inSCight

He kōrero whakahihiko nō roto mai i Te Whare Pūtaiao

Inspiring stories from the Faculty of Science

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Redefining possibilities

The science behind the technology

From the vast ocean to outer space, we celebrate the research fuelling exciting and innovative technologies.

Waipapa Taumata Rau
University of Auckland

inSCIght 2025

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A word from the Dean

E ngā mana, e ngā reo, tēnā koutou.

Welcome to the latest edition of *inSCight*, our annual publication celebrating the inspiring stories from the Faculty of Science at Waipapa Taumata Rau, University of Auckland.

Each edition of *inSCight* showcases the impactful research contributions of our esteemed staff, dedicated students, and distinguished alumni.

This year, we showcase the research and technologies shaping our future. From our oceans to the vastness of outer space, we bring you news of accessible search and rescue devices, human health innovation, cutting-edge communications and more.

This issue demonstrates the power of collaboration through international partnerships, Joint Graduate Schools, and the inherently interdisciplinary nature of our research.

As the Dean of Science, it is my pleasure to invite you to enjoy our 2025 *inSCight* magazine. We hope you are inspired to learn more, connect with our academics, and support the incredible work emerging from the Faculty of Science.

Professor Michael Kingsley
Interim Dean of Science
University of Auckland

Ehara taku toa i te toa takitahi. Engari, he toa takitini.

Success is not the work of one, but the work of many.

Kia ora koutou, and welcome to *inSCight* for 2025

Having taken up the reins as Associate Dean (Research) in February, it has been a pleasure for me to get to know more about the outstanding research taking place in our Faculty of Science, and an absolute honour to represent our researchers within the University and beyond.

New Zealand's scientific community faces changing and challenging times. The largest review and reform of our research sector in a generation is under way, and the purse strings of public funding have been tightening across the board. We are facing up to these challenges by delivering research that is relevant and important for our stakeholders – the people of Aotearoa New Zealand. The breadth and quality of research in our Faculty will allow us to adapt and thrive.

This issue of *InSCight*, themed "Technology of the Future", showcases pathways to sustained future success – from the emergence of space-faring technologies to the frontiers of new computing methods and their applications, and beyond. Among the featured researchers, several are also targeting and accessing funding from sources beyond conventional channels. Researchers such as Claude Aguergaray, Thomas Dowling, and Jami Shepherd are making sterling efforts to commercialise new technologies. Nick Rattenbury's free space optics research supports projects that are funded to strengthen international collaborations and unlock new commercial opportunities.

Recent highlights have included successes in the latest Ministry of Business, Innovation & Employment (MBIE) Endeavour funding rounds. Six large Programme grants and four Smart Ideas grants were led or co-led by Faculty of Science researchers. The newly-funded 'ideas' range from the use of AI for pest management to new applications for spatial skills training. We also had two winners of the University's major internal awards: Nicholas Shears (Research Impact Award) and Rebecca Gladstone-Gallagher (Early Career Research Award), both from our Institute of Marine Science.

Further exciting developments are on the horizon for the remainder of 2025. At the time of writing, Auckland has just been announced as the host of the New Zealand Institute for Advanced Technology, a new Public Research Organisation closely aligned with future technology themes. This announcement was undoubtedly buoyed by Mayor Wayne Brown's promotion of an Auckland Innovation and Technology Alliance earlier in the year. That initiative drew upon the rise of the local deep tech ecosystem, exemplified by Outset Ventures in Parnell and the portfolio of companies incubated in the Newmarket Innovation Precinct. In the coming years, there will be first-rate industrial opportunities for our Faculty's researchers right on our doorstep, and the University will undoubtedly align parts of its own strategy with these developments.

External challenges to our research are stimulating change in new directions, and we welcome and encourage readers to connect and collaborate with the Faculty of Science as we head down those trails. Within the Faculty and the University, we have an enormous amount of talent, capability, and equipment, and there are a variety of mechanisms for stakeholders to harness and utilise these. Please do get in touch to start a conversation.

Auckland City. iStock

Associate Dean Research
Professor Geoff Willmott

Space-based rescue tech could help find missing boats in the Pacific

A low-cost floating device that reflects radar signals back to satellites could become a vital new tool for saving lives at sea, especially in the vast and remote regions of the Pacific Ocean.

Waipapa Taumata Rau, University of Auckland Earth observation scientist Dr Tom Dowling and engineer Ella Fasciana are developing the passive radar reflector in collaboration with the New Zealand Defence Force. The project is known as SAR4SaR – Synthetic Aperture Radar for Search and Rescue.

The concept is simple: a lightweight object that can be carried on a small vessel and, in an emergency, popped open and dropped into the water. From there, it floats upright and reflects radar signals back to satellites orbiting overhead, enabling rescuers to spot the vessel's location even in stormy or low-visibility conditions.

"The aim is integration into real-world search and rescue systems, particularly those serving the seafaring cultures of the Pacific," says Dowling. "Affordability, reliability and independence from electronic infrastructure are essential."

The project is in collaboration with Defence, Science and Technology, the science arm of the New Zealand Defence Force.

> "The aim is integration into real-world search and rescue systems, particularly those serving the seafaring cultures of the Pacific... affordability, reliability and independence from electronic infrastructure are essential."
>
> – Dr Tom Dowling

Many communities in the Pacific Islands depend on small boats for fishing and transport, often without high-end navigation or emergency gear. If a vessel breaks down or drifts off course, the consequences can quickly become life-threatening. Emergency beacons and radios are expensive, require batteries and maintenance, and have a shelf life. For many, they are simply out of reach.

"This is a different approach," says Dowling. "If we can make something that just works – that you don't have to charge, you don't have to activate, and it tells satellites where you are – that could be a real breakthrough."

The reflector they are developing is designed to be folded flat and stored under a seat or in a compartment on a small boat. Unlike electronic devices, the reflector is completely passive. It doesn't transmit a signal or require power. Instead, it focuses and reflects the energy of radar signals sent from satellites – like how a mirror reflects light – making it visible in the radar images.

Synthetic aperture radar, the satellite-based technology, is "synthetic" because it simulates the results from an unfeasibly large antenna by combining the data from sequences of radar readings recorded as the satellite moves across the sky.

This process allows it to generate detailed images of the Earth's surface, even through cloud, rain, darkness or smoke.

"Synthetic aperture radar has been around since the 1970s and NASA did some early research into using it for search and rescue," says Dowling. "But recent advances in low Earth orbit satellites – smaller, cheaper satellites flying much closer to Earth – have made it feasible to use this technology for something like search and rescue for a wider range of actors."

An artificial intelligence tool will scan the radar imagery for the distinctive signature of the reflector so authorities can be alerted to the distress signal.

Working in the fabrication space at Te Pūnaha Ātea – Auckland Space Institute, the pair began by experimenting with origami-like concertina designs. They used computer modelling to test different shapes and materials for the strength of the signal returned, then constructed dozens of prototypes using items such as corflute, gaffer tape, aluminium foil and tarpaulins from local hardware stores.

Early tests took place at the University's Ardmore field station in South Auckland, where the team worked out whether satellites could even detect the reflectors from orbit. Encouraged by the results, they moved to water trials, testing stability and radar visibility in real-world sea conditions.

One of the most demanding tests was conducted with the Royal New Zealand Navy from the HMNZS Canterbury near subantarctic Campbell Island. In conditions that included 50-knot winds – over 90km/h – the reflector stayed afloat and visible to satellites.

"We were very nervous to begin with but got more confident as the test progressed and are absolutely thrilled at the results," Dowling told a reporter.

Early land-based trials at Ardmore.

Testing the device at sea.

More recently, in July 2025, the team completed a week-long experiment at Omaha, north of Auckland. With support from the University's Leigh Institute of Marine Science and the research vessel Te Kaihōpara, the reflectors were put through a series of trials that confirmed their detectability, durability and ease of deployment.

For Ella Fasciana, who will dedicate her PhD research to the project, the work combines her knowledge from engineering and environmental science degrees with a passion for practical solutions.

Designing the device has involved balancing several tough requirements: it must be light enough to carry and store, strong enough to survive a storm, and cheap enough for widespread use. Different configurations – diamond, cube, wedge – have been tested to find the most effective shape.

Bobbing on the ocean's surface, the geometry of aluminium-surface plates inside the device focuses radar energy back toward the satellite.

The goal is to manufacture a device that could retail for $50 to $60. The team has filed a patent and, pending further testing, hopes to move towards production-ready prototypes. One remaining challenge is filtering out potential false positives from ice and some waves.

The University and the Defence Force have jointly contributed some $40,000 to the project so far, while the scientists have donated time and the Defence Force has provided logistical support. "It's been a highly cost-efficient and collaborative project," says Dowling.

The reflectors would not replace emergency beacons or radios but could complement them or serve as substitute for vessels without access to high-tech gear.

> "When you're searching for a missing boat in the Pacific, it really is like looking for a needle in a haystack ... this kind of technology could give you the one clue you need to start narrowing things down."
>
> – Dr Tom Dowling

Any tool that shortens the time it takes to find a missing boat could also reduce the enormous cost of search and rescue operations. In New Zealand, this often involves long-range maritime patrol aircraft such as the Royal New Zealand Air Force's P-8 Poseidon, which are essential but resource-intensive to operate.

