Riddet Institute

KŌKIRI - TE HĀ O TE KAI

A NEW ZEALAND CENTRE OF RESEARCH EXCELLENCE HOSTED BY MASSEY UNIVERSITY

FOCUS

ANNUAL REPORT

1 JANUARY - 31 DECEMBER 2022

OUR CORE VALUES

The Riddet Institute operates under a set of core values:

Strive for excellence in all activities and endeavours.

Operate ethically and with integrity.

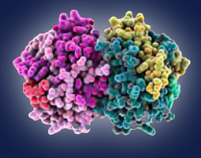
Be collaborative and inclusive, sharing knowledge and resources for mutual benefit.

Be committed to its responsibilities under Te Tiriti.

Embrace equity and diversity, and support inclusion.

Pursue research and training that supports both commercial and public good outcomes.

Create an enduring global network of scientists to facilitate knowledge transfer across disciplinary boundaries.



COVER IMAGE: Chymotrypsin digestive enzyme, molecular model. Chymotrypsin is a protease, an enzyme that breaks down proteins and peptides. It is secreted into the duodenum (small intestine) by the pancreas.

OUR VISION

The Riddet Institute will generate the future knowledge and skills that are required to help address the unprecedented challenges and disruptions facing the food sector in a rapidly changing world.

It will be the world's top institute in discovery-led research at the frontier of food materials science, nutrition and health, and will develop high calibre human capital to ensure rapid innovation, a vibrant food sector and long-lasting socioeconomic benefits for New Zealand.

CONTENTS

This report summarises the achievements and outputs of The Riddet Institute Centre of Research Excellence for the period 1 January 2022 to 31 December 2022

Te Kunenga ki Pūrehuroa Massey University

agresearch

Plant & Food Research

The University of Auckland New Zealand

University of Otago

Riddet Institute
Advancing Frontiers in Food Science

Riddet Institute
Kōkiri - Te Hā o te Kai

Sad passing of 2022 Board Chair Professor Stuart McCutcheon

The Riddet Institute's staff and students were extremely shocked and saddened by Riddet Institute Board Chair Professor Stuart McCutcheon's unexpected death in January 2023.

Prof McCutcheon was appointed as the Chair of the Riddet Institute Board in 2021 and was an enthusiastic supporter of the Institute. He was a visionary leader, and we were truly fortunate to have appointed him in this role. Prof McCutcheon was very well known in New Zealand having held senior academic positions for many years, including Assistant Vice Chancellor Research at Massey University and Vice Chancellor of both Victoria University of Wellington and the University of Auckland.

Having attended our Riddet Institute Conference and Student Colloquium in Napier in November, both staff and students found him approachable and interested in people and their research. An engaging and perceptive person, his ability to connect with people at all levels was truly inspirational.

We thoroughly enjoyed working with Prof McCutcheon for his positive outlook, friendly manner, and great humour – he has been sorely missed.

CHAIR'S REPORT

Tēnā koutou katoa,

I am delighted to share this report as the acting Chair of the Riddet Institute Board.

I would first like to start by acknowledging Stuart McCutcheon, the Riddet Institute Chair who tragically passed away in January. Stuart's passing was felt by many of us but his legacy lives on in his family and the great many people he touched in his long and distinguished career.

While it feels like most of the global pandemic is behind us, we are still living with its shadow. There are ongoing health concerns globally, people are still hesitant to travel and to relocate to countries far away from family. This, combined with global economic uncertainty impacting the accessibility and affordability of food, further reinforces the relevance of institutes like the Riddet Institute.

One thing that hasn't changed is people's desire for new, nutritious, and safe food, something always front of mind at the Riddet Institute.

We have established a new Scientific Advisory Panel, chaired by Prof Alastair Robertson (Australia) with Prof Tracey McIntosh (Ngāi Tūhoe, Aotearoa New Zealand), Prof José Miguel Aguilera (Chile), Prof Manny Noakes (Australia), Prof Oded Shoseyov (Israel) and Prof Rickey Yada (Canada).

"While it feels like most of the global pandemic is behind us, we are still living with its shadow."

The SAP will assess the relevance and quality of our work, including from a Māori/indigenous perspective.

