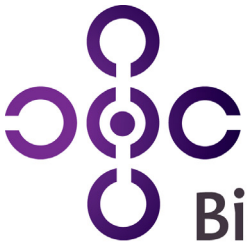


Biomolecular Interaction Centre

Research report
2019 - 2020

Contents

Our mission

The Biomolecular Interaction Centre is a multi-disciplinary research centre dedicated to the study of molecular interactions critical to biological function. Understanding these interactions is central to a range of fundamental sciences, new treatments for disease and a wide range of highly functional products.

The Centre was founded in 2007 at the University of Canterbury. It includes researchers from across UC, Victoria University of Wellington, the University of Otago, the University of Auckland and the University of Waikato and has a growing network of collaborators from many of New Zealand's Crown Research Institutes and Callaghan Innovation. BIC has a strong and increasing network of international collaborators.

Directors' comment

Prof. Matt Watson (Deputy Director) and Prof. Renwick Dobson (Director)

2020 has been a challenging year and we've been pleased to see the motivation, enthusiasm and drive from investigators, postdoctoral fellows and PhD students from across BIC to support one another and the Centre. Thank you.

There was a change in the BIC leadership this year, with A/Prof. Volker Nock stepping down as co-Director and A/Prof. Matt Watson becoming deputy-Director. Rebecca Hurrell took a secondment to Research and Innovation at the University of Canterbury, and the Institute Manager position now rests in the capable hands of Dr Ria Chapman.

We invited 17 new Associate Investigators into BIC and this has seen our team grow to 62 Associate Investigators supported by 11 Principle Investigators, 12 postdocs and 24 PhD students with research interests ranging from chemical formulation design to environmental and species conservation to biomedical engineering. We are fortunate to welcome investigators from seven departments across UC and 12 universities and research organisations across New Zealand and internationally. As a research institute, we attracted $2,162,000 of new research funding in 2019 and this has increased to ~$3,750,000 in 2020. This includes research funding from the Ministry of Business, Innovation and Employment, the Royal Society of New Zealand and the National Science Challenges, as well as subcontracts with our collaborators and nationwide centres such as the Maurice Wilkins CoRE and the Riddet CoRE (see page 7 for our current grants).

As a result of our research funding success, we have been able to seed fund research to the value of $184,250 and support 15 summer students (see page 8 for more details on the grants awarded). We're really proud to be able to contribute to supporting postdoctoral fellows and postgraduate students through BIC (see page 17 and 19 to learn more about our growing team).

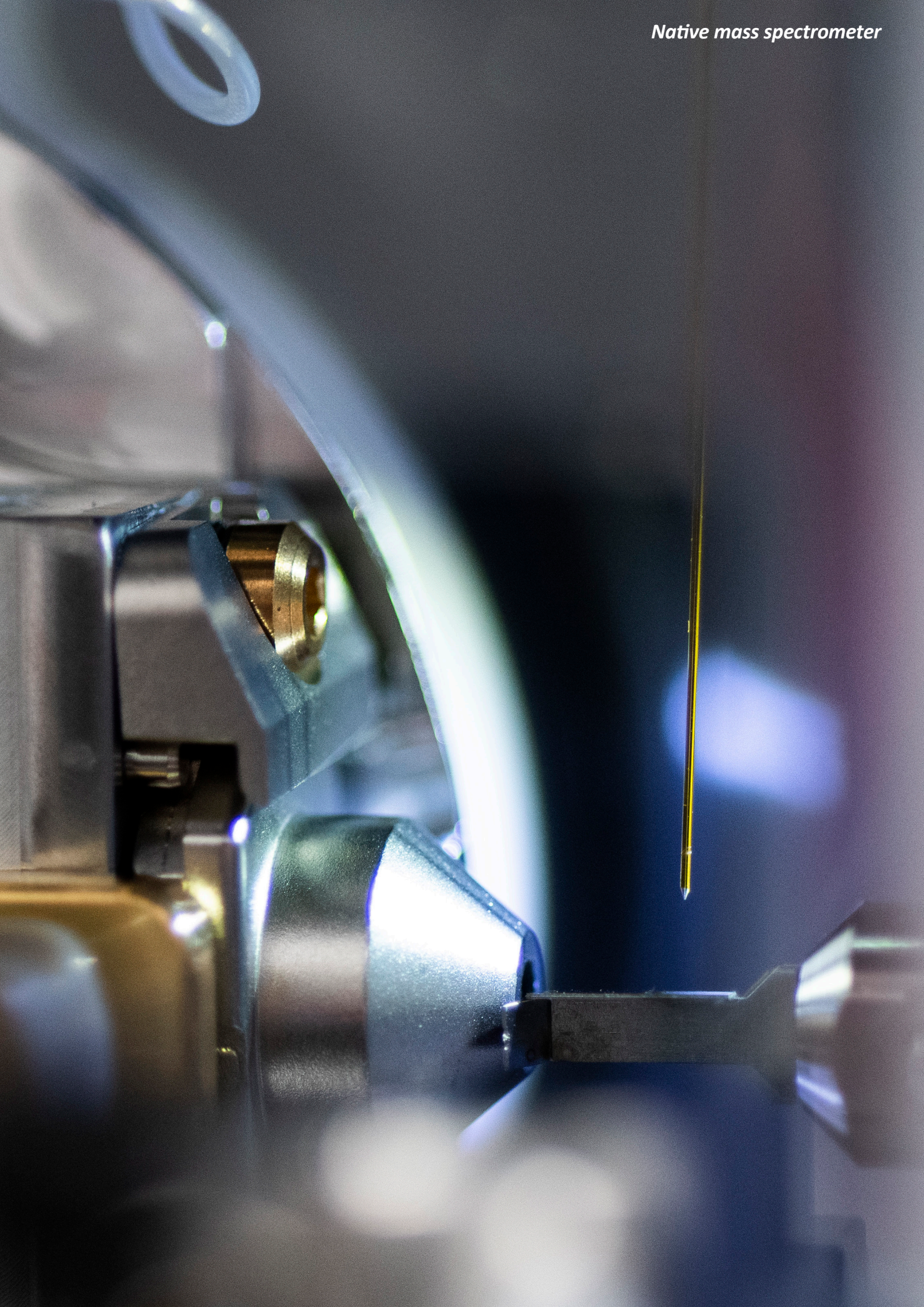
Furthermore, we continue to invest in capabilities that benefit both BIC and the University of Canterbury. We are delighted to have supported A/Prof. Volker Nock, Dr Tim Allison and Dr Vanessa Morris to leverage monies from UC's strategic investment fund and Lottery Health funding to purchase a Nanoscribe, a native mass spectrometer and a biological nuclear magnetic resonance (NMR) instrument, respectively.

Ideas in the wider community

- Papers published: 140 refereed journal articles
- Conferences: 72 conference presentations
- 5 book chapters
- 2 patents
- BIC Symposia

Where next?

As we look forward, we will maintain our focus on securing external research funding to expand our research capability and increase impact. We will re-engage with our stakeholders, build our relationships with industry, iwi, and the broader community and articulate how BIC can support these groups to solve problems and achieve their goals. Alongside this, we want to raise the profile of the Centre and BIC researchers internationally. We will look to strengthen our impact through identifying opportunities to commercialise our research, building upon on our societal, environmental and Vision Mātauranga impacts.