New Zealand's Rescue Coordination Centre is responsible for maritime search and rescue across one of the largest search and rescue regions in the world – 30 million square kilometres, from the mid-Tasman Sea to halfway across the Pacific Ocean, and from the South Pole almost to the Equator.

"When you're searching for a missing boat in the Pacific, it really is like looking for a needle in a haystack," says Dowling. "This kind of technology could give you the one clue you need to start narrowing things down."

A simple device that increases the chances of being spotted – and doesn't rely on electronics, batteries or someone remembering to switch it on – could make all the difference.

"Sometimes it's the simplest things that save lives," says Dowling.

Above: Testing the device at sea. Otago Daily Times

Taiaho Observatory

How UoA is contributing to the next generation of communications

Over the past two years, Associate Professor Nick Rattenbury and Dr Joe Ashby have been building the Taiaho Observatory, transforming University land in South Auckland's Ardmore into a cutting-edge field station for free space optical communications (FSOC) research.

The FSOC project was set in motion after a conversation with Professor Anna Moore, the Director of the ANU Institute for Space (InSpace) at the Australian National University, about a group of Australian universities that are collaborating on a network of telescopes across Australia.

Nick is the principal investigator overseeing the project and sourcing funding for the research. He explains that the conversation with Anna Moore led to an introduction to the German Space Centre (DLR), which is a world leader in Free Space Optical Communications. New Zealand was already interested in developing closer research links with Germany and looking for research ideas, so the timing was favourable and eventuated in funding streams, which successfully targeted working specifically with the DLR.

"It's a project I got excited about because it involved things I'm really interested in, specifically telescopes. It gave us the opportunity to work with our colleagues in Australia, and it's clearly aligned with one of the strengths of the physics department here, which is laser communications and photonics," says Nick.

He credits Joe Ashby as the person who is driving the research progress and managing the team of students working on related research.

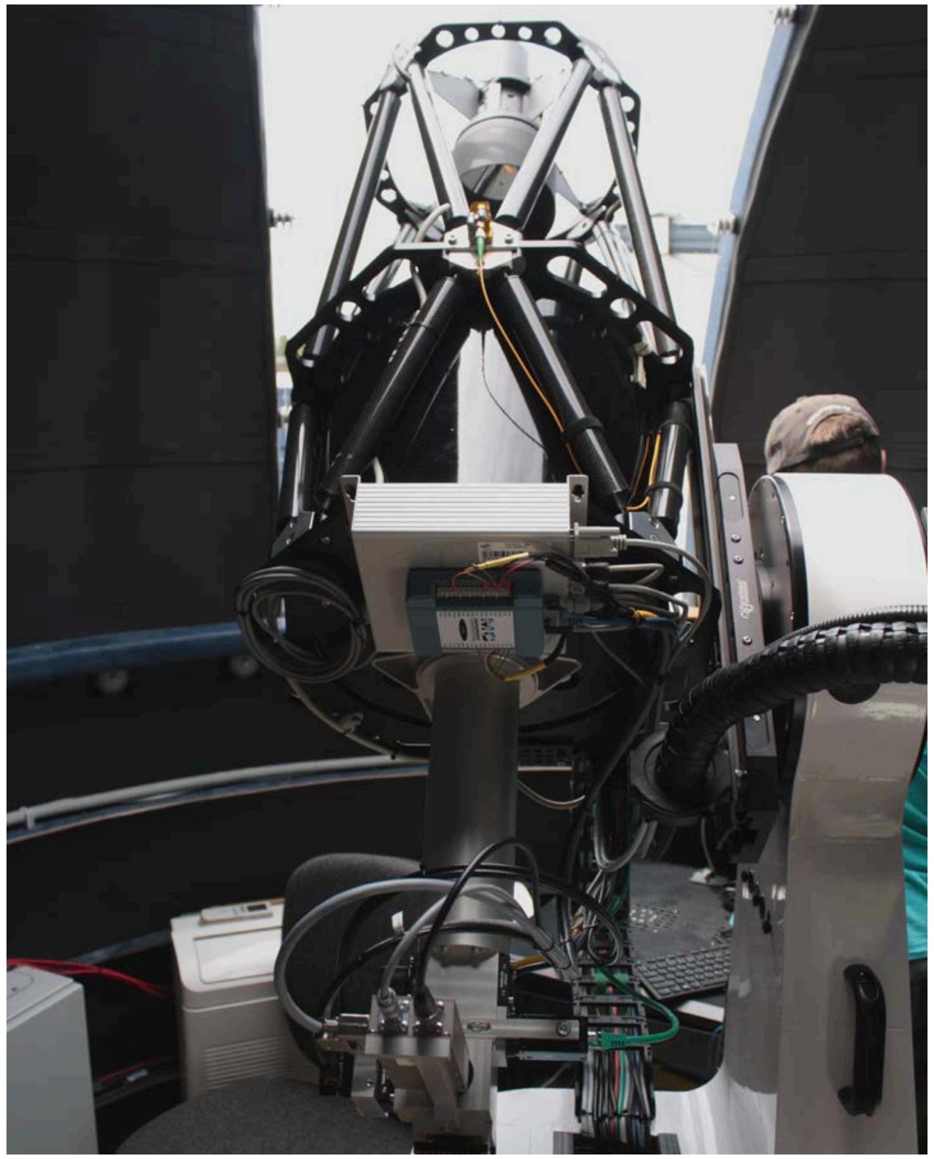
"In the field of optical communications, there's a lot of science to be done on the measurement of atmospheric turbulence. Even in a completely clear sky, you've got this turbulent effect that distorts the lasers as they come in," says Joe.

Joe also managed the commissioning of the dome, which is essentially on a permanent loan or a gift from the Defence Science and Technology (DST), and the technology installation on site. This process faced its fair share of challenges, ranging from mechanical to organisational, and was further complicated by the less-than-ideal existing infrastructure at the Ardmore site.

Inside the dome, the team has been collaborating with a group that was sent to New Zealand by the DLR to install the Small Optical Ground Stations Focal-Optics Assembly.

"The actual technology installation, and commissioning that we did in collaboration with the DLR was probably the fastest I've ever seen something like that get put together. They were here for three weeks. I think we had pretty much everything installed by the end of week one," says Joe.

> "It's a project I got excited about because it involved things I'm really interested in, specifically telescopes."
>
> – Associate Professor Nick Rattenbury



The primary telescope of Taiaho Observatory, with the DLR Small Optical Ground Station Focal-Optics Assembly mounted on the rear.

The team saw its first signals in mid-February, from the DLR satellite, meaning, in theory, they have commissioned the ground station and have proven its capability.

The student projects focus on: atmospheric turbulence to better understand and measure how atmospheric conditions affect laser signals and Optical Communications; and Satellite Laser Identification Systems, centred around a student-built satellite prototype designed to broadcast laser signals for identification.

The goal is to develop the capabilities for performing quantum optical communications and advanced adaptive optics systems to correct signal distortions due to atmospheric turbulence. The team has established the first New Zealand FSOC node, forming part of an Australasian Optical Communications Ground Station Network.

Nick explains, "Free space optical communications is talking between the Earth and orbit using laser light as opposed to radio frequency light."

There are many benefits to this technology; it's faster, it can process more information and, significantly, it has the ability to be more secure.

"The thing that you can do with an optical communications link is that you can include a level of security which is not available for any other type of communications," says Nick.

He explains the difference is that radio frequencies are broadcast everywhere, requiring the application of encryptions, which are increasingly less secure as technology evolves. In contrast, the use of laser communications introduces a level of security that can not be compromised by technology because it's a function of fundamental quantum mechanics.

"There's a way of sending the communication so that the two people who want to communicate with each other know whether their communication has been eavesdropped... and that's something the eavesdropper can do nothing about," says Nick.

Joe explains that a phenomenon driving much of the investment in this research is Q-day (Quantum Day). Scientists predict quantum computers will soon be theoretically capable of quickly decoding standard encryptions, presenting a significant risk to currently considered secure communications.

"We believe they will be able to decrypt all current encryption protocols in a matter of minutes instead of taking thousands of years," says Joe.

A view of the full moon from Taiaho Observatory, taken during the commissioning phase of the project.

The biggest challenge for the technology is the cloud and atmospheric interference. Even with clear conditions, dropouts can occur due to the Earth's atmosphere causing laser instability.

This is where the collaboration across nations is valuable for what they term 'site diversity'. "If you have a group of telescopes separated by several hundred kilometres over a wide area, all working together as a network, then you can dodge the clouds at one site. For instance, if it's cloudy in Auckland, then maybe Western Australia will be clear and able to see the same satellite during its next pass as it goes over," says Nick.

While the project is largely collaborative, a level of secrecy is expected with significant technological advances. However, this is limited by the reliance on collaboration and information sharing necessary for the technology's success.

"If you want to communicate worldwide, you have to develop standards. And those standards must be developed in conjunction with other people around the world who are working in the same area," says Nick.

This is a hot topic of debate right now, given how critical security is to the success of the collaboration.