It has been great to be able to welcome back visitors, including our Scientific Advisory Panel, to help us continue our collaboration across the globe.

While the last few years have proved challenging to navigate, the Riddet Institute has continued to develop great scientists, great researchers, and great connections globally. I look forward to the future efforts of the Riddet Institute in continuing to drive a healthy and sustainable future.

Ngā mihi,

Mark Piper
Chair (acting) Riddet Institute

DIRECTOR'S REPORT

Tēnā koutou katoa,

I am pleased to bring you this 2022 report about the year's achievements and the progress of our Centre of Research Excellence (CoRE) research projects.

We had a year of highlights and positive progress in all our endeavours, but we also had sadness in January 2023 with the sudden death of our Riddet Institute Board Chair Professor Stuart McCutcheon.

Stuart took up the role of Board Chair at the start of the new CoRE in July 2021. During his 18 months leading the Board, he made an indelible mark. His vision and leadership were incredible, and he is very much missed around the board table.

This report provides a summary of our activities and the highlights from our CoRE programme of research for 2022. The year marked something of a turning point for Covid-19, with many of the difficulties brought about by the pandemic starting to ease. It was great to see some elements of our former routine return, such as taking up opportunities to attend international conferences in person and rebuilding research and industry networks.

We resumed our schedule of hosting visiting scientists and exchange students in 2022, which provided a sense of seeing the beginnings of a post-pandemic reboot. Still impacted, however, was our recruitment of international students: the challenges of signing up students post-Covid and filling research positions are still on-going.

Despite Covid-related disruptions, the Riddet Institute continues to perform exceptional research, and the world is taking notice.

Our investigators and researchers are invited to speak at international conferences, our scientists are sought out by news media, our students and staff win awards, and our work is published in the best academic journals.

The global impact of our innovative research continues to provide pleasing results, in particular the continued success of Ferri-Pro™, our novel iron supplementation technology.

The international Nestle product BUNYAD IRON+ using the technology launched in 2022 and is now having real impact on the nutritional outcomes of vulnerable populations around the world. Also pleasing was seeing Riddet Institute's contributions to the creation of two new start-up companies, Miruku and Opo Bio, both at the frontier of food science.

I would like to thank all our Riddet family for their efforts over 2022 and the Board members and the Science Advisory Panel as we work together to shape the future of food. I look forward to continuing our progress in building new knowledge for the benefit of future generations.

"Despite Covid-related disruptions, the Riddet Institute continues to perform exceptional research, and the world is taking notice."

Harjinder Singh
PhD, FRSNZ, FIAFoST, FIFT, FNZIFST
Distinguished Professor
Director, Riddet Institute

HIGHLIGHTS

JANUARY → DECEMBER 2022

→ RIDDET INSTITUTE MARIE CURIE SCHOLAR COMPLETES FELLOWSHIP

A Senior Research Officer for the Riddet Institute, **Dr Alejandra Acevedo-Fani** returns from a two-year Marie Skłodowska-Curie Individual Fellowship at the Iberian Nanotechnology Laboratory (INL) in Braga, Portugal. She was awarded the Fellowship from the EU Horizon 2020 research programme to work on a project using nanotechnology and 3D printing to enhance nutrition and flavour for foods tailored to seniors.

→ RESEARCH FUNDING TOPS $8 MILLION

$8.2 million in aligned research co-funding received in 2022 including $2.6 million in funding from domestic and international industry.

→ RIDDET INSTITUTE MAKES HEADLINES

High news coverage of research activities, with staff in demand for interviews for radio and print media.

→ ADVANCE LEADS TO NEW PRODUCT

The Kiwiso CoQ10 Ultra Radiance Serum cosmetic product, based on a nano-emulsion containing co-enzyme Q10 developed at the Riddet Institute, is launched by Alpha.

→ LAB GROWN FOOD CAPABILITY CULTIVATED

AgResearch and Riddet Institute join forces to create new cellular agriculture post.

HIGHLIGHTS

JANUARY → DECEMBER 2022

→ MILK RESEARCH WINS AWARD

Dr Debashree Roy awarded 2nd place in international Pieter Walstra Award 2022 based on her PhD thesis on the digestion behaviour of milks of different species.