Native mass spectrometer

Financial summary

		2018 $000	2019 $000	2020* $000
Externally funded research				
	Funding received	1,935	2,162	3,750
	Expenditure	1,897	2,166	3,614
	Surplus (deficit)	38	(3)	136
Operations				
Income				
	Overheads	246	275	550
	PBRF	240	237	237
	Other	376	520	358
	Total income	862	1,032	1,145
Expenditure		911	1,043	1,039
	Surplus (deficit)	(49)	(10)	107

*forecast as at 30 November 2020

External research grants

Active grants

Prof. Conan Fee, A/Prof. Don Clucas, A/Prof. Ken Morrison, A/Prof. Matt Watson, A/Prof. Daniel Holland, A/Prof. Digby Symons, Prof. Richard Green, Dr Tim Huber: 3D printing porous media for process engineering. MBIE Endeavour Research Programme. $9,812,551 (2019 - 2024)

Prof. Antony Fairbanks, Prof. Renwick Dobson: Glycoprotein manufacture. MBIE Smart Idea. $1,000,000 (2017 - 2021)

Prof. Renwick Dobson, Prof. Conan Fee, A/Prof. Volker Nock and Dr Neil Pattinson: A simple biomarker assay platform. MBIE Smart Idea. $1,000,000 (2017 - 2021)

Prof. Renwick Dobson: Understanding bacterial membrane transport proteins: Setting an antimicrobial TRAP. Marsden. $890,000 (2020 - 2023)

Prof. Antony Fairbanks: A new paradigm for organelle targeting. Marsden. $870,000 (2017 - 2021)

A/Prof. Volker Nock: Electrotaxis and protrusive force generation in fungal and oomycete pathogens - pathways to new biocontrol strategies. Rutherford Discovery Fellowship from the Royal Society of New Zealand. $800,000 (2020 - 2025)

Prof. Renwick Dobson: How do bacteria scavenge sialic acids from their human hosts? Marsden. $770,000 (2016 - 2020)

Dr Jodie Johnston: Understanding internal communication with proteins. Marsden. $703,167 (2018 - 2022)

Dr Mitja Remus-Emsermann and A/Prof. Volker Nock: Using Synthetic Communities to Visualise Bacterial Plant Leaf Community Development and Pathogen Invasion Processes at the Single-Cell Resolution. Marsden. $300,000 (2018 - 2021)

Prof. Renwick Dobson: Advanced tools for food structures and interactions. CoRE Riddet Institute. $283,800 (2018 - 2021)

A/Prof. Ashley Garrill: Beyond myrtle rust: toward ecosystem resilience. MBIE Research Programme led by Landcare Research NZ. $232,175 (2018 - 2023)

Dr Sarah Kessans: Bringing biology to new heights: development of biological laboratories on nanosatellites. National Science Challenge: Science for Technological Innovation. $200,000 (2019 - 2021)

Dr Azadeh Hashemi: Developing a simple and effective method for directing the differentiation of stem cells in the lab. Rutherford postdoctoral fellowship. $170,000 (2020 - 2022)

Prof. Conan Fee: Advanced tools for food structures and interactions. CoRE Riddet Institute. $136,200 (2018 - 2021)

Rebecca Hurrell: New Zealand Product Accelerator funded by Callaghan Innovation and led by the University of Auckland $120,000 (2019 - 2021)

Prof. Renwick Dobson: New Biophysical Methods to Understand How Bacteria Import Metabolites Across Their Cell Membrane. Royal Society of New Zealand - Catalyst: Seeding. $80,000 (2018 - 2021)

Prof. Renwick Dobson. Endolysins. ESR. $20,000 (2020 - 2021)

Dr Mitja Remus-Emsermann: Excuse me, can you show me the way? Microbial chemotaxis survival in the phyllosphere. Marsden Fund led by Victoria University of Wellington (2019 - 2022)

Dr Jodie Johnston: Overcoming antimicrobial resistance. CoRE: Maurice Wilkins Centre (2019 - 2021)

A/Prof. Volker Nock. Biological mimicry for medical diagnostics. SfTI led by Massey University. (2019 - 2021)

Grants completed

2020

Dr Sarah Kessans: Delivering methane inhibitors to pasture-fed ruminants. Ministry of Primary industries, led by Victoria University of Wellington. $189,706 (2018 - 2020)

Dr Rachel North: Unravelling the molecular details of a bacterial sialic acid membrane transporter to inform antimicrobial development. Canterbury Medical Research Fund. $100,000 (2018 - 2020)

Dr Jodie Johnston: The effect of menaquinone biosynthesis inhibition on biofilm formation in *S. aureus*. Canterbury Medical Research Fund. $99,251 (2018 - 2020)

Prof. Renwick Dobson: Sucrase inhibitors as insecticides against sap-feeding insects. Plant & Food Research. $87,000 (2018 - 2020)

Prof. Conan Fee: Developing Micro Mimics for Investigating Legionella Mobility and Persistence in the Plumbing Systems. $82,500 (2017 - 2020)

Dr Jodie Johnston: Testing of lead inhibitors on NDH-2 and MenD against *M.Tuberculosis* growth. CoRE: Maurice Wilkins Centre. $14,800 (2019 - 2020)

2019

A/Prof. Volker Nock: Hyphae on-a-chip - A microfluidic platform for the study of protrusive forces in hyphal invasion. Marsden Fast-Start. $300,000 (2016 - 2019)

Prof. Conan Fee: Sequestering natural and anthropomorphic trace metals from water. Scion. $158,800. (2017 - 2019)

Dr Jennifer Crowther: Development of a bioassay to detect pre-eclampsia. Canterbury Medical Research Foundation. $100,000 (2018 - 2019)

BIC grants awarded

Seed funding

2020

Dr Pram Abhayawardhana: Exploring how 3D printing could be a useful tool in developing smart formulations for agriculture and conservation, $12,000

Dr Ali Reza Nazmi: Enzymatic synthesis of novel high-value sustainable polymers, $40,000

Dr Debbie Munro: Characterization and optimization of 3D bioprinted hydrogels for tissue scaffolds in spinal cord injury repair, $34,500

Dr Grant Pearce: Using Rubisco to improve NZ's agricultural economy, $40,000

Dr Tammy Steeves: Building an integrative genomics framework to mitigate maladaptive reproductive traits in endangered species, $15,000

2019

Prof. Ren Dobson: Understanding bacterial gene regulation is to understand how bacteria think, $6,000

A/Prof Ashley Garrill: Dynamics of actin polymerization at hyphal tips - correlation with growth pulses and protrusive force generation in oomycetes and fungi, $7,500

Dr Tim Huber: 3D printing protein-scaffolds, $7,500

Dr Jodie Johnston: Engineering CUEs for Efficiency and Novel Amination Chemistry, $7,750

Dr Amy Osborne: Optimisation and refinement of Oxford Nanopore MinIon technology within BIC, $7,500

Prof. Matt Watson: Sap flow in maple trees, $6,500

Summer scholarships

2020

Dr Ali Reza Nazmi: Screening marine associated bioplastic producing bacteria for improved end-of-life sustainability. Student: Kamla Vaoatea Phal

Dr Claudia Meisrimler: Expression and purification of the two *Bremia lactucae* RxLR effector proteins BLR05 and BLR09 involved in down mildew disease in lettuce. Student: Tyler Matthew Johns

Dr Daniel Foley: Development of a selective chemical probe for cdc2-like kinase 4 (CLK4). Student: Alexis Caroline Blackie.

Dr Euan Coutts: Improving medication compliance in at-risk patients with mental health disorders with advanced device-enabled biomolecular technologies. Student: Callum Patrick McGregor

Dr Jodie Johnston: Characterising the vitamin K2 biosynthesis protein MenI from the pathogen *Staphylococcus aureus*. Student: Lisa Patmore

Dr Sarah Kessans: Moulds for mould? Quantifying the advantages of using fungi in additive manufacturing. Student: Deane Renee Thomas

Dr Vanessa Morris: Production of the aryl-hydrocarbon receptor protein – a small molecule sensor. Student: Abigail Joy Schwartfeger

A/Prof Volker Nock: Replicating Mycelial Networks to Study Mass Transport in Fungi and Oomycetes. Student: Renee Harris (co-funded with MacDiarmid Institute).

2019

Dr Hossein Najaf Zadeh: Supporting the development of a high-speed 3D printer. Students: Campbell Shelly and Nathan Beckers

Dr Amy Osborne: Responses of New Zealand native plants to a changing environment. Student: Jessica Faris

A/Prof Deborah Crittenden, Dr Daniel Foley: Photodegradable drug design. Student: Kim Fowler

Dr Mitja Remus-Emsermann: You smell nice: altering the flavour profile of wines. Student: Flynn Adcock

Dr Jodie Johnston: Protein targets for Glaucoma and aging related diseases. Student: Robin Krauss (funded by UC seed funding).