"Some sectors are looking into this very carefully, questioning, how do we possibly trust these communications when those communications go outside our own borders and our own control?", says Nick.

Nick and Joe credit support from the DST and the DLR German Space Centre as an invaluable contribution that has made it possible to progress the project to where it is today.

"We are, in theory, fully operational. It's just a matter of proving that before we announce it to the world that we are 100% ready to go," says Joe.

He will be attending the International Aerospace Conference in Sydney, where they will be presenting their data on the capabilities of the network as well as the capabilities of each of the individual ground stations.

"This has been my first term as a postdoc after my PhD, returning to academia, and it's been fantastic. The whole last two years have been thoroughly enjoyable," says Joe.

"I think it's fair to say that these have been the most exciting few years of my career, trying to run a project like this with people across two nations at least, and developing a group who are doing fun things with telescopes and lasers," says Nick.

Find out more:

iafastro.directory/iac/browse/IAC-25/B2/4/

iafastro.directory/iac/paper/id/97609/abstract-pdf/IAC-25,B2,4,1,x97609.brief.pdf?2025-03-28.21:58:20

Taiaho Observatory First Light - FLYING LAPTOP 2025-02-14

youtube.com/watch?v=Li1vUD-ss0E

taiaho.nz/news/firstlight/

taiaho.nz/

Australasian network: onlinelibrary.wiley.com/doi/10.1002/sat.1564

Marine biology PhD candidate

The Cawthron Institute, Joint Graduate School

Therese Miller is passionate about biodiversity and everything relating to marine biology. Her interest in marine biological research began during her undergraduate studies. She is working on a postgraduate degree at the Cawthron Institute in Nelson, where she is using eDNA to detect the migration routes and spawning sites of New Zealand longfin (*Anguilla dieffenbachii*) and shortfin (*A. australis schmidtii*) eels. Therese's PhD is funded by a Marsden grant obtained by Amandine Sabadel (Auckland University of Technology) and is expected to be completed by the end of 2026.

Aboard the *R.V. Tangaroa* (Therese Miller in centre).

What inspired you to pursue postgraduate study, and why this particular field?

We live in an age of global extinction, and characterising biodiversity is more critical than ever. Employment opportunities in marine biology can be difficult to come by, and I've been fortunate enough to have academic opportunities that allowed me to conduct fieldwork in the ocean. This has allowed me to engage in what I truly love while working towards a career in science.

Please tell us about your academic background and what led you here.

I developed my passion for marine biological research during my undergraduate studies when I began volunteering in a natural history museum and assisted with research in marine invertebrate biodiversity. I thoroughly enjoyed laboratory and museum work and looked for opportunities to work in the field. From there, I earned a master's degree in biology, during which time I conducted fieldwork and lab work on coral biology. This further drove me to find new experiences in studying marine science, so when this opportunity to do a PhD in marine environmental DNA (eDNA) came up, I knew I had to accept it.

What is your research/ thesis topic?

My research entails using eDNA to detect the migration routes and spawning sites of New Zealand longfin (*Anguilla dieffenbachii*) and shortfin (*A. australis schmidtii*) eels. This involves developing ways to exclusively target the DNA of each of these species, collecting water samples from a research cruise throughout the Western South Pacific Ocean, and using my developed methods to detect the DNA of each species of New Zealand eel from the seawater samples I collect. Ultimately, this aims to give insight into how managers can make informed decisions about where to target conservation efforts to protect these animals.

Can you share any accomplishments or milestones you've achieved?

I collected all of my seawater samples from the research cruise aboard the *R.V. Tangaroa* and am in the midst of laboratory work and data analyses to see what we find. I also won Best Poster from the Fisheries Research Development Corporation at the 2024 Australian Marine Science – New Zealand Marine Science joint conference.

What's been the most rewarding or challenging part of your programme?

Taking the lead on conducting my project has been rewarding and challenging. I'm so grateful for the opportunity to live at sea for five weeks and focus on fieldwork. Conducting all of the laboratory and data analyses truly makes it feel like this project is my own. I've had to be much more independent than I have been accustomed to in the past. This is also a larger workload with tighter timelines than my previous degrees. But it has taught me to rely on myself in many ways, which is very valuable.

Finally, tell us something about yourself we can't learn by Googling you.

I can do a backbend from a standing position.

Biological sciences PhD candidate

Plant and Food Research, Joint Graduate School

Tian Tian is originally from Kunming City, Yunnan Province, China – a region she claims has perfect weather and the most diverse ethnic minority cultures in China. She is an off-campus student and spends most of her time at the Plant and Food Research Institute in Nelson where she is working towards her latest PhD with the University of Auckland. Her research is focused on monitoring marine biofouling using machine learning and DNA metabarcoding. She will graduate in 2026.

Tian Tian

Please tell us about your academic background and what led you here.

I have a multidisciplinary academic background, including Marine Sciences (PhD), Ecological Applications (MSc), and Molecular Biology (BSc).

What is your research/thesis topic?

The Temporal and Spatial Community Composition of Biofouling on Marine Structures Using Metabarcoding and Machine Learning (Biological Sciences).

Can you share any accomplishments or milestones you've achieved?

We have finished developing and validating the ML models for biofouling occlusion estimation and visible species identification with 92% accuracy. We have completed the metabarcoding and data analyses for the eukaryotic (18S) and diatom (rbcL) communities. Strong seasonal and spatial patterns were found for both communities.

What has your experience been like so far as a postgraduate student?

My overall experience has been awesome. I like the comprehensiveness of my PhD, involving fieldwork, lab work, and computing work. These bring me a lot of different experiences and research skills. I also love being part of a research institute and working with different people, which is valuable for my professional career development. In addition, I've made many friends and travelled to many places in New Zealand; these are the happiest experiences in my life.

What's been the most rewarding or challenging part of your programme?

The most rewarding part of my PhD is that we developed efficient and complementary tools with lower costs for biofouling community monitoring, which is practical and valuable for marine industries and healthy aquatic ecosystem maintenance. Also, we found substantial differences in seasonal patterns, with heavier and faster biofouling accumulations in winter but less and slower in summer, which was out of our expectations and exciting.

What are your goals after completing your postgraduate degree?

I would love to try different types of jobs to determine future career interests. It could be a post-doc research position, a university research assistant, or a related industry or conservation job. I'd like to work in a field relevant to my current research interests, such as marine biology, ecology, and technology development and application.

What advice would you give to someone considering postgraduate study?

Choose a subject you're passionate about and clarify your goals. Plan your time reasonably for research and study, and maintain good health. Utilise available resources and seek support when needed. Postgraduate study is a significant commitment, but it's a rewarding journey with clear objectives.

Finally, tell us something about yourself that we can't learn by Googling you.

I am an outdoor activity lover, with many exciting experiences in tramping, mountain biking and aquasice. I have explored most of the places of the north part of the South Island with my friends and we are planning to explore more in the future.

Boron Neutron Capture Therapy

Targeting cancer at the cellular level

With the global incidence of cancer expected to rise dramatically by 75 per cent to 35 million new cases annually in 2050, Associate Professor Paul Harris hopes to address what he believes is a "critical need" to develop new technology in cancer therapeutics.

"Cancer is increasing and they just seem to get harder and harder to treat. And while we have an arsenal of drugs to treat people, sometimes they just don't respond," he says.

Rather than using chemotherapy or radiation that can "flood the whole body", Paul wants to restrict the lethal damage to tumours by using Boron Neutron Capture Therapy (BNCT), which places atoms of enriched boron-10 directly into cancer cells to absorb a neutron beam.

"Boron will decompose into a lithium and some gamma rays and other charged particles which are also toxic, so should hopefully kill cancer cells," says Paul, who leads a passionate chemistry group within the School of Biological Sciences.

Not that the use of BNCT to treat cancer is anything new. Far from it. The therapeutic potential of boron-10 was recognised as far back as the 1930s, and Finland was one of the first countries to embrace the treatment – albeit with the downside that a hospital had to be located next to a nuclear reactor to provide neutron beams.

However, the "big game changer," according to Paul, is the development of neutron accelerators powered by electricity which have opened up new avenues of treatment in Europe, the United States and Asia. "And hopefully we can be a part of that soon," he says.

The more immediate challenge is to tackle some of the chemistry which has fallen behind because some of the boron compounds being used are not selective for cancer cells.

"There must be a better way of getting boron into the cancer cells rather than using indiscriminate chemotherapy-like drugs that attack the cancer cells but make you very ill in the process because they also target your healthy cells," says Paul.

To that end, researchers in the Harris Peptide Laboratory are looking to develop a peptide consisting of a chain of amino acids that will effectively act as a "trojan horse" to carry boron-10 inside cancer cells.

"We're targeting this particular cell surface protein that's pretty much only expressed by cancer cells but not by healthy ones," Paul says. "It's almost like tricking the cancer cells to uptake a cargo that can then be irradiated."

While BNCT has been a niche cancer therapy that targeted inoperable squamous cell head and neck cancers overseas, the Auckland project aims to develop peptide boron-10 carriers capable of achieving therapeutic delivery to multiple cancer types to achieve its full potential.