The award is given by the Dutch Dairy Organization (NZO) in tribute to Prof Pieter Walstra for his contributions and advances to the dairy industry.

→ DAIRY SECTOR MIXES AND MEETS

Annual Dairy Industry Workshop held in Palmerston North, 17-18 August 2022: co-hosted by the Riddet Institute and AgResearch with delegates from the dairy sector attending.

Pictured, from left, session one speakers: **Ao Chen, Siqi Li, TA Mungure, Warren McNabb, Natalie Ahlborn** and **Amber Milan.**

→ HIGH-TECH IRON SUPPLEMENT WINS ACCOLADES

Ferri-Pro™ is a patented technology that allows iron fortification in food without adversely affecting taste and product quality that was developed by Massey University-based researchers at the Riddet Institute. Ferri-Pro™ had three milestones in 2022.

- → Launched by Nestlé in Pakistan, under the brand name BUNYAD IRON+.
- → Massey Ventures Limited awarded "Best Licensing Deal" at the 2022 KCA Australasian Research Commercialisation Awards held in Melbourne, September 2022.
- → Nestlé awarded the Innovation in Research & Development – Consumer Nutrition Award at the International Dairy Federation (IDF) World Dairy Summit, India, September 2022. Pictured is the Nestle team accepting the award.

HIGHLIGHTS

JANUARY → DECEMBER 2022

→ TOP SCIENTISTS RECRUITED TO ADVISORY PANEL

Scientific Advisory Panel appointed. Pictured, from left: **Oded Shoseyov, José Miguel Aguilera, Alistair Robertson, Tracey McIntosh, Rickey Yada** and **Manny Noakes.**

→ DIRECTOR APPOINTED AS JOURNAL EDITOR

Dist. Prof Harjinder Singh appointed by American Oil Chemists Society (USA) as Inaugural Editor in Chief for their new open access journal Sustainable Food Proteins in partnership with Wiley publishing company.

→ STAFF ARE CREAM OF THE CROP

Dr Debashree Roy (Postdoctoral Fellow) and **Dr Nick Smith** (Research Officer) were both awarded places in the inaugural International Dairy Federation (IDF) Professor Pavel Jelen Early Career Scientist Prize 2022:

2nd place: **Debashree Roy** (Composition, structure, and dynamic digestion behaviour of milk from different species);

3rd place: **Nick Smith** (Understanding dairy's contribution to a sustainable food system).

→ PACIFIC SCHOLAR WINS STUDENT PRESENTATION

Riddet Institute's **Salanieta Naliva**, pictured, wins the three-minute poster competition at her first Riddet Institute Conference and Student Colloquium.

→ SOCIAL MEDIA FOLLOWERS GROW

The institute exceeded 3000 followers on the Riddet Institute LinkedIn page.

HIGHLIGHTS

JANUARY → DECEMBER 2022

→ BUSINESS LAUNCHED FROM CELL LINE DISCOVERIES

Start-up company Opo Bio Aotearoa Ltd is launched by **Dr Laura Domigan** (pictured second from right), **Dr Olivia Ogilvie** (pictured third from left) and others to exploit their intellectual property in cultivation of cell lines from disease-free non-GM New Zealand livestock.

→ ACADEMIC PUBLISHING TALLY IMPRESSIVE

176 articles were published in international scientific journals in 2022.

77% of these articles were published in the top quartile of journals.

→ TEAM ATTENDS FOOD CONFERENCE

The Riddet Institute team attend Foodomics in Auckland in September where Simone Frame, third from right, wins best poster via people's choice vote. From left, **Natalie Ahlborn, Jacqueline Tonkie, Vitor Geniselli Da Silva, Anubhavi Singh, Alex Kanon, Simone Frame, Asher Brook,** and Melanie Ruffell.

→ ANNUAL CONFERENCE HELD IN NAPIER

Students come together for Riddet Institute's annual Conference and Student Colloquium in Napier in November.

Pictured from left, **Faith Bernadette Descallar, Laia Ferreres Serafini, Mariero Gawat, Linda Nezbedova** and **Marit van der Zeijden.**

STRATEGIC IMPACTS

JANUARY - DECEMBER 2022

1 Global science excellence: Aotearoa New Zealand is recognised for its world-class expertise in food science and related disciplines.