Prof. Daniel Holland: Gathering preliminary data for a Smart Ideas funding application. Student: Tom Meaclem

Evolving and Engineering Biomolecules

Flagship Leader: Professor Renwick Dobson

Under this flagship theme, we are exploring fundamental questions of how molecules evolve, function and interact. We are focused on harnessing biomolecular interactions, creating enzymes with novel properties, rewiring cells to produce biomolecules in short supply, utilising long-term evolution experiments to better understand structure, function and evolution of proteins and mining evolutionary diversity for new function. We have welcomed two new academic staff members to Biology in the last two years bringing new perspectives and directions to the flagship; Dr Claudia Meisrimler studies plant pathogen interactions, while Dr Vanessa Morris studies protein interactions in the context of disease states, such as Alzheimer's disease.

Flagship highlights

Biological nuclear magnetic resonance at UC

Dr Vanessa Morris has secured funding to purchase a new nuclear magnetic resonance (NMR) instrument to study protein structure and function. The instrument will also be used for metabolomics and drug discovery, bringing new capability to UC and NZ. It will be housed within Biology.

AUC2019

It was a pleasure to host the 24th International Analytical Ultracentrifugation Conference and Workshop. We hosted 70 international guests from Europe, North America and Asia. A highlight was truffle hunting in North Canterbury.

Funding success

Dr Vanessa Morris was awarded a Marsden Fast-start grant ($330,000), starting in 2020, to elucidate the importance of protein-protein interactions involved in Alzheimer's disease. Despite being one of the leading causes of death worldwide, there is currently no effective treatment against Alzheimer's disease. Development of therapies has been hampered by a lack of mechanistic understanding of events that underlie disease progression. Peptide amyloid-beta and the receptor protein TREM2 have both been linked to development of the disease, and a direct protein interaction has been reported. Dr Morris will use an integrative approach to gain a complete molecular picture of this key interaction in Alzheimer's disease.

Dr Laura Domigan from the University of Auckland is leading an MBIE funded project ($3,000,000) to understand the interactions between plant-based proteins and cellular agriculture. The team includes Prof. Renwick Dobson (University of Canterbury), Prof. Warren McNabb (Massey University), Dr Sophia Rodrigues (University of Auckland), and Dr Olivia Ogilvie (University of Canterbury) and connects with colleagues in Singapore. This work started in October 2020.

Prof. Renwick Dobson has secured $890,000 funding from the Royal Society's Marsden Fund for a project titled "Understanding bacterial membrane transport proteins: setting an antimicrobial TRAP". Joining Prof. Dobson in this study are A/Prof. Jane Allison (University of Auckland), and Prof. Soichi Wakatsuki (School of Medicine, Stanford University). Collectively, their expertise spans biophysics, structural biology and molecular modelling. This project commenced in October 2020.

In addition to these large grants, the flagship has supported a number of smaller, successful grant applications, including: ESR ($20,000) to work on engineering endolysin enzymes to kill bacteria; Plant and Food Research ($90,000) to study sucrase enzymes to treat insect pathogens; BioHeritage National Science Challenge ($180,000) to understand plant-fungi interactions; Brain Research New Zealand ($43,000) to study 'Blood and tears, alpha-synuclein and Parkinson's disease'; and, KiwiNet ($15,000) to engineer novel milk proteins.

Flagship funding awarded

As a flagship, we have continued to seed projects that support early career researchers, build new connections and have tangible potential for gaining new research funding. For example, Dr Claudia Meisrimler received a summer scholarship ($5,000) to investigate plant pathogen effector proteins that target the plant response system. Dr Vanessa Morris received $10,000 to co-fund a project studying the potential of alpha-synuclein to be used in the diagnosis of Alzheimer's disease. The project is co-funded with the School of Psychology (UC) and Brain Research New Zealand.

Engineering Biotechnology

Flagship Leader: Associate Professor Volker Nock

This flagship brings together rapid prototyping and advanced manufacturing technologies from the engineering disciplines to help inform molecular and cellular life sciences. To achieve this, the flagship incorporates a diversity of input from the physical sciences and engineering with the aim to develop new platforms that help unravel the complexity of biology.

We work with cells, animals and plants and our research spans the biological hierarchy from molecules to whole organisms. We are focused on the following broad areas of activity: 3D printed devices for bioseparations, biomolecular interactions on surfaces, biomolecular interactions related to disease, biochemistry on chips and sourcing of advanced materials from nature's pantry. In a drive to increase cross-disciplinary research, several major projects are currently being funded under this flagship.

Flagship highlights

Nanoscribe

A/Prof Volker Nock successfully secured $800,000 funding from the University of Canterbury, BIC and Lottery Health to purchase a Photonic Professional GT2 by Nanoscribe. The first of its kind in New Zealand, this instrument allows users to build up complex, arbitrarily shaped structures with nanometer-sized features. It will be housed in UC's Nanofabrication Facility (Nano Lab) and hosted by the Department of Electrical and Computer Engineering in the College of Engineering.

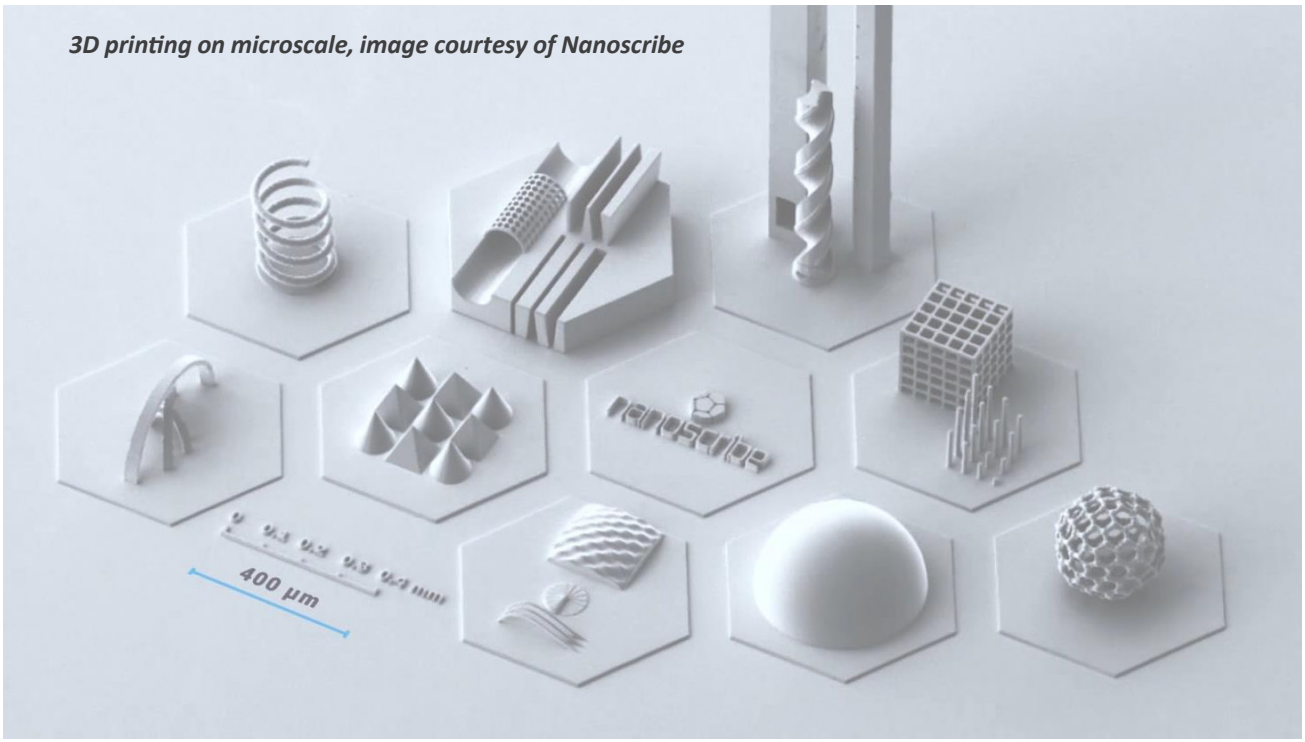
Funding success

A/Prof Volker Nock was awarded $800,000 over 5 years as a Rutherford Discovery Fellowship for research titled "Electrotaxis and protrusive force generation in fungal and oomycete pathogens – Pathways to new biocontrol strategies".