However, because peptides are degraded by enzymes when they enter the body, their half-life will need to be extended in order to find their cancerous targets.

> "Boron will decompose into a lithium and some gamma rays and other charged particles which are also toxic, so should hopefully kill cancer cells."
>
> – Associate Professor Paul Harris

The UK's first of its kind facility for pre-clinical research for BNCT.

University of Auckland staff Dr Jiwon Hong, Associate Professor Paul Harris, and Dr Renata Kowalczyk.

> "Why can't we bring everyone together including all the communities, academic researchers, Te Aka, Auckland Hospital, oncologists, imaging people ... I think people will see there's a future in doing some science in New Zealand."
>
> – Associate Professor Paul Harris

Nevertheless, Paul says that "once we have what we call in chemistry a 'hit' compound that works, we can work out where we're going from there".

Given the various challenges involved, from peptide and boron chemistry to drug formulation and clinical radiation oncology, a transdisciplinary research team consisting of a mix of experienced, mid-career and young scientists has been assembled in five countries.

In addition to chemistry and biology research fellows Dr Renata Kowalczyk and Dr Jiwon Hong, who lead those areas respectively, the team includes an oncologist and formulation chemist in Auckland, a boron chemist in Sydney, and contacts at the University of Birmingham, which recently commissioned a scaled-down version of the UK's first neutron accelerator.

"Hopefully we could go over there with our boron-containing compounds and see how they interact with cancer cells in real time," says Paul.

Interestingly, the Birmingham facility, and another full-scale version in Finland – where Paul eventually hopes to conduct animal studies – were built by the US company Neutron Therapeutics which was co-founded by Auckland businessman Bill Buckley ONZM.

Well known as a world leader in the supply of precision electromagnets through his South Auckland-based Buckley Systems, the 81-year-old speedway fan who won a 2020 New Zealand Innovator of the Year Award "knows what we're doing", says Paul.

Earlier this year, Finland's Helsinki University Hospital treated its first head and neck cancer patients using the Neutron Therapeutics nuBeam® device, and it's hoped that the Kiwi connection will lead to the installation of a neutron accelerator in New Zealand.

Kick-started by an MBIE Smart Ideas grant in 2020, the project was initially interrupted by COVID and has since received additional funding from the University of Auckland's Te Aka Centre for Cancer Research, which allowed PhD students to make boronated peptides.

Funding from the Maurice Wilkins Centre of Research Excellence has helped to set up biological assays, and a Health Research Council Explorer Grant will fund consumables and hopefully a trip to the UK to inspect the Birmingham accelerator.

But having drafted an ambitious ten-year pathway toward human clinical trials and commercialisation, Paul knows better than most about the trials and tribulations of achieving goals, which can take at least 20 years in some cases.

As the co-inventor of Trofinetide, one of only a handful of drugs developed in New Zealand to gain all-important FDA approval, the medication now marketed as DAYBUE was fast-tracked because it was the first known treatment for Rett Syndrome.

That probably means the researchers will need to develop a peptide that targets a specific problem, such as lung cancer in the Māori population or a cancer with no other cure or very limited treatment options, to attract the interest of multinational pharmaceutical companies.

"If we have a really good peptide that goes inside cancer cells specifically and effectively, then big pharma may be interested and they can say we want to license this off you and we want to sell it to XYZ, and then we will generate royalties and support people in New Zealand."

As always, gaining FDA approval and future funding will be key issues. However, Paul believes that instead of shipping our intellectual property overseas, a real opportunity exists for New Zealand to become a BNCT hub that supports local scientists and clinicians.

"Why can't we bring everyone together including all the communities, academic researchers, Te Aka, Auckland Hospital, oncologists, imaging people, and get this moving as a big team. And then I think people will see there's a future in doing some science in New Zealand."

And while neither the boron nor the peptides are currently manufactured commercially in New Zealand, he believes that peptide manufacture could be done here. "In the end it's just chemistry, time and people really, so there's no reason we couldn't do it here as long as there was a will and a way to fund it."

Having lost both his parents to cancer after their condition deteriorated rapidly, Paul says there has to be other treatment options. "I'm not saying complete cure, but increase the quality or quantity of their life really."

Rather than just making a new compound, he's also motivated by doing chemistry for a purpose.

"It'd be nice to actually make a difference, not just in the lab but outside the lab and to see something progress further beyond just your day-to-day experiments you do with everyone."

Find out more:

pmc.ncbi.nlm.nih.gov/articles/PMC10915318/

doi.org/10.1002/cac2.12581

doi.org/10.3390/curroncol29100622

Smart wound healing

Meet the interdisciplinary team working on a novel multifunctional technology that could revolutionise treatment

Thoughts of cyborg Terminators instantly repairing damage to their outer living tissue readily springs to mind with the development of a smart wound-healing device which combines electrical stimulation and controlled drug release to accelerate the healing process.

Jointly led by Professor Jadranka Travas-Sejdic and Associate Professor Lisa Pilkington in the School of Chemical Sciences, the project has been developed from the ground up through an interdisciplinary collaboration of chemists, biologists and engineers.

"The underlying chemistry is that we can provide certain voltages that should allow for the controlled release of particular drugs on demand," says Lisa, "but it can also offer electrical stimulation to promote wound healing."

Not that researchers started out with that goal in mind. "We had the technology before we had the application," says Lisa, referring to the fact that Jadranka had been investigating strategies to selectively capture biological entities on porous substances as far back as 2019.

The change of focus came in 2022 when PhD student Jingwen (Kourtney) Yang (see sidebar story) began to make some new fibres in Jadranka's lab and then conducted experiments under the watchful eye of biology supervisors Professor Anthony Phillips and Dr Jiwon Hong.

Having performed all of the experimental work related to the adaptation of the previous 'capture-release' system to one that is used for wound healing, Lisa says that Kourtney's contribution "cannot be overstated".

Included among Kourtney's challenging scientific milestones was the creation of flexible fibre 'mats' able to be coated with a conducting polymer, chemically adapting and then 'capturing' a drug onto the fibre mats, and developing strategies for the controlled 'release' of the drug through application of an electrochemical potential.

"The 'wow' moment for Jadranka and me was more the mechanism of action, the how it does it," says Lisa. "And then we're thinking about, how can this be applied and what could this be useful for?"

"There is obviously a market for that, because chronic wounds are super difficult for people and super expensive to treat – and they are long-term wounds ... There is a real need for devices like these."

– Professor Jadranka Travas-Sejdic

Kourtney's experiments were conducted with scratch assays on mouse cells, and found that wound closure was significantly enhanced on Day 2 for an electrochemically-released drug group compared with a control group without drugs (78.26% vs 55.9%).

"This is the proof of concept stage," says Jadranka, who says that several academic publications on the research will be required, along with further animal model studies, and that a "significant gap" exists in the progression toward having a marketable product.

Using a smart wound device to heal the chronic wounds caused by diabetic ulcers is one possibility, given that they cost thousands of dollars per patient every year to treat and have become a big health burden for sufferers and hospitals.

"There is obviously a market for that, because chronic wounds are super difficult for people and super expensive to treat – and they are long-term wounds," says Jadranka. "There is a real need for devices like these."

The key to the potential efficacy of the device is the dual function of timely drug delivery and electrical stimulation, with the added bonus that the surface appears to have anti-fouling or antibacterial properties.

"A single function for wound healing is not enough," says Kourtney. "So we think the dual function system is much more helpful for healing chronic wounds."

And because the dressing is electrochemically active, it would need some sort of power pack. "It's a smart dressing that does need power and an energy storage device to go with it," says Jadranka.

Being 'smart' also means that it has to be programmable to have control over the drug release and the electrical stimulation. "You can write a protocol in the small chip on your device which will tell your device what to do. It's smart in that sense."

Beyond that, Jadranka says there's also potential to incorporate sensors – possibly assisted by AI – that could detect some biomarkers about the state of the wound to perhaps indicate whether it is inflamed so that the device can react to that.

Ultimately, Lisa says that she'd love to provide some bespoke wound dressing programs or protocols depending on the wound type.

"You could essentially respond to what the wound condition is and then provide the right stimulation, provide the right sort of drugs at the time that it's most needed and most effectual."

While Jadranka's early research was supported by an MBIE Smart Ideas grant, the smart wound-healing project has been funded from departmental operating expenses and Lisa says they're now at something of "an inflection point" in terms of future funding if they want to scale up.

"We've got something that we really believe in and we can show that it works," she says. "We've got the proof of concept, but we would need to secure more advanced funding because anything from now on starts to become a very expensive process."

And while Lisa says that her role has been about making the "building blocks" for the system, Jadranka has brought complementary skills as a materials chemist with expertise in chemical engineering – and a strong focus on applications.

"Applications are always in my mind when we share projects in my group, they have to have some ideas that could be useful," she says.

It's also about "really pushing the boundaries" at the intersection of a new trend toward bioelectronics or electroceuticals. And while the project is still in its early stages, Lisa says "it's something that we're really passionate about and I think there's real potential".

"We've got something that we really believe in and we can show that it works ... it's something that we're really passionate about and I think there's real potential."