176 journal articles published.

77% of articles published in top quartile of journals.

1 Pacific scholarship awarded.

4 Overseas interns/PhD students.

Planning started for Food Structures, Digestion and Health International Conference 2023 to be held in Queenstown, New Zealand.

2 Visiting Scientists.

5.6 Mean number of authors on journal articles.

53% Percentage of PhD students with multi-partner supervisors.

2 Capability building: A world-leading, innovative and sustainable food sector in Aotearoa New Zealand.

22 postgraduate students commenced studies.

A total of **70** students will continue their studies in 2023.

17 graduates find employment in prestigious research or academic institutions in New Zealand or overseas, or find employment in New Zealand industry.

26 postgraduate students completed their studies.

12 key industry strategic partners continue to work with the Riddet Institute on world-class research projects.

$1.6m received from NZ industry in 2022.

3 commercialisation projects continue to flourish, notably with Nestlé and the innovative FerriPro™ technology, Alpha Group, and Opo Bio.

3 Industry Leadership: A future-proofed and future-focused food sector in Aotearoa New Zealand that addresses local and global sustainability challenges.

SNi® and the DELTA Model® have continued to receive interest from government, industry, research collaborators and the media for its impact on global food security and sustainability.

Recruited **Dr Hannah McKerchar,** in association with the Office of the Prime Minister's Chief Science Advisor, to produce tools to help scientists contribute to policy setting and regulation.

12 radio or television interviews by Riddet Institute staff or associate investigators.

116 news media articles published featuring Riddet Institute research.

The Riddet Institute contributed to several government strategy documents, in particular the report for New Zealand's Food and Fibre Sector Think Tank Te Puna Whakaaronui's "Well NZ: Alternative Protein 2022 – establishing a fact-base".

3 industry events hosted or co-hosted by Riddet Institute: the Aotearoa Cultured Meat and Seafood Symposium in February, HVN Science of Food Programme Webinar Series, the Annual Institute Dairy Industry Workshop in Palmerston North in August. Several investigators also participated and presented at other industry events throughout the year.

4 Māori partnerships: A stronger indigenous food sector in Aotearoa New Zealand, supporting improved outcomes for Māori.

With our goal to facilitate innovation in Māori food companies, we have continued to extend our reach within the Māori agri-food sector, and to add breadth and depth to our relationships with Māori entities, SMEs, and iwi.

4 new initiatives or partnerships commenced with Māori partners.

The Riddet Institute embarked on a new strategic partnership with East Coast iwi Ngati Porou, with a Memorandum of Understanding with Ngati Porou Holdings signed.

An initiative to help build academic pathways began in a tripartite collaboration with Ngati Porou, the Riddet Institute and Pūhoro STEMM Academy to help provide industry-relevant summer projects with iwi to whom rangatahi have whakapapa.

Discussions also began regarding Riddet Institute support for a Ngati Porou internship programme for rangatahi.

5 Equity and inclusion: The food sector in Aotearoa New Zealand is more inclusive, diverse and equitable, and provides more opportunities for Māori and Pacific People.

60% of our current postgraduate students and emerging scientists, & **51%** of staff overall, are women.

3 Māori postgraduate students.

In 2022 Dr Jane Mullaney was appointed Adjunct Senior Lecturer with Massey University, with a focus on supporting Māori capability building and supervising Māori post-graduate students.

80% of students are international;

New EDI initiatives implemented in 2022: **3** 3 lunch and learn sessions, & **2** cultural check-ins.

1 Pacific PhD student.

6 Informing consumer choice: New nutritional indices of food and nutritional guidelines that provide more informed food choices for consumers.