Dr Azadeh Hashemi was awarded $170,000 for a two-year Rutherford Foundation Fellowship for research towards developing a simple and effective method for directing the differentiation of stem cells in the lab.

A/Prof Volker Nock and A/Prof Ashley Garrill secured a $232,000 subcontract with Landcare Research to study myrtle rust.

Dr Mitja Remus-Emsermann was awarded $300,000 to understand how the topography or landscape of the leaf determines and changes microbe-microbe interactions independent of plant responses to microbes. By using a mimic of the leaf surface, they aim to subtract plant interference in these inter-microbial interactions.



3D printing on microscale, image courtesy of Nanoscribe

Chemical Biology

Flagship Leader: Professor Antony Fairbanks

Chemical Biology is where synthetic chemistry acts as an enabling science to allow the study and manipulation of biological systems and processes. The goals of Chemical Biology are two-fold: firstly to provide molecular level insight into biological processes, and secondly to reveal windows of opportunity for interference with said processes, for example for the development of new therapies. Our labs provide a world class Chemical Biology research environment, where synthetic chemistry goes hand-in-hand with biological studies.

Flagship Highlights

Native mass spectrometry

Dr Tim Allison secured a combined total of ~$1M from the University of Canterbury's specialised strategic research capital fund, Lottery Health, BIC and the Maurice and Phyllis Paykel Trust to establish a 'native mass spectrometry' capability at UC. Native mass spectrometry is the process where large biomolecules (and their complexes) are transferred to the gas phase by electrospray ionization and analysed by mass spectrometry. Critically, the method of transfer and ionisation are so mild that both the biologically active conformation and any non-covalent interactions are preserved. This type of mass spectrometry, pioneered by luminaires such as Prof's Joseph Loo (UCLA), Albert Heck (Utrecht), and Tim's post-doctoral supervisor Dame Carol Robinson (Oxford), is now a cutting edge tool for the study of biomolecular interactions. Recent technological developments have been so impressive that now even whole intact virus particles can be analysed in this fashion. The establishment of a native mass spec capability within BIC is a first for New Zealand, and will significantly increase our ability to study biomacromolecules, their complexes, and even their supramolecular assemblies, in native folded biologically active conformations.

Research to help tackle tuberculosis

Dr Jodie Johnston and co-workers have discovered a novel mechanism that controls vitamin K2 production in the bacterial pathogen *Mycobacterium tuberculosis*, the causative agent of TB. Johnston has shown that regulation of an enzyme called MenD, which catalyses an early step in the biosynthetic pathway to make vitamin K2, is controlled by a product from a later biosynthetic step. This feedback inhibition allows the pathogen to reduce or increase how much vitamin K2 is made which is likely to help the pathogen adapt to the hostile and changing environment in the human host during infection. Since humans do not produce vitamin K2, the enzymes that work to produce it in TB-causing bacteria could be targets for new antimicrobial drugs. Their work has been published in the Journal of Biological Chemistry and was highlighted as an editor's pick.

Understanding how bacteria use host food sources

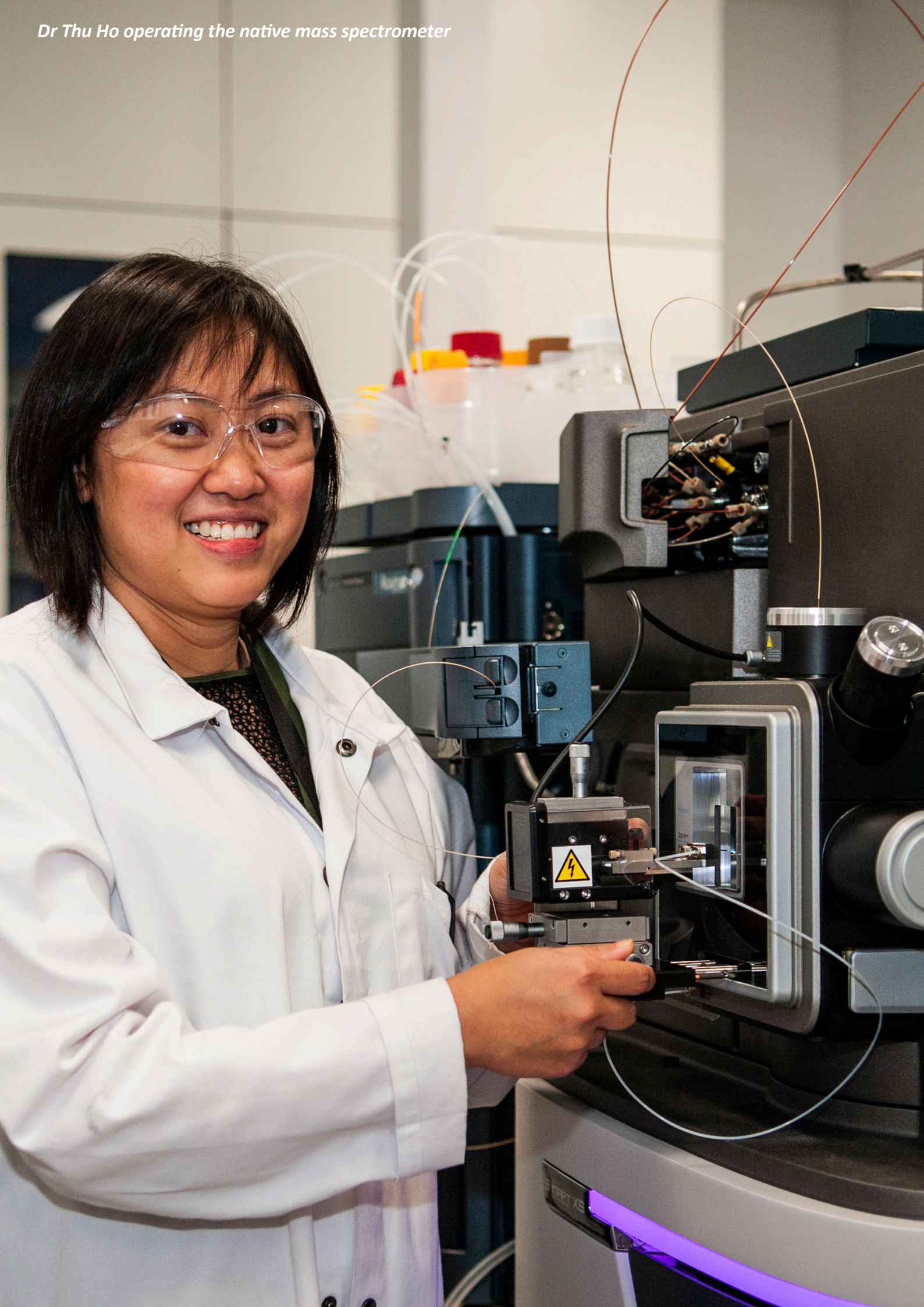
Dr Rachel North has completed a project funded by the Canterbury Medical Research Foundation to understand how *Haemophilus influenzae* scavenges and uses sugars from its human host. Importantly understanding how bacteria such as *H. influenzae* scavenge and use food sources from their hosts may provide insight into potential novel methods for the treatment of bacterial infection; an important objective in this age of ever-increasing bacterial resistance to known antibiotics.

Funding success

Dr Jodie Johnston successfully secured $14,800 funding from the Maurice Wilkins Centre for "Testing of Lead Inhibitors of NDH-2 and MenD against M. Tuberculosis growth".

Flagship funding

Dr Daniel Foley was supported by a BIC flagship grant to support two talented UC undergraduate students to undertake short research projects in his laboratory. BIC has also provided support for high-performance liquid chromatography (HPLC) purification facilities in the Ernest Rutherford Chemical Biology Laboratory.



Dr Thu Ho operating the native mass spectrometer

Impact and application

Biomolecular interactions find applications in a broad range of fields including drug design, nanotechnology, food science, agritech and diagnostics.

An established strength of BIC is our capacity to take ideas from the research lab into the real world.

