni life. From your first week you can pair up with a second or third year "student buddy" who will show you the ropes and make sure all your questions are covered. Approaching graduation your Co-Curricular Record — an electronic record of verified extra-curricular activities — will add that real-world edge to your CV.

Brendain

'Recently I became a Go Canterbury student leader. That's a development programme that helps students from other cities integrate into Christchurch.'

We have a vision of people prepared to make a difference – tangata tū, tangata ora.

Our mission is to contribute to society through knowledge in chosen areas of endeavour by promoting a world-class learning environment known for attracting people with the greatest potential to make a difference.

We seek to be known as a University where knowledge is created, critiqued, disseminated and protected and where research, teaching and learning take place in ways that are inspirational and innovative.

Looking towards 2023, the 150th anniversary of our founding, the primary components of our strategy are to Challenge, Concentrate and Connect.

University of Canterbury Statement of Strategic Intent

An electronic copy of this publication and details of our 2018 research outputs are available from the Research & Innovation website www.canterbury.ac.nz/research/specialties/research-report/

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