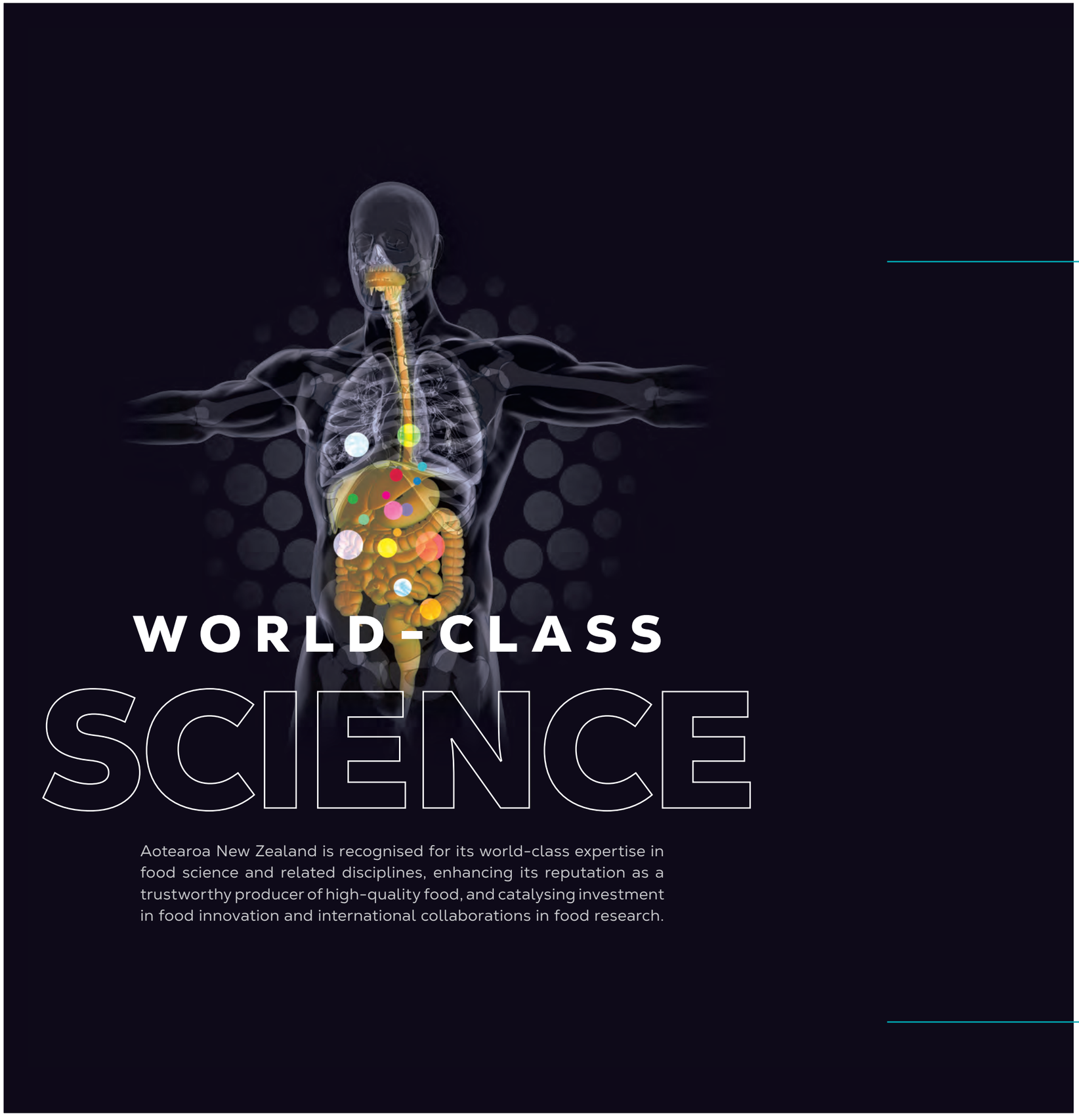
Dr Barbara Burlingame *(Adjunct Professor)* is a member of the High-Level Panel of Experts - Food Security and Nutrition (HLPE-FSN) steering committee. Dr Burlingame was also appointed to a newly formed IUFoST Task Force on food classification systems for diet and health.

Dr Suzanne Hodgkinson *(Associate Investigator)* was invited to participate and present at the Joint FAO/IAEA Technical Meeting on the Development of a Protein Database and the Way Forward for Reviewing Protein Requirements, held in Vienna, Austria, 10-13 October 2022.

Prof Indra Oey and **Dr David Everett** *(Principal Investigators)* were appointed as Fellows of Food Standards Australia New Zealand (FSANZ).