Sustainable is Attainable

Established in May 2019, Sustainable is Attainable is a project launched by the South Canterbury Food Processors and Manufacturers Business Connection Group, led by Venture Timaru (the economic development agency for the Timaru region) in collaboration with the University of Canterbury.

The Timaru District and the wider South Canterbury area has a rich, productive primary sector, with more than 5000 people employed in the food processing and manufacturing sector alone. Timaru is home to small family food businesses, national and multi-national companies exporting food and beverages around the world.

Left to right: Courtney Wright-Watson, Greg Hatley and Blair Masters collecting samples in Timaru

One of the biggest challenges identified by these businesses is managing their waste streams and by-products. Many of these end up as very low value products or in landfill.

To better understand the problem and help identify possible solutions, Sustainable is Attainable secured funding from Callaghan Innovation for three studentships.

The students identified over 35 discrete biowaste streams with a combined total of more than 120,000 tonnes annually.

This included eight streams common across multiple business such as solid food waste, general animal waste, oil and sludge. A minority of the biowaste streams go directly to landfill with the majority being used on farm, on-sold directly to end-users or sold to other organisations who develop new products, including stock feed.

Almost every company identified soft plastics, of varying composition, as problematic. A specific problem within the food processing industry is Personal Protective Equipment (PPE) that is necessary to meet food safety requirements. This includes mixed plastic aprons, gumboots, nitrile gloves, hairnets, and sleeves. All companies that export products are required to use these and presently there is no alternative. Some PPE are single use like nitrile gloves and hairnets while others, for example aprons, may last weeks, depending on the application. Finding a solution to deal with waste PPE would significantly reduce the amount of waste sent to landfill by the companies.

Subsequently, BIC and the New Zealand Product Accelerator are supporting a number of research projects that aim to add value to waste streams and by-products. These projects include developing high value soil conditioners, led by Prof. Brett Robinson and turning dairy sludge into biohydrogen, led by Dr Carlo Carere.

3D printed porous media for process engineering

In 2019, Prof. Conan Fee was awarded $9.8 million in research funding from the Ministry of Business, Innovation and Employment for an Endeavour Research Programme exploring 3D printed porous media for process engineering.

Almost every item we touch is created by industrial processes that involve heat exchangers, separators and catalytic reactors and these critically depend on heat and mass transfer between gases, liquids or solids. Chemical engineering design involves maximising the heat and/or mass transfer rate, whilst minimising the pressure drop. Traditionally, design choices have been limited by manufacturing methods using tubes, plates and randomly-packed particles. 3D printing introduces new possibilities for the design of optimal geometrically-complex flow channel structures, potentially enabling game changing performance in a variety of applications.

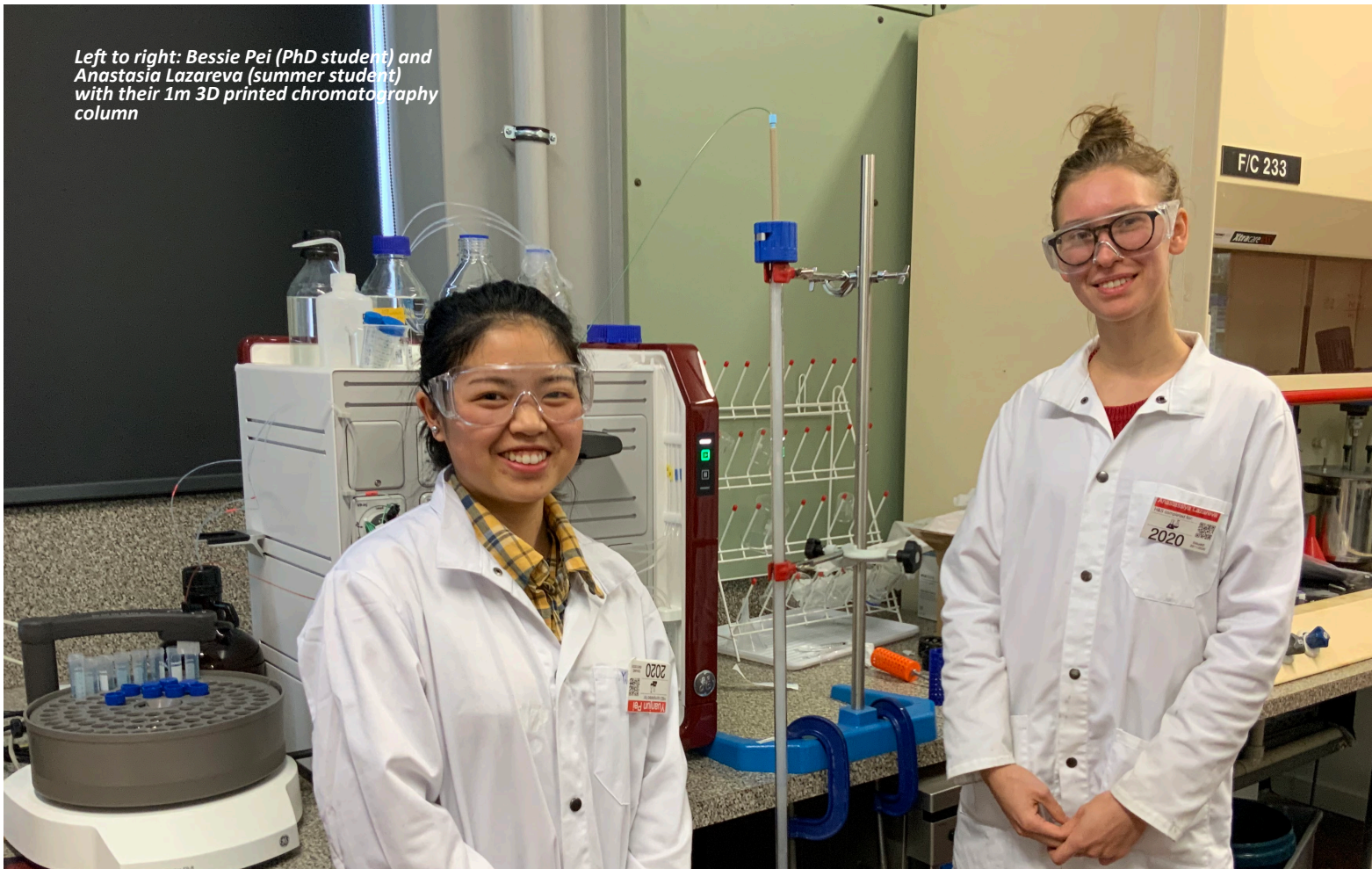
Prof. Conan Fee's research programme addresses all aspects of 3D printing in chemical engineering, from the design of the pore structure and materials, to the design of the 3D printers themselves. The team is a collaboration across UC, Victoria University of Wellington, University of Otago and Callaghan Innovation and comprises chemical engineers, mechanical engineers, biologists, computer scientists and materials scientists dedicated to disrupting 130 years of chemical engineering science.

Research objectives

The programme's first research aim is led by Prof. Daniel Holland and A/Prof. Ken Morison. The purpose is to use magnetic resonance imaging (MRI) and computational fluid dynamics (CFD) to investigate fluid flow and characterise heat and mass transfer in 3D-printed structured porous materials. This will define the equations needed for the chemical engineering design process.

The second research aim is led by Prof. Conan Fee and Prof. Richard Green (Head of the Department of Computer Science at UC). It focuses on enabling the physical design of microstructure objects. First, the team will use computer science to circumvent the large file sizes and long rendering times associated with 3D printing fine porous structures. Then, machine learning will be used to optimise porous geometries.

The third research aim is led by Prof. Matt Watson and resolves to understand the effects of our 3D printing method on material properties. This will enable the development of new, highly specialised material formulations. Combined with the results of the other research aims, this will enable the development and characterisation of applications of structured porous materials such as catalytic reactors, heat exchangers and chromatography purification processes.