– Associate Professor Lisa Pilkington

Associate Professor Lisa Pilkington

Find out more:

ACS Appl. Nano Mater. 2023, 6, 5, 3981–3989

doi.org/10.1021/acsanm.3c00151

DOI: 10.1039/D3LP00047H (Paper) RSC Appl. Polym., 2023, 1, 304-314

DOI: 10.1039/D1PY01394G (Paper) Polym. Chem., 2022, 13, 508-516

doi.org/10.1002/admi.202102475

Being part of a cutting-edge research project with global potential is a dream come true for PhD chemistry student Jingwen (Kourtney) Yang, who graduated from the South China Agricultural University with a Master of Food Engineering before coming to the University of Auckland to complete her education.

"It's not just about working with new materials or developing technologies for wound healing, it's more about pushing boundaries and solving real-world problems. I feel proud knowing that the work I do in the lab might one day make a difference in people's lives."

Not that her time at Auckland has been plain sailing. There were some moments when she "felt overwhelmed" using technologies like electrospinning, chemical synthesis, and electrochemistry that were all absolutely new to her.

"It was a steep learning curve, but it pushed me to grow. I spent long hours reading, experimenting, troubleshooting, and asking questions. Problem-solving became part of my daily routine, not just for the experiments, but for navigating new fields one by one that were so new to me."

Moving from China to New Zealand added yet another layer of challenge and growth, not only having to present complex research in English, but also competing for funding as an international student – something which required more initiative, especially for an interdisciplinary project that sits between chemistry, engineering and medicine.

"In China, the education system tends to be more rigid, with a clear hierarchy in research teams. Here in New Zealand, I found a more open and collaborative environment, where independent thinking is strongly encouraged."

Nevertheless, she says the challenges have made her stronger and more resilient – and more capable than she had ever imagined. "I hope my story encourages other students to step outside their comfort zones too. Because that's exactly where the most meaningful growth begins."

Ko ā Mātou Rangahau **Our Research**

Real-time prostate cancer detection

A diagnostic tool that could revolutionise future prostate treatment

It's a sad fact that around 14 New Zealanders die every week from prostate cancer and that many are subjected to invasive and inaccurate diagnostic and surgical procedures, which is why Dr Claude Aguergaray wants to improve the medical outcomes.

"You have issues with screening, and MRI still has limitations despite recent improvements. You also have issues when you take the biopsies and when you try to analyse them," says Claude. "So this is a bleak picture for the diagnosis of prostate cancer right now."

What's also bleak is New Zealand's current prostate cancer rate of more than 100 cases per 100,000 people. Amongst the world's highest, it means that almost 4,000 are diagnosed each year and more than 700 die from the disease.

In his role as a senior research fellow in the Department of Physics, and a Dodd-Walls Centre principal investigator, Claude has spent the past seven years developing a diagnostic tool that could revolutionise future prostate treatment by using light to accurately identify cancer cells.

"Our goal is to demonstrate an ability to detect cancer and to classify benign and cancerous tissue – and also to grade the cancer in vivo and provide feedback to clinicians in real time during procedures."

Initially funded by an MBIE Smart Ideas grant in 2018, which helped to develop instruments and conduct pilot studies on animal tissue, a clinical trial was then conducted on fresh prostate biopsies removed from a cohort of 180 patients.

Using Raman spectroscopy, which involves the use of scattered light from a laser beam, researchers were able to "interrogate the tissue", as Claude puts it, and obtain biomedical information which was then compared with pathology reports to create a classification system.

"We just shine a laser light on the tissue and use our detector to measure the subtle changes in the properties of light, says Claude.

And because the measurements contain information linked to molecules in the tissue, such as DNA, RNA, proteins and lipids, any changes in the signal can be used to create

> "Our goal is to demonstrate an ability to detect cancer and to classify benign and cancerous tissue – and also to grade the cancer in vivo and provide feedback to clinicians in real time during procedures."
>
> – Dr Claude Aguergaray

an optical 'biopsy' of healthy and cancerous tissue. "We have direct access to what we call the molecular fingerprint of the tissue."

Over time, Claude's classification model is being 'trained' to predict future measurements, and the research has now progressed to a new clinical trial in late 2025 when measurements will be taken in vivo just before biopsy cores are taken.

"Our instrument will predict benign or cancerous tissue, and we will compare our prediction with what the pathologist says to improve our ability to diagnose cancer."

The next step in 2026 will be another clinical trial at the time of surgery when clinicians will be provided with a laser light probe in the form of a 'pen' to measure the surgical margin and ultimately help determine how much tissue should be removed.

"The goal is to test our instrument and demonstrate its potential for in-surgery use. The clinician will use our device to read the surgical margin at precise locations, and then take biopsies from these locations to compare the results and continue training our system."

Beyond that, the plan is to organise multi-site clinical trials at different locations in New Zealand and overseas to show the strength of the classification system and further demonstrate scientific validity.

The ultimate goal is to develop a new hand-held tool that is capable of analysing tissue very accurately in real-time to address existing gaps at the time of diagnosis and surgery – and the practical implications of Claude's research are wide ranging.

Once someone has presented with persistently high prostate specific antigen (PSA) blood tests, which he says has led to "a huge amount of overtreatment in the past few decades", they normally progress to an MRI scan – *if* one is available close to where they live.

"The MRI is good but has limitations nonetheless. The MRI will miss a significant amount of the smaller cancer clusters, and it can still miss 15 to 20% of aggressive cancers."

Biopsies come next, which Claude says are "not a fun moment" because the procedure is invasive and involves the taking of up to 14 cores which represent a large amount of prostate tissue. There's also the risk of subsequent infection as well as urinary and rectal dysfunction.

Despite the number of biopsies, the cancer could still be missed, and there is also potential for the misclassification of cancer in understaffed pathology labs. "There is a big bottleneck worldwide in the pathology lab, and an overwhelming amount of tissue having to be analysed."

By using a laser probe that's only 800 microns (0.8mm) thick to minimise invasiveness, Claude's vision is to reduce the need for biopsies to perhaps only two or three if clinicians are informed in real time whether cells are benign or cancerous.

"There is a significant reduction in the trauma to the prostate," says Claude. "Furthermore, fewer biopsies would lead to dramatic financial savings for the health sector and a significant step improvement in the standard of care for the patient. That's how we see it."

When it comes to prostate removal, real-time analysis of surgical margins and the detection of any remaining cancerous tissue would help to improve outcomes. One possibility is to communicate with the clinician using a traffic light system, to identify what tissue should be removed,

> "... fewer biopsies would lead to dramatic financial savings for the health sector and a significant step improvement in the standard of care for the patient. That's how we see it."
>
> – Dr Claude Aguergaray

or is safe to remove, near nerves or other important functional structures.

"You will have a significant improvement in the standard of care, because 30 percent of men today have a positive margin – have cancer left. We can reduce that to five percent. So it's a very compelling improvement."

Along the way, Claude is also involved in a separate study in partnership with a team at the Auckland Bioengineering Institute which is using AI to more accurately analyse data from MRI prostate scans – something that could work in parallel with the optical biopsies to further minimise the risk of misdiagnosis.

"Can we use the information from the MRI and feed this into the classification model of the Raman spectroscopy to try to obtain even better classification, even better recognition of what is healthy or cancerous?"

In addition to two MBIE Smart Ideas grants, the project has also been supported by the Dodd-Walls Centre and MedTech whose $80,000 RAP Stage II grant has gone toward instrument development and improving the team's understanding of the regulatory environment, particularly in the United States.

"We must understand those landscapes for commercialisation, and shape our studies to ensure they are FDA compliant and avoid having to redo them later on."

To fund future development, Claude has established a company called Probentis Limited with the help of Uniservices and the 'Return on Science' commercialisation programme and is about to venture into the sometimes daunting world of capital raising.

Last but not least, he's grateful for the ongoing support that he's had from academic colleagues and staff at the Manukau Super Clinic, where the clinical trials have taken place, and Middlemore Hospital pathology lab.

"For this research to happen, you need to have a strong clinical network with people in hospitals who are willing to work on this project and help provide the expertise that you need."

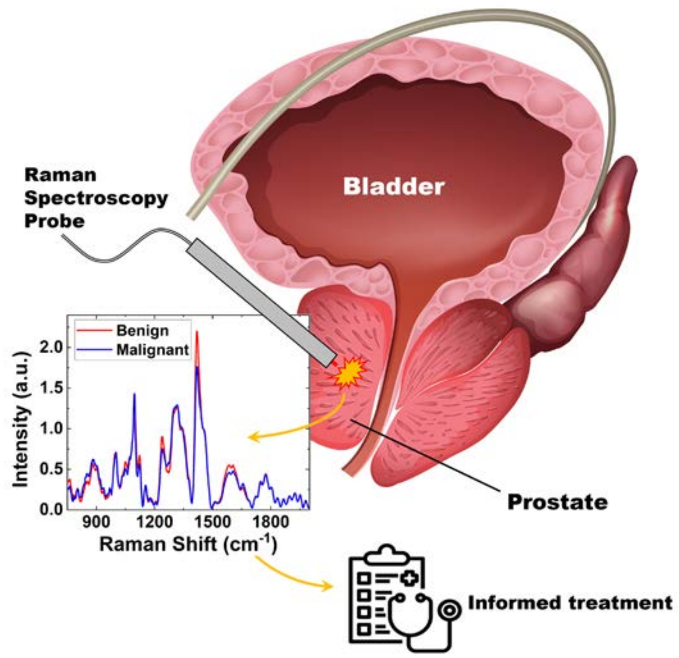
Find out more:

cancer.org/research/acs-research-news/prostate-cancer-is-number-1-for-118-countries-worldwide.html

doi.org/10.1186/s13000-024-01590-2

doi.org/10.1002/jbio.202200334

Researchers from the University of Auckland testing the new photonics sensing solution in a clinical setting.