Dist. Prof Paul Moughan was invited to organise and chair a scientific session on Protein Quality and Global Food Security, for the 22nd International Union of Nutritional Sciences (IUNS) Congress of Nutrition, Tokyo, Japan, December 2022.

Assoc. Prof Lisa Te Morenga *(Principal Investigator)* was appointed as Co-Chair of Health Coalition Aotearoa, in September.



WORLD-CLASS SCIENCE

Aotearoa New Zealand is recognised for its world-class expertise in food science and related disciplines, enhancing its reputation as a trustworthy producer of high-quality food, and catalysing investment in food innovation and international collaborations in food research.

Research programme looks to a healthy future for humanity

RESEARCH PLAN FOR NEW CoRE 2021 - 2024

The Riddet Institute intends to generate the future knowledge and skills required to help address the unprecedented challenges and disruptions facing the food sector in a rapidly changing world. It aims to be the world's top institute in discovery-led research at the frontier of food materials science, nutrition and health, and will develop high calibre human capital to ensure rapid innovation, a vibrant food sector and long-lasting socioeconomic benefits for New Zealand.

The food sector is undergoing a significant transformation, with the need for more food, healthier food, less food wastage, and sustainable low emission, resource-efficient production. This constitutes a complex challenge, providing both opportunities and risks for New Zealand's food-export-led economy.

The Riddet Institute's contribution to this challenge is well recognised – it is internationally regarded as a leading centre of research and scholarship at the interface of food science and nutrition. It has undertaken ground-breaking, discovery-based research into the science of food structures and their complex interactions with nutrient absorption, metabolism, and human health and wellbeing. It is an innovation engine for the New Zealand food industry.

The next generation of food products will need to address not only nutrition and health, but also the most pressing environmental and ethical issues of our time.

Foods need to become more sustainable: environmentally, nutritionally, socially, and economically. This will require the introduction of new materials in the food chain, as well as the creation of foods that appeal to consumers and deliver their nutritional needs with less wastage. This could include novel crops, animal protein replacers, marine plants, and food materials from bioreactors.

The Riddet Institute CoRE research programme comprises three interlinked research themes and two overarching supporting elements. Each theme has several tightly connected projects that will generate new knowledge in defined areas. Investigators will work across themes and projects to collectively contribute to the overall vision of: "Future Foods in Harmony with Nature".

The vision of the new Riddet Institute Centre of Research Excellence (CoRE) research programme is:

Future Foods in Harmony with Nature:

This vision provides fundamental science to support tomorrow's innovations in advanced foods. These foods will be sustainable, support optimal nutrition, human health and wellbeing, and appeal to the preferences of tomorrow's global consumers.

THEMES

01: THEME

FOOD STRUCTURE DESIGN AND NUTRIENT DELIVERY

THEME OVERVIEW / This research theme addresses one of the most important scientific challenges for optimising the nutritional value of sustainable foods by unpacking what happens to the nutrients in food during processing and gastrointestinal digestion. Crucially, this theme will integrate advanced computational and mathematical modelling, human clinical studies and microbiome science with food structure and digestion science to provide advanced knowledge. This research theme will completely transform current food design processes and food dietary guidelines, and ultimately give rise to a range of high value healthy foods. There are five research projects under this theme.

02: THEME

SUSTAINABLE FUTURE PROTEINS

THEME OVERVIEW / This research theme addresses the challenges of transitioning from animal proteins to more sustainable plant and other alternative proteins, driven by consumer perceptions around nutrition, health, animal welfare and the sustainability of food production. This transition can take place either by turning plant proteins into food products that mimic animal product functionality and nutritional quality or by consuming foods that contain some animal protein but proportionately more plant protein. The latter option becomes a sustainable alternative with a lower environmental footprint and it also provides significant opportunities for the New Zealand animal protein industry to become directly involved in the development of new products from diversified protein sources. There are three research projects under this theme.