Left to right: Bessie Pei (PhD student) and Anastasia Lazareva (summer student) with their 1m 3D printed chromatography column

New Associate Investigators

Over the past two years, we have welcomed 17 new Associate Investigators into BIC:

Dr Pram Abhayawardhana, School of Product Design

Dr Vanessa Morris, School of Biological Sciences

Dr Steve Pawson, School of Forestry

Dr Carlo Carere, Department of Chemical and Process Engineering

Dr Debbie Munro, Department of Mechanical Engineering

A/Prof. Tammy Steeves, School of Biological Sciences

Dr Natalia Kabaliuk, Department of Mechanical Engineering

Dr Ali Reza Nazmi, School of Product Design

A/Prof Matthew Stott, School of Biological Sciences

Dr Sarah Kessans, School of Product Design

Dr Amy Osborne, School of Biological Sciences

Dr Adele Williamson, Department of Biological Sciences, University of Waikato

Dr Khoon Lim, Department of Orthopaedic Surgery and Musculoskeletal Medicine, University of Otago

Dr Heon Park, Department of Chemical and Process Engineering

Prof. Brett Robinson, School of Physical and Chemical Sciences

Dr Euan Coutts, School of Product Design

Dr Claudia Meisrimler, School of Biological Sciences

Postgraduate students

BIC hosts honours, masters and doctoral students across a broad range of topics. Some of their projects are externally funded and others are partially or fully supported by BIC ***via*** contestable funding rounds and flagship funding. Here we profile some of our newest doctoral students.

Michael Love

Bacteriophage endolysins as antimicrobial agents against Gram-negative bacteria

Michael Love is working on a collaborative project between BIC and ESR, investigating the potential for bacteriophage endolysins to replace or supplement antibiotic use against Gram-negative bacteria such as ***Escherichia coli*** and ***Pseudomonas aeruginosa***. He is based at the School of Biological Sciences at the University of Canterbury under the supervision of Prof. Renwick Dobson and ESR's Dr Craig Billington.

The growing prevalence of antimicrobial resistant bacteria is cause for global concern. Michael's research works towards developing an innovative approach to treating bacterial infections. Through characterising the structural and biochemical properties of novel endolysins, the aim is to then engineer endolysins into effective bacterial killing weapons.

Michael is interested in the commercialisation of research and ideas. Working on a PhD project with medical application potential has allowed Michael to gain insight and skills towards commercialisation, which will be essential for his future endeavours.

Sarah Sale

Beyond myrtle rust: Insight into the invasive growth of rust fungi

Sarah Sale is a new PhD student, co-supervised by A/Profs Ashley Garrill and Volker Nock. Sarah's research is a part of a large, collaborative, multifaceted research programme known as 'Beyond Myrtle Rust'. Her section aims to provide insight into the invasive growth of rust fungi in the hope that they can be better managed and their negative impacts reduced. She intends to do this by firstly establishing a way to grow the fungi on artificial surfaces (including artificial leaves), secondly by developing a lab-on-a-chip platform that hosts the fungi, thirdly by using this platform to measure the exerted forces, and finally by screening for the impacts of microorganisms and bioactive substances.

Sarah was born and raised in Hawkes Bay and came down to Christchurch to study at UC. She received her Bachelor of Science and Bachelor of Science with First Class Honours, both in Biochemistry, from UC. She loves biochemistry because of how versatile it is and that it allows for solving real world problems. When she is working, she is often listening to Pink Floyd and various blues artists as she is a massive music fan.

Michael Currie

Investigating the structure of TRAP transporters from pathogenic bacteria using small-angle X-ray scattering

Michael is a PhD student studying biochemistry, working to understand the structure and function of bacterial membrane transporters involved in disease. Supervised by Prof. Renwick Dobson in the School of Biological Sciences, he hopes to characterise membrane transporters to enable the development of inhibitors to target pathogenic bacteria and reduce infections.

Michael moved to Christchurch from the West Coast for his studies where he completed both his Bachelor's and Honours degrees at the University of Canterbury. During his scientific journey he has analysed samples using several world-class research facilities: the Australian Synchrotron and the OPAL nuclear reactor. To be able to access these facilities from Christchurch has significantly improved the quality of his research.

Michael is interested in drug design for preventing disease and hopes to use his knowledge in protein biochemistry to pursue this area after his PhD.

Hannah McKerchar

Detecting crosslinks in milk using mass spectroscopy

Hannah is a BIC PhD student co-funded by AgResearch, studying protein-protein crosslinks that form in food proteins during food preparation. Utilising the mass spectrometers in the Proteomics platform at Lincoln, Hannah is seeking to understand more about crosslinks that reduce foods' nutritional value. She is supervised by Prof. Ren Dobson, Dr Stefan Clerens, Dr Jolon Dyer and Prof. Juliet Gerrard.

During her undergraduate degree, Hannah enjoyed summer scholarships at Plant & Food and the Australian National University (Canberra) before graduating with honours in biochemistry and a law degree. After practising law in New Zealand and Australia for 10 years, she returned to UC to commence a PhD and resume her enjoyment of science.

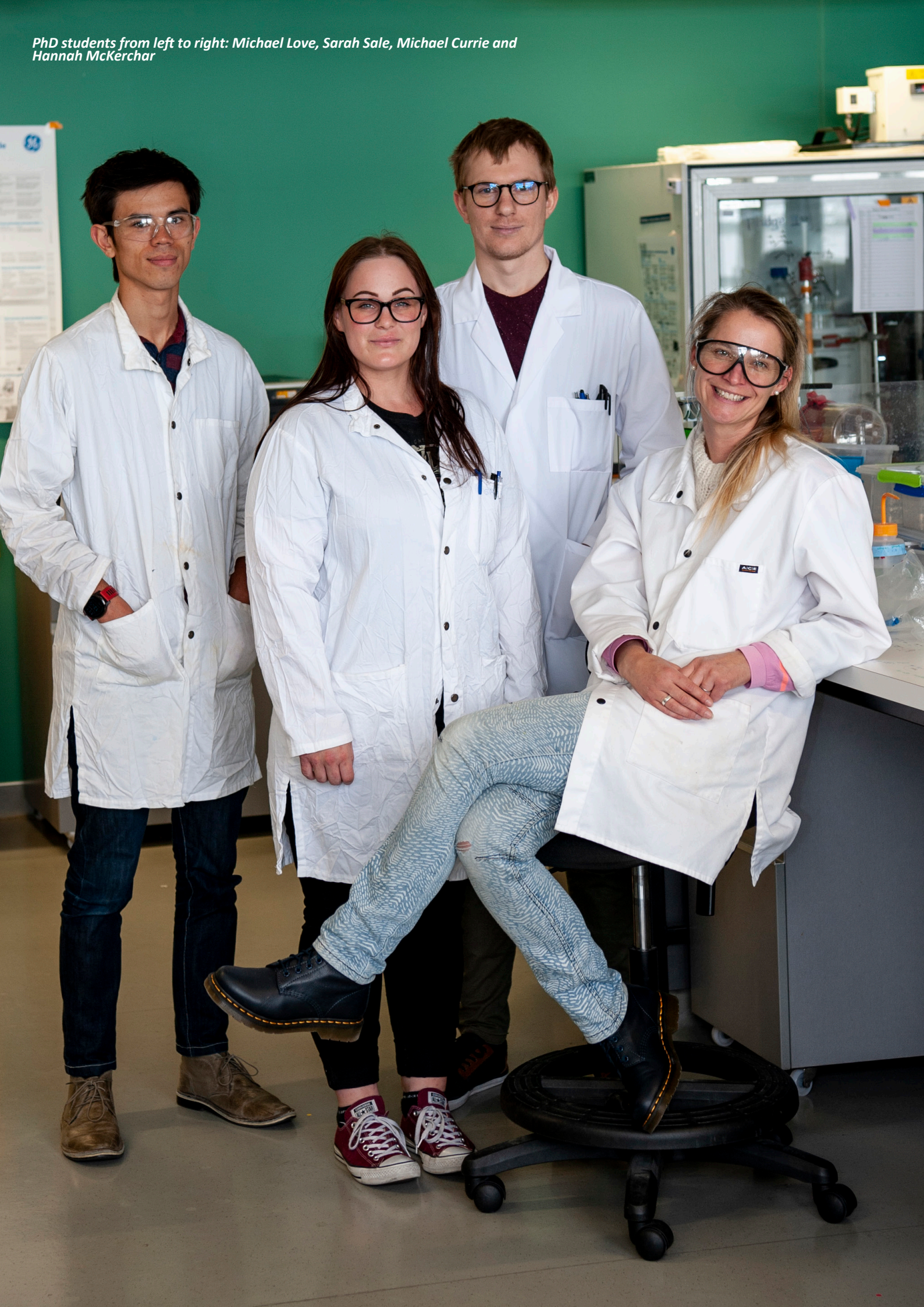
Bessie Pei

Fabrication of printed uniform monolith for protein chromatography

Bessie started her PhD in 2020 under the supervision of Prof. Conan Fee. She holds a Bachelor of Bioengineering degree at the College of Life Science and Technology, Huazhong Agriculture University (HZAU) in China and a Master of Bioengineering degree at State Key Laboratory of Agricultural Microbiology, also at HZAU.