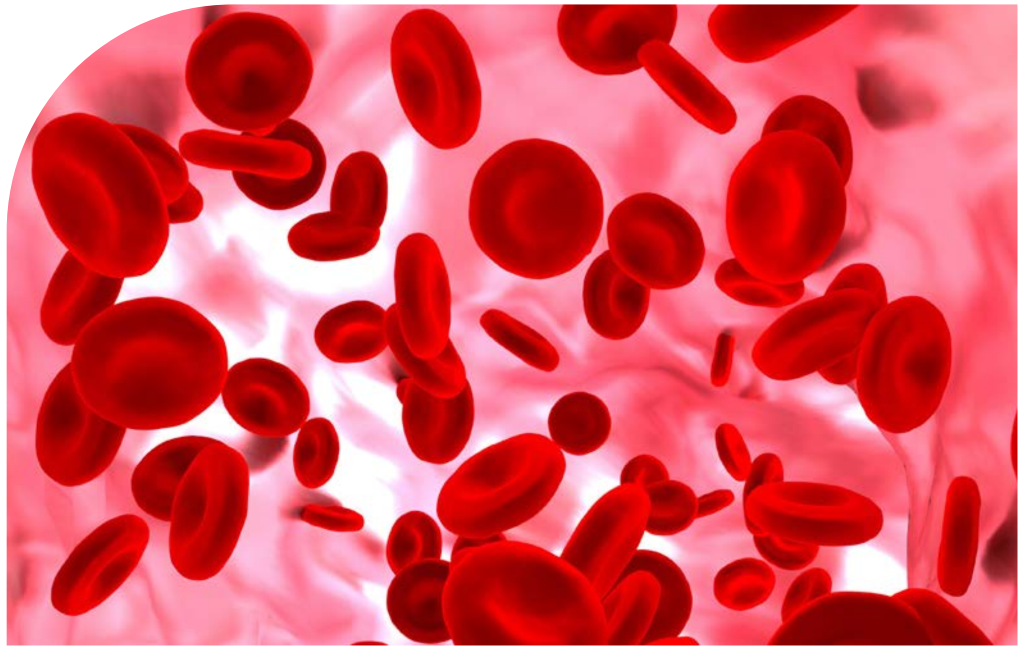
The new biosensing technology provides real-time tissue analysis and cancer detection to guide clinicians during surgical procedures.

Beneath the surface

Imaging blood flow in bones using photoacoustics

When we think of bones, we tend to think of them as being rigid, passive, and lifeless structures that are solely meant to provide a framework to support the human body. But biologically, bones are anything but static. They are living tissues that house a network of blood vessels, produce blood cells, and are capable of remodelling and repairing themselves. Blood flow within bones is vital for healing and overall bone health. However, despite wide consensus about the vitality of blood flow within bones, it remains largely unexamined in modern clinical practice. This has more to do with technological gaps than a lack of interest.

Dr Jami Shepherd, a senior research fellow in the Department of Physics at the University of Auckland, is among a group of imaging scientists seeking to close that gap. Her work in combining photoacoustic imaging with existing ultrasound technologies offers a window into the vascular life of bones, which can be crucial to understanding, detecting, and treating bone diseases.



3D rendering of red blood cells in blood vessel. iStock

Why care about blood flow in bones

Blood supply to bones is rarely assessed in clinical settings, but that's not because it's insignificant. Studies have shown that adequate bone perfusion (blood flow) is essential to ensuring adequate oxygenation and delivery of nutrients within bones. This is crucial to bone growth, healing, and overall health. "There have been links found between reduced blood supply and bone diseases like osteoporosis and even bone death," Jami says. "Or in oncology, if we can say something about the blood flow in a tumour in the bone, you might be able to say how aggressive it is and how it's responding to treatment."

Even in the case of fractures, adequate blood flow is essential to the healing process, as Jami explains by recalling her own experience. "Before I did this project, I had a fracture in my foot. It's called a Jones fracture and it's in an area that's known to have low blood flow, so it took forever to heal. It did heal on its own, but sometimes they have to go in and perform a surgery to increase blood supply to that area."

Where are the technological gaps?

While current imaging techniques each have their strengths, none of them can accurately, safely, and non-invasively measure real-time blood flow within bones.

Ultrasound is safe, portable, inexpensive, and can provide real-time imaging. However, it's still not the whole package. "Ultrasound is great for imaging soft tissues and measuring blood flow in large, fast-flowing vessels. However, existing clinical ultrasound techniques cannot image the interior of bones or measure blood flow in small, slow-flowing vessels in bone," says Jami.

Filling the gaps with Photoacoustics

This is the gap that photoacoustic imaging fills. "Photoacoustic imaging is essentially an add-on to ultrasound which gives us chemical and functional details," she says. A laser fitted onto the ultrasound probe sends a pulse of light, which is absorbed by red blood cells. These red blood cells heat up and expand, generating ultrasound waves which are recorded by the ultrasound probe at the surface of the tissue.

> "Basically, you're using light to generate sound, then using an ultrasound probe to detect that sound and reconstruct the image. Since red blood cells absorb the light, you can image where the blood is; and if you take images over time, you can quantify how it's moving."
>
> – Dr Jami Shepherd

As Jami explains, "Basically, you're using light to generate sound, then using an ultrasound probe to detect that sound and reconstruct the image. Since red blood cells absorb the light, you can image where the blood is; and if you take images over time, you can quantify how it's moving."

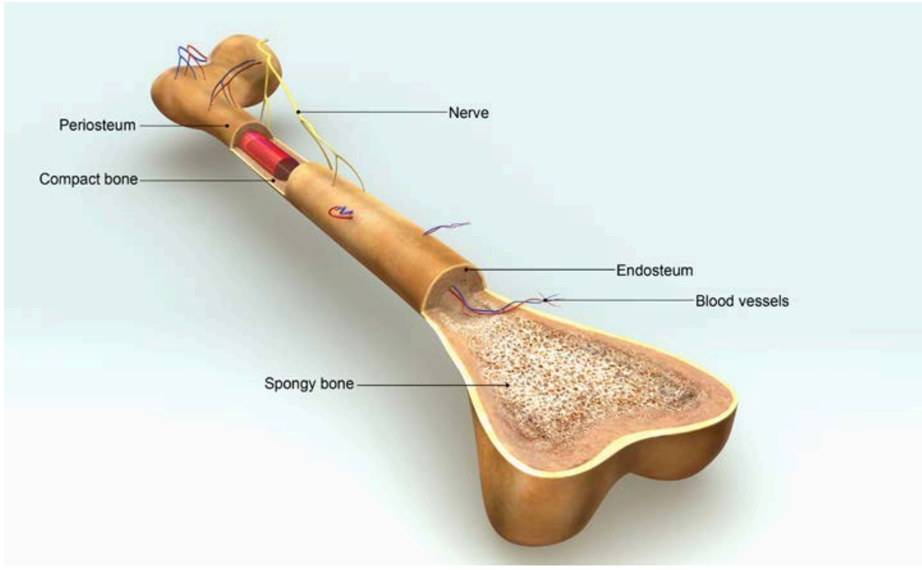
The advantage of photoacoustics is that it provides functional information, such as oxygen saturation and direction and speed of blood flow, as a very important add-on to the structural information that ultrasound provides. Using this method, it's possible to non-invasively measure real-time data on blood flow within bones without needing to expose patients to radiation.

However, imaging of bone perfusion presents a unique problem. "Most ultrasound and photoacoustic systems in use today work under the principle that the entire body is made up of water or a uniform medium," Jami says. "While that's accurate for most of our organs and tissues, the bone, of course, is solid." As high school physics tells us, sound travels at different speeds in different mediums. Sound travels in bone at more than twice the speed than it does through other tissues. Therefore, the physical properties of the bone have to be accounted for in order to reconstruct an accurate image using photoacoustics and ultrasound.

Jami and her international colleagues at TU Delft in the Netherlands are developing new models and software that correct for these unique properties of bone. With the support of external funding through the Dodd-Walls Centre and Marsden Fund, Jami has been able to supervise a PhD student (Caitlin Smith) and make significant advancements on this project. "We're testing our approach on ex-vivo samples, with bone models, and on healthy volunteers to prove that we can measure blood flow accurately," she says.

Further to proving that blood flow in bone can be accurately measured, the next step in their research is to detect differences between normal and impaired bones. "We want to measure how blood flow is different for someone with osteoporosis. How a cancerous tumour affects perfusion; how a tumour responds to treatment; or how different blood flow is at various stages of fracture healing," says Jami. "Ideally, since early detection is key, we want to discover changes in blood flow before structural degradation occurs."