03: THEME

TRANSFORMATIONAL TECHNOLOGIES

THEME OVERVIEW / The intersections of food, biotechnology, digital technologies and robotics are beginning to disrupt and transform the global food industry. 'Food Tech' is now considered to be the final frontier of disruptive innovation. New and emerging technologies are being harnessed to design new ways to produce and consume food, responding to both consumer trends and an imperative to improve sustainability and human health. Many of the innovations are based on the use of synthetic biology and bioengineering approaches to produce animal protein foods in non-traditional ways, leading to the emergence of synthetic, cultured and engineered foods. There are two research projects under this theme.

Future foods in harmony with nature

Pictured is the graphic depiction of the three research projects, with the over arching themes: The Human Dimension, and Complex Systems Science around the outside rings.

To understand and predict the behaviour of food systems, we will adopt an overarching complex systems science approach to our research themes and will embed the human dimension in our research.

01: THEME FOOD STRUCTURE DESIGN AND NUTRIENT DELIVERY

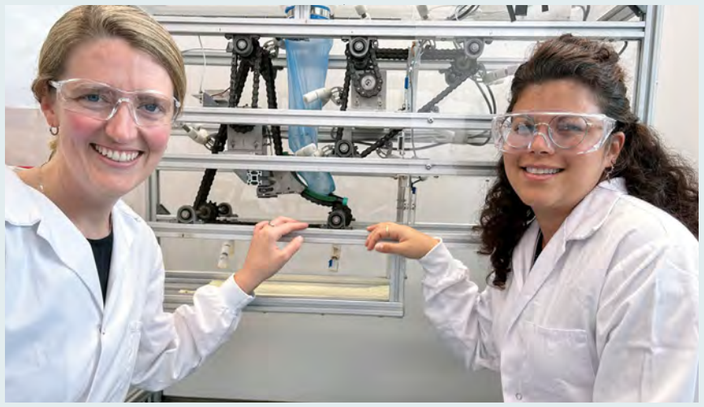
What happens to food when we eat?

In the 'Food structure modification in the digestive tract' project under research Theme 01, a team of scientists, including Professor Gail Bornhorst (UC Davis, USA), Dr Alejandra Acevedo-Fani (Massey University) and Dr Carlos Montoya (AgResearch) has been examining the modification and breakdown of foods in the stomach.

Prof Bornhorst says the science of food nutrient delivery might mean people can look at their genetic profile, age, and health status and learn what they should be eating for optimum health. But to get to that future point of 'Personalised Nutrition' we need to understand how foods break down during digestion and what affects the uptake of nutrients.

As part of the project, the team has been researching the breakdown of solid food carbohydrates such as rice and pasta, including *in vitro* experiments in a human gastric simulator. The gastric simulator includes physiologically relevant stomach acid secretions and enzymatic secretions, as well as peristaltic movements of the stomach wall.

The researchers examined six different carbohydrate foods, tailoring acid secretions to replicate real life digestion processes. The cooked starch-rich foods were three wheat-based foods (semolina porridge, couscous and pasta) and three rice-based foods (rice couscous, cooked rice, and Thai rice noodles). The breakdown of those six different structures were all different, which in turn impacted glycaemic response and digestibility.



Prof Gail Bornhorst, left, and Dr Alejandra Acevedo-Fani with one of the Riddet Institute's human gastric simulators in the lab.

On a related project, Dr Acevedo-Fani and her team are exploring how liquid foods can restructure in the stomach environment due to acid and enzymatic conditions, using the adult and infant gastric simulators. Emulsion-based foods were shown to undergo dramatic changes in structure and physical properties in the stomach, which consequently affected the rate of nutrient absorption.

Further work is planned to validate these results in human MRI studies, in collaboration with the University of Newcastle, Australia.

Much of the previous research on the interplay of digestion and food structure has focused on simple food components such as milk, or various protein foods, or basic carbohydrate foods. The next step will be a 'combined foods' approach. Dr Acevedo-Fani is working with Prof Bornhorst on this approach, where the team will expand the simple systems and put them together, moving to a mixed meal where something like a portion of rice, chicken, and a spinach salad with a bioactive compound like turmeric in a salad dressing, for instance, will be put together.

"We want to be able to understand what is going to happen when we actually eat these foods together," says Prof Bornhorst.

She says while this approach will be much more difficult than investigating individual food components due to the complex interactions and effects on physiological responses, it will bring us a step closer to producing foods with targeted nutrition and health outcomes.