She spent six years in biopharmaceutical research and development where she became interested in transforming experimental results into industrial applications. The main objective of her PhD project is to refine production of a 3D printed, uniform monolith chromatography column to purify proteins and compare this new method with the conventional Packed Bed Adsorption (PBA) and Expanded Bed Adsorption (EBA) to help drive industrial uptake.

Bessie enjoys learning about history, and is ready to experience the beauty and cultural charm of New Zealand.



PhD students from left to right: Michael Love, Sarah Sale, Michael Currie and Hannah McKerchar

Postdoctoral fellows

The Biomolecular Interaction Centre has continued strong investment in postdoctoral fellows. We are lucky to have a large cohort of externally funded fellows working on a range of research projects and we have funded a number of short-term fellowships directly from our Centre. Here, we profile some of the 2019-2020 cohort.

Dr Tamsyn Stanborough

Tamsyn completed her undergraduate study in Molecular Biology and a Master's degree in Molecular Microbiology at the University of Graz in Austria. She then moved to Melbourne, where she completed a PhD at Australian's national science agency Commonwealth Scientific and Industrial Research Organisation (CSIRO) through the University of Tasmania. Her PhD research was focused on genomic and phenotypic characterisation of food spoilage bacteria.

Tamsyn is a BIC postdoctoral fellow working on Canterbury Medical Research Foundation (CMRF) and BIC-funded projects with BIC AI Dr Jodie Johnston and BIC PI Dr Deborah Crittenden, respectively in the School of Physical and Chemical Sciences. The 15-month-long CMRF-funded project is to investigate the effect of menaquinone biosynthesis inhibition on biofilm formation of *Staphylococcus aureus*. In New Zealand, the incidence rate for *S. aureus* infections is among the highest reported in the developed world. Results from this work will help identify new drug targets to treat *S. aureus* infections and biofilms. The aim of the BIC-funded project, led by Dr Crittenden, is to develop a point-of-care device for the detection of the SARS-CoV2 virus. Tamsyn will investigate the suitability of a range of spectroscopic methods for viral antigen detection.

Dr Olivia Ogilvie

Olivia is a postdoctoral fellow with BIC Director Prof. Ren Dobson in the School of Biological Sciences, conducting a collaborative project with Dr Laura Domigan at the University of Auckland. Olivia is working with the Office of the Prime Minister's Chief Science Advisor to explore the policy and regulatory implications of novel foods, focusing on cultured animal cells. The project is funded by the Ministry of Business, Innovation and Employment (MBIE)'s New Zealand-Singapore Bilateral Research Programme on Future Foods. It will also consider the banking and characterisation of satellite cells from domesticated animals.

Olivia recently completed her PhD at The University of Auckland, which used peptidomics to model the digestion and release of gluten peptides that cause celiac disease. This project also examined how modern food processing altered the release profile of immunogenic gluten peptides. Olivia is also interested in research commercialisation.

Dr Clara Bah

Clara Bah is working on a project funded by the Riddet Centre of Research Excellence with BIC PI Prof. Conan Fee in the School of Product Design. Clara's project involves developing surface plasmon resonance (SPR) biosensor techniques to measure real-time insulin to insulin receptor (IR) binding kinetics as well as investigating the effect of novel food compounds on insulin-IR interactions.

Clara completed her Masters and PhD in Food Science at the University of Otago. Her previous research has focused on generating value to New Zealand food industry by-products such as fish roe and slaughterhouse animal blood, as well as emerging technologies to increase the value of New Zealand meat products.

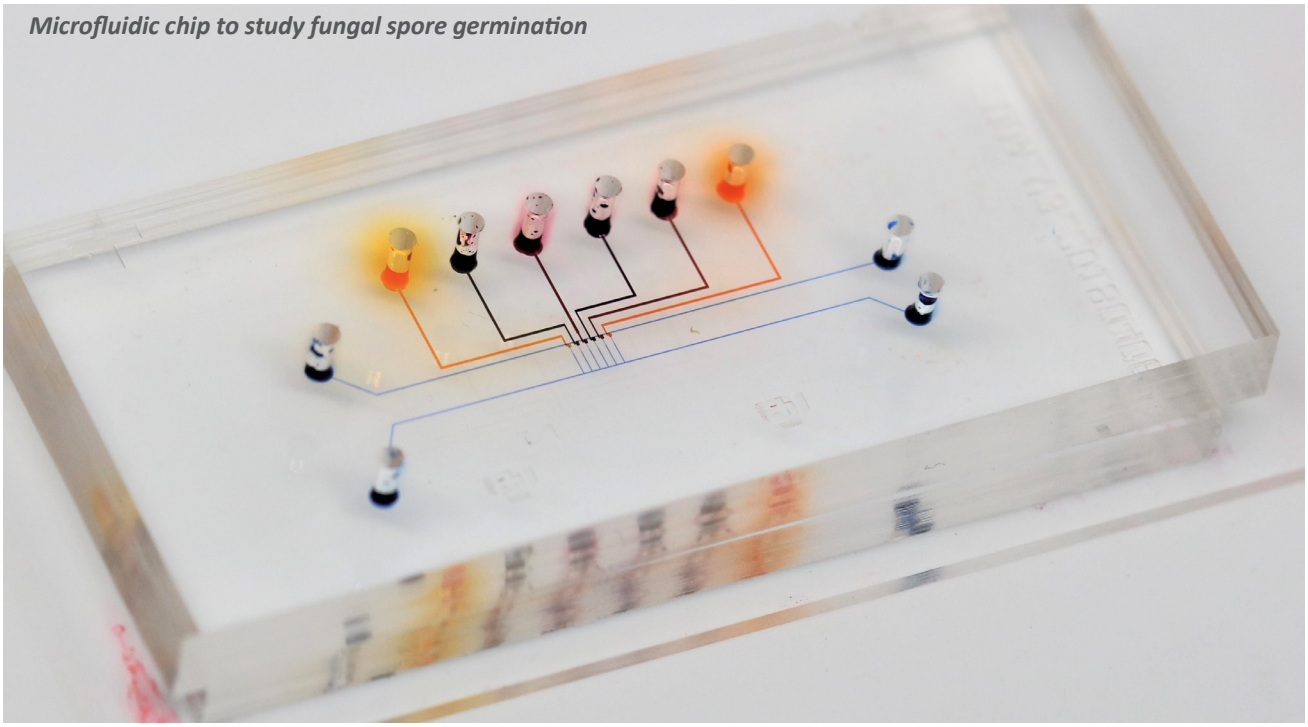
Dr Hossein Najaf Zadeh

Hossein Najaf Zadeh is a postdoctoral fellow in BIC working with A/Prof. Don Clucas in the Department of Mechanical Engineering and BIC AI Dr Tim Huber in the School of Product Design. Hossein is working on a MBIE-funded Endeavour project titled '3D printing porous media for process engineering' led by BIC PI Prof. Conan Fee. Hossein will continue work started during his PhD to develop a method of mass manufacturing Triply Minimal Periodic Surface (TPMS) structures using thermal 3D screen printing. Additionally, he is expanding the use of the developed technology to mass manufacture other materials such as metal alloys and ceramics.