Ko ā Mātou Rangahau **Our Research**



A cross-section of a bone showing the anatomy. iStock

Clinical future

Photoacoustic imaging is relatively cheap because the technique can be integrated into existing ultrasound machines with the addition of a laser and new software. It also doesn't have the logistical challenges that come with machines like MRIs and CTs, where you need an entire dedicated room. So it would seem that the barrier to clinical use is relatively low. Yet there are stages of more research, clinical trials and approvals that it would need to go through before being introduced clinically. Then come the subsequent challenges of convincing clinicians of this new technology, training sonographers in using it and integrating it into clinical workflows.

If successful, Jami and her team's research could lead to earlier diagnoses, better monitoring of bone healing, and even help in tailoring treatments for diseases like osteoporosis and bone cancer. And it may shift our entire perception of bones – not as mere structural support, but as dynamic, living tissues deserving of closer scrutiny.

Find out more:

pmc.ncbi.nlm.nih.gov/articles/PMC8567494/

sciencedirect.com/science/article/pii/S2213597924000193

pubs.aip.org/aip/apl/article/116/24/243704/1075922/Photoacoustic-imaging-through-a-cortical-bone

> "We want to measure how blood flow is different for someone with osteoporosis. How a cancerous tumour affects perfusion; how a tumour responds to treatment; or how different blood flow is at various stages of fracture healing."
>
> – Dr Jami Shepherd

PhD Fellow Jacob Ngaha heads to Madrid

Tēnā rā koutou! Ko Hākopa Ngaha tōku ingoa, ā, he uri tēnei nō Waikato, nō Ngāti Maniapoto, nō Ngāti Kahu hoki. Heoi anō, i whānau mai au, i tipu ake hoki, i Tāmaki Makaurau.

Jacob Ngaha completed a Doctor of Philosophy in Physics at the end of 2023. After graduating, he accepted a position at the University as a postdoctoral research fellow in the Department of Mathematics and is now preparing for a new position with the Instituto de Ciencia de Materiales de Madrid (ICMM) in Spain, focused on quantum super-computing. He will be studying how quantum effects can enhance the computing abilities of optical machines. He hopes to bring his new expertise and experience back to New Zealand to improve and develop the quantum technology and industry at home.

Jacob Ngaha

"I was fascinated by space, the stars, and the universe, which pushed me towards studying physics at an undergraduate level. As I learnt more, I became increasingly interested in the underlying physics of the universe, which nudged me towards quantum mechanics."

– Jacob Ngaha

What initially drew you to the field?

I was fascinated by space, the stars, and the universe, which pushed me towards studying physics at an undergraduate level. As I learnt more, I became increasingly interested in the underlying physics of the universe, which nudged me towards quantum mechanics.

How did your time at UoA prepare you for your career?

Each step along my academic journey – from bachelor's to master's, through to my PhD – I feel like I have been neatly guided into my current work as a postdoctoral researcher.

Is there a project you are particularly proud of that you can share with us?

The work from my PhD on frequency filtering in quantum optics. In quantum optics settings, we often measure interactions of light through a filter, which picks out different frequencies, or colours, of light. One of the main issues with standard filters is that there is a trade-off between how many colours you can let through and how much the filter delays the light. Ideally, a filter allows a narrow range of frequencies with minimal time delay. I came up with a model for a filter – the multi-mode array filter – that avoids this issue by allowing one to pick a very narrow range of frequencies, while introducing only a small delay into the system. I am also proud of this work given that I began my PhD just before COVID, so completing my PhD during that time feels like a real achievement.

Another smaller project I'm proud of was creating a kupu Māori for "quantum physics". The word for "physics" has been around for a while, so choosing the right "modifier" to describe quantum was a bit of a challenge. The word "quantum" here describes the quantised, or discrete, energies of atoms and light. Hence, we decided on the word "tataunga," which means "countable" or "quantifiable".

What advice would you give to someone considering studying in this field?

Try not to let grades get in the way of what you really want to do. If you had told undergraduate Jacob that he would get a PhD, he probably would not have believed you.

Finally, tell us something about yourself that we can't learn by Googling you.

One fun fact is that I'm a black belt in karate.

Find out more:

journals.aps.org/pra/abstract/10.1103/PhysRevA.110.023719

journals.aps.org/pra/abstract/10.1103/3lrt-ygwp

Technology for trust in science

Developing AI-based technology to combat scientific misinformation

Neşet Özkan TAN completed his PhD in Computer Science at the University of Auckland in 2025, specialising in Natural Language Processing (NLP) and Scientific Document Understanding. Since graduating, he has held a Research Fellowship within the School of Computer Science, leading projects in NLP and developing AI technologies to combat scientific misinformation.

Neşet Özkan TAN

What initially drew you to the field?

My background is in mathematics and artificial intelligence, with a strong emphasis on the practical applications of natural language processing. Early on, my work in functional analysis, the study of abstract spaces and the transformations within them, helped me appreciate the structure and logic underlying complex deep learning systems. A pivotal moment came in 2017, when I read the now-seminal paper Attention Is All You Need. It completely changed my trajectory, motivating me to dive deeper into NLP and its applied dimensions. Since then, my work has focused on understanding the foundations of language models while developing practical tools that address real-world challenges, particularly in the context of scientific research and communication.

How did your time at the University of Auckland prepare you for your career?

The University of Auckland offered an exceptional environment for interdisciplinary exploration, which was instrumental in shaping my research direction. I collaborated with world-leading AI institutes and worked across diverse fields, including computational biology and psychology, applying deep learning in novel contexts.

These experiences taught me how to build technically robust, ethically grounded systems that bridge theory and practice, capable of making a broad and meaningful impact beyond computer science itself.

What is your current position?

I am currently a Research Fellow conducting research at the leading edge of Natural Language Processing (NLP), focusing on how humans interact with and understand scientific knowledge. My work aims to enhance transparency, counter misinformation, and make complex research more accessible. This research has produced innovative outcomes that have attracted the attention of UniServices for potential real-world applications. I also supervise Masters and PhD students working on advanced topics in NLP and Artificial Intelligence.

Beyond this, I contribute to both international and local research initiatives – from using deep learning to predict gout disease risk through genomic data, to exploring how human attention patterns compare with those of large language models.

Is there a project you're particularly proud of?

One project I'm especially proud of is SciTrue, a transparent scientific claim verification system that I led as the primary developer. SciTrue empowers users to evaluate scientific claims through verifiable, source-grounded explanations, addressing key shortcomings in existing AI tools such as hallucinated citations and lack of transparency.

Now evolving into a commercial initiative, scitrue.org aims to establish a trustworthy, open framework for scientific claim verification. It is tailored for science, journalism, and policy domains, where credibility and auditability truly matter.

What's next for you?

In the coming years, I aim to push the boundaries of how artificial intelligence can transform the way we make scientific discoveries. My immediate focus is on advancing tools such as SciTrue, which promotes transparency and accountability in scientific communication by enabling automated claim verification – a step toward making evidence-based evaluation a standard in both science and policy.

Looking ahead, I plan to strengthen interdisciplinary collaborations that connect AI with industry, helping to address some of the world's most pressing challenges.

My long-term vision is to help create an AI-driven future where machines not only process data, but also help humans think more clearly, discover more boldly, and make decisions grounded in truth.

In parallel, I am in the process of launching a company dedicated to helping organisations harness the power of AI to enhance decision-making, streamline operations, and unlock new opportunities for innovation.

What advice would you give to someone considering this field?

I've learned that staying curious and open-minded is essential. Every challenge is really an opportunity to grow, even when it doesn't feel that way at first. Discipline and persistence matter far more than quick wins – real progress comes from steady effort over time.

I always encourage students to ask questions and seek mentorship because that's where genuine learning happens. Balancing their hard work with self-care is just as important. Staying connected to what truly inspires you is what keeps the journey meaningful.

Finally, tell us something about yourself we can't Google.

I'm a multi-instrumentalist who loves jamming with local bands, and a father of two toddlers. My kids' endless curiosity inspires me every day and offers profound insights into human behaviour – including my own. They continually remind me why curiosity, creativity, and wonder lie at the heart of both parenting and scientific exploration.