Hossein obtained his PhD in engineering at the University of Canterbury in 2019, supported by BIC. Hossein's PhD work was focused on mass manufacturing microstructure cellulose hydrogels, to be used primarily in chromatography purification applications.

Hossein was awarded an M.Sc. in Mechanical and Manufacturing Engineering with distinction at the University of Greenwich, London, England and his B.Eng. in Mechanical Engineering in Iran in 2008. In addition to his engineering qualifications, he also has received an MBA specialised in supply chain management.

Postdoctoral fellows



Microfluidic chip to study fungal spore germination

Dr Thu Ho

Thu is a postdoctoral fellow with Dr Jodie Johnston in the School of Physical and Chemical Sciences. Her research has been part of a Marsden-funded project focusing on the mechanism of critical enzymes in the menaquinone synthesis pathway of *Mycobacterium tuberculosis*. She is particularly interested in understanding the dynamics and the function of proteins at the molecular level, which serve as the basis for both drug discovery and bioengineering toward novel reaction systems. For the next year, Thu will be splitting her time between her Marsden work and a seed project, funded by a BIC seed grant, with Dr Ali Reza Nazmi and Dr Timothy Allison, engineering bioplastic-producing enzymes.

Thu obtained her PhD in Structural Biology at the University of Auckland and joined the Johnston group at UC in 2018. Her main experience is in structural biology, particularly protein crystallography, with specific expertise in DNA binding proteins. She has a growing interest in using chemical techniques such as analytical chromatography and mass spectrometry for more in-depth understanding of enzymatic reactions.

Dr Yiling Sun

Yiling Sun is a new Postdoctoral Fellow in the Biomolecular Interaction Centre working with A/ Prof. Volker Nock on his Rutherford Discovery Fellowship funded by the Royal Society | Te Apārangi. The research is directed towards electrotaxis and protrusive force generation in fungal and oomycete pathogens and will lead to new biocontrol strategies.

Yiling received her Bachelor's degree in Biomedical Engineering from Shanghai Jiao Tong University, China and a Master's degree in Micro-nano Systems Engineering from Nagoya University, Japan. She recently completed her PhD with the Department of Electrical and Computer Engineering at UC. Her research interests include microfabrication and lab-on-a-chip devices for use in biology.

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Prof. Matt Watson, Deputy Director

A/Prof. Deborah Crittenden

Prof. Antony Fairbanks

Prof. Conan Fee

Prof. Juliet Gerrard

A/Prof. Paul Gardner

A/Prof. Volker Nock

Prof. Emily Parker

Dr Grant Pearce

Prof. Ant Poole

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Abby van den Berg, University of Vermont

Steven Gray, University of Texas Southwestern Medical Center

Outputs 2018 -2020

140 refereed journal articles

72 conferences and presentations

5 book chapters

2 patents

Journal articles

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A Hashemi, MA Ali, M Alkaisi, VM Nock (2019). Characteristics of bioimprinted casein microdevices as biodegradable cell-culture substrates. Wellington, New Zealand: 9th International Conference on Advanced Materials and Nanotechnology (AMN9), 10 Feb 2019.

S Onal, M Alkaisi, V Nock (2019). Design and Fabrication of a Microfluidic System for Force Application on Cancer Cells. Wellington, New Zealand: 9th International Conference on Advanced Materials and Nanotechnology (AMN9), 10 Feb 2019.

D Crittenden (2019). DFT with error bars:how far can DFT results be trusted? New Zealand Institute of Chemistry Conference 2019.

N Altenhuber, R Soffe, A Downard, VM Nock (2019). Diabetes Management: Developing a Point-of-Care Insulin Sensor. Wellington, New Zealand: 9th International Conference on Advanced Materials and Nanotechnology (AMN9), 10 Feb 2019.

N Yang, A Scott, M Watson, V Shah, C Oze (2019). From Moon Rock to Cement: Extraction of silica from serpentine and the use of waste acid to produce magnesium chloride cement.

M Bernach, R Soffe, M Remus-Emsermann, VM Nock (2019). Hybrid PDMS with increased permeability for phyllosphere microbiology. Wellington, New Zealand: 9th International Conference on Advanced Materials and Nanotechnology (AMN9), 10 Feb 2019.

M Currie, R Dobson (2019). Invited speaker

(2019) - Structural and Biophysiocal Characterisation of the TRAP family transporters - the ARRTI speaker series Lecture (Lethbridge, Canada).

J Davies, R Dobson (2019). Invited speaker (2019) - Structural and Biophysiocal Characterisation of the TRAP family transporters - the ARRTI speaker series Lecture (Lethbridge, Canada).

M Love, C Billington, R Dobson (2019). Invited speaker (2019) CanterburyTech seminar series - Killer proteins.

R Dobson (2019). Invited speaker (2019) NZ Cryo-EM symposium (Dunedin) - On the gene regulation of bacterial sialic acid metabolism.

AM Poole (2019). Keynote speaker, Albany Senior High School Impact Project Conference (28 Nov 2019).

M Reis, S Pawson, V Nock (2019). Miniaturized assay on biofuntionalized surface for selective detection of a single volatile organic compound. Sevilla, Spain: SEB Annual Meeting, 2-5 Jul 2019.

L Orcheston-Findlay, A Hashemi, A Garrill, V Nock (2019). Oxygen control and measurement to incorporate drug resistant regions into the cancer model. Wellington, New Zealand: 9th International Conference on Advanced Materials and Nanotechnology (AMN9), 10 Feb 2019.

AM Poole (2019). Plenary speaker, Te Pae Matihiko – Digital Horizon Forum, Ngā Pae o te Māramatanga, New Zealand's Māori Centre of Research Excellence (6-7 November 2019), Auckland, New Zealand.

AM Poole (2019). Probing the early paths of life with experimental evolution. AbSciCon Meeting, Seattle, USA (24-28 June 2019).

M Reis, S Pawson, V Nock (2019). Protein Functionalization on Atomically Flat Gold for Electrochemical Impedance Spectroscopy Sensing. Wellington, New Zealand: 9th International Conference on Advanced Materials and Nanotechnology (AMN9), 10 Feb 2019.

C Meffan, N Cheradame, M Sellier, E Calius, V Nock (2019). Spatially-resolved 3ω thermal flow sensing for microfluidics and biology. Berlin, Germany: 20th International Conference on Solid-State Sensors, Actuators and Microsystems, 23-27 Jun 2019.

R Soffe, M Bernach, M Remus-Emsermann, V Nock (2019). The Art behind an Artificial Leaf-on-a-Chip. Wollongon, Australia: 10th Australia and New Zealand Nano and Microfluidics Symposium (ANZNMF), 1-3 Jul 2019.

A Tayagui, Y Sun, V Nock, A Garrill (2019). The use of Lab-on-a-Chip devices to study the invasive growth of oomycetes. Oban, Scotland: 20th Oomycete Molecular Genetics Network Annual Meeting, 10-12 Jul 2019.

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N Erfani, C Fee, MJ Watson (2019). Topology Optimization of Monolithic Catalyst Support in Steam Methane Reformer Using Genetic Algorithm. Chemeca 2019, 29 September – 2 October, Sydney.

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Y Sun, A Tayagui, H Shearer, A Garrill, V Nock (2018). A microfluidic platform with integrated sensing pillars For protrusive force measurements in neurospora crassa. Belfast, UK: The 31st IEEE International Conference on Micro Electro Mechanical Systems (MEMS 2018), 21-25 Jan 2018.

A Yulia, A Kara, P Wallroth, J Gerrard, D Williams (2018). Cancer and pregnancy: National and a tertiary unit experience. BJOG-AN INTERNATIONAL JOURNAL OF OBSTETRICS AND GYNAECOLOGY 125, 83-83.

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N Yang, A Scott, M Watson (2018). Investigation of the solubility of olivine for use in carbon dioxide storage. Queenstown, New Zealand: 47th Chemeca Conference (Chemeca 2018, 243), 30 Sep-3 Oct 2018.

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R Soffe, VM Nock (2018). Leaf-on-a-chip: artificial or art? Auckland, New Zealand: Australia and New Zealand Nano and Microfluidics 2018, 27-29 Jun 2018.

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