Ko ā Mātou Rangahau **Our Research**

Rebranding carbon

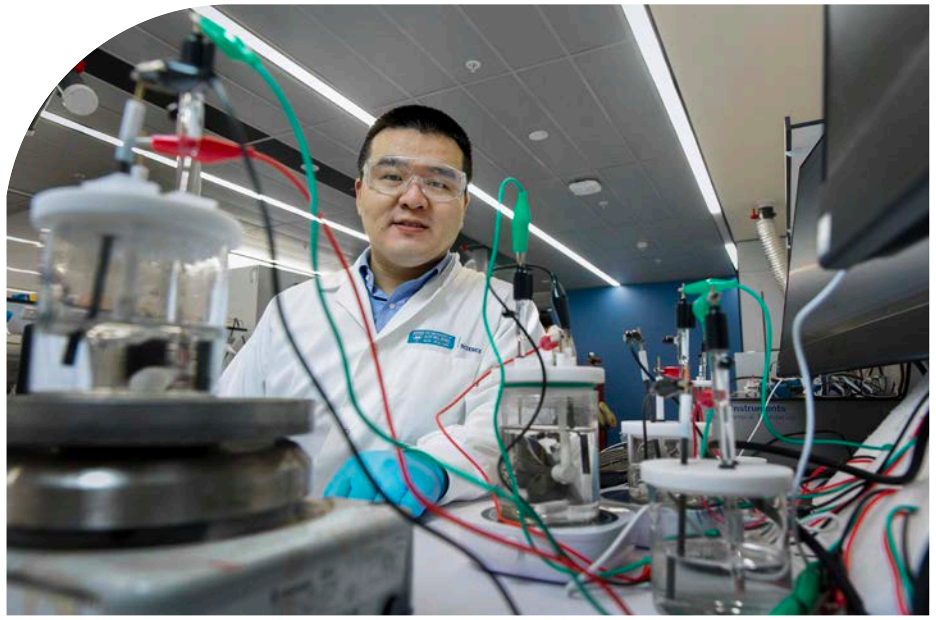
A catalyst for change?

What if there was a way to close the carbon loop by making fossil fuels renewable? Dr Ziyun Wang and his academic group at the University of Auckland, the Theoretical Catalysis (TCAT) Group, are working to harness the power of catalysts to make it possible.

Wang explains a catalyst, in chemistry, as a hand fitting Lego pieces together. Its role is to cause something new to happen with chemicals, something novel, something potentially valuable to science. Like Lego, it's a game of trial and error. This is where Artificial Intelligence (AI) and machine learning can help.

Wang is fortunate to have a team to experiment with solutions for what he calls the 'CO_2 problem'. The TCAT Group comprises around 15 University staff and postgraduate students and their diverse backgrounds allow for fresh takes on complex problems.

By experimenting with catalysts, Wang and his team have made progress converting carbon dioxide (CO_2) to formic acid, a liquid which has broad usage in the chemical industry and potential as a fuel. They did this by taking a used lead-acid battery, from an Internal Combustion Engine (ICE) vehicle, and extracting the lead element for use as the catalyst that enabled the conversion.



Dr Ziyun Wang

If formic acid in fuel-use comes to fruition, the fuel-cell vehicles that could potentially use it would employ much smaller, lightweight Li-ion batteries. Rather than being the sole source of power for the vehicle, like the much larger batteries in the now widespread Battery Electric Vehicles (BEVs), these act only as a support to the fuel-cell system. In a win for the environment, it would mean less extraction of minerals, like lithium, cobalt and nickel, in the battery's production and less environmental impact in its end-of-life disposal.

The other side of this potentially two-pronged solution is the reuse pathway it could open for electrical waste, like the lead batteries Wang experimented with. Though not present in most modern EVs, they are still commonly used in e-bikes in many parts of the world, particularly developing countries, and in some lower-end EVs.

Scientists have long grappled with the problem of closing the carbon loop: achieving net zero emissions by reusing CO_2, rather than letting it accumulate in the atmosphere. Finding a productive use for CO_2 has proved challenging, because its level of volatility makes it notoriously difficult to work with. Formic acid, as a compound, has a good level of stability.

Testing out endless catalysts in the lab is time-consuming work. This is where Wang's work is different, by harnessing the power of AI and machine learning. Sometimes, identifying a suitable catalyst involves detective work – drilling down through a vast range of possible states or energy levels for a particular element or material. Figuring this out takes time. "We may know that lead works well, but we don't know which type specifically – should we use lead carbonate, or something else," says Wang.

Traditional lab work requires manual processes, trial and error. With machine learning, a calculation can be run with hundreds of thousands, even millions of combinations at the same time. The use of AI to learn from previous data also drastically improves precision: by selecting the perfect catalyst, the resulting reaction will perform at exactly the level it needs to, thus wasting less energy in the process.

> "Our system and a computer game are actually very similar. The way we experiment with different catalysts is like tweaking design layouts and managing budgets in Sim City."
>
> – Dr Ziyun Wang

Wang and his team are currently working on how to make widespread carbon capture a reality at the industrial level. Capturing pure CO_2 is an energy-intensive process, but understanding the use of industrial flue systems (which contain a mixture of other chemicals too, including sulphur) to achieve the same purpose is now virtually assured. Thus, the CO_2 to formic acid initiative now primarily relies on industry effort. Scientifically, the exploring of new products from CO_2 would be the next logical research goal.

A fascination with all things technical has been a lifelong thread for Wang. As a teenager, he loved computer games and diving into virtual worlds. "I wanted to play computer games all day every day," he says, and even thought about becoming a professional gamer. He later realised that computational chemistry was essentially a computer game to solve a real-world problem.

"Our system and a computer game are actually very similar. The way we experiment with different catalysts is like tweaking design layouts and managing budgets in Sim City.

"In both cases, you're constantly looking at cause-and-effect dynamics – a computer algorithm gives you feedback about whether you're doing well or not."

The combined strengths of the TCAT team are key to exploring the opportunities that present themselves. "Some have a background in pure Physics, some Chemistry and others Computer Science," says Wang. "Everyone brings something to the table. One member works for a large IT company and brings experience from the industry side; others are doing a lot of theoretical work." The team clearly works in the here and now but has a foot firmly in the future – daring to look ahead to what might develop.

This future focus is part and parcel of cutting-edge science. "One thing about machine learning is that we always underestimate how fast it will move and how impactful it will be," says Wang, citing how critical people were of ChatGPT just three years ago and how underestimated it was. This is why he finds it such an exciting field.

"Everything is moving very fast and we're very lucky to be in the game earlier than most people."

Find out more:

nature.com/articles/s41586-023-06917-5

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Taking a complex systems view to advanced technologies

Artificial intelligence, quantum computing, biotechnology and space. It's easy to lump these fields together as advanced technologies. But they all operate very differently, they all need unique skill bases, and they all interlink in distinct ways.

Take artificial intelligence (AI) for example. AI will play a role as an enabling technology in all these areas, but it's also an advanced technology itself. Here in Aotearoa, do we want to become adept at creating AI as an advanced technology, or applying it to enable other advanced technologies? Or is it feasible and smart for us to try to do both?

To make decisions like these, we need to consider the talent we already have and need to grow in Aotearoa, the conditions that we need to create for people to develop fulfilling careers in these areas, the cost of developing these technologies, and the impact of our geographic location. We're a long way from Silicon Valley, where some top AI engineers are being paid more than US$10 million a year.

Advanced technologies have become geopolitical assets. Have we focused on the advanced technologies that make sense with the strategic global partnerships that we have or want to create, or the resilience to geopolitical disruptions we need?

As we develop future technologies in Aotearoa New Zealand, they will impact humans and our environments in unexpected ways. Alongside research to ensure that we can rapidly leverage emerging technology to understand our world and make decisions, we also need to study the impact of these emerging technologies on humans and the environment – on Earth and beyond.

Grappling with these issues needs collaboration across disciplines, cultures, institutions and communities. The University of Auckland is growing a network of researchers skilled in these approaches by hosting Te Pūnaha Matatini, the Aotearoa New Zealand Centre of Research Excellence (CoREs) for complex systems. CoREs are inter-institutional research networks that support outstanding research that is collaborative, strategically aligned, and contributes to the advancement of Aotearoa.

The tools of complex systems can help us understand potential consequences as advanced technologies like artificial intelligence, quantum computing, biotechnology and space travel develop and are applied at scale.

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Complex systems research can help reveal the underlying universal mechanisms of these developments and show us how they might affect our lives in the future. Understanding our country as a complex system will help us to understand the implications of focusing on specific advanced technologies.

Faculty of Science Postdoctoral Fellow Mackay Price is part of the Modelling for Impact Hub at Te Pūnaha Matatini, an ambitious project to model an entire country as a complex system. After building his modelling skills in wastewater epidemiology in the School of Environment, Mackay is now working with researchers across the country to develop a unique infrastructure for the models, algorithms and datasets created by Te Pūnaha Matatini researchers over more than a decade.

This infrastructure will be made available to researchers and practitioners to model or simulate aspects of life in Aotearoa – such as the impact of advanced technologies on the economy, environment and society.

In complex systems, small parts play vital roles. These systems are characterised by interconnections and feedback loops where a minor event can trigger widespread, unpredictable and sometimes dramatic consequences. We're a small nation, and small players have important roles to play in developing these exciting new technologies. We know that we can strategically intervene at critical points to create significant change.

Taking a complex systems view to decisions around advanced technologies is useful for both economic and strategic reasons, often showing how technologies link to everything else that is feeding into the innovation system.

Almost 15 years after Paul Callaghan laid out a vision for Aotearoa as "the place where talent wants to live", understanding the complex system that surrounds advanced technologies offers a way to realise this vision, with care for people and planet.

Markus Luczak-Roesch, Co-Director, Te Pūnaha Matatini

Jonathan Burgess, Communications and Marketing Senior Adviser, Te Pūnaha Matatini

Find out more:

tepunahamatatini.ac.nz/our-research/modelling-for-impact

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