THEME 01: FOOD STRUCTURE DESIGN AND NUTRIENT DELIVERY

Pioneering simulator will feed knowledge of human digestion

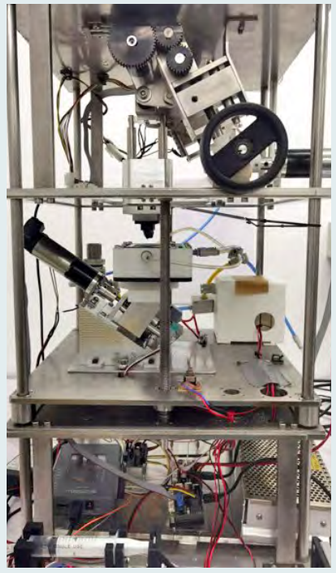
A cornerstone of the Riddet Institute research programme is designing and building a physical model to simulate the human gastrointestinal system and the digestion of food. The development of this model looks ahead to a future that will reduce the need for human or animal trials in nutritional studies of food bioavailability and nutrient release.

The complex human digestive system is made up of several diverse components, all with essential roles: the mouth for chewing and swallowing, the oesophagus for transporting chewed food and liquid to the stomach, and the specialised back-to-back digestive duties of the stomach and large and small intestines for extracting nutrients from food.

The Human Digestome project, under Theme 01, pulls together expertise from medical imaging, mechatronics, robotics, computational modelling, and nutrition science, with leaders in these fields across the Institute working together toward the combined goal of a complete system simulating the human digestive tract.

The ambitious task of simulating each component is well underway, and has involved extensive research, design, and engineering work, with multiple concurrent projects.

Chewing and swallowing robots have been built at the University of Auckland by Professor Peter Xu and his robotics team, in conjunction with Professor John Bronlund and Massey University mechatronics engineers. First, a Biomimetic Robot was built to simulate chewing, with molar-like chewing trajectories, a soft oral cavity and adjustable chewing frequency, molar angles and saliva flow rates. This robot, designed by Dr Bangxiang Chen in Auckland, has real time chewing force sensors and can prepare food bolus for food science research and measure texture properties of food. This robot has been put to work evaluating the release rate of controlled-release medicinal tablets when chewed and dissolved in the mouth.



The Biomimetic Chewing Robot and its "teeth".

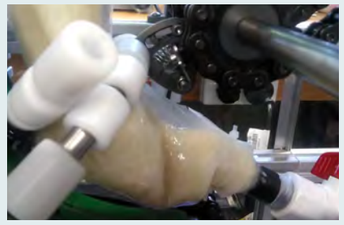
The latest, multi-chamber chewing robot has been developed by PhD candidate Xudong Wang in 2022.

This Chewing Robot is inspired by the workings of an internal combustion engine and uses crankshafts to employ a trio of oral chambers, allowing for three parallel experiments from one motor. Food can be repositioned, much like when a human chews food. This robot chews by means of two spring-loaded plates that open when molars close together, returning thereafter to their initial positions, with the Teflon-coated plates allowing food and the chewed bolus to move back and forth.

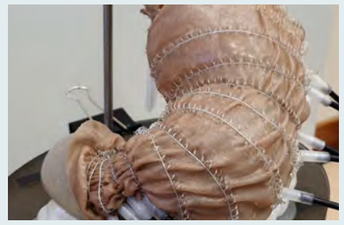
A lot of activity in the wider project has gone into finding ways to simulate the stomach. Key to simulating the gastric system is effectively mimicking the substantial muscular compressions the human stomach undertakes in mixing and moving food through the gastrointestinal tract by contracting and relaxing muscles in a linear sequence. Various methods have been contrived to replicate this gastric motility, using symmetric and asymmetric compressions, controllable ring actuators or a series of rollers, and mechanical or pneumatic controls. The stomach itself has been formed from sleeves made of various materials.

The team has also employed medical diagnostic technologies such as Magnetic Resonance Imaging (MRI) to observe the workings of the human stomach and to quantify the properties of gastric motility in live individuals. These images have recorded flow patterns of food within the stomach and captured contraction measurements. This MRI data has also been used to check the accuracy of the simulators, or to derive the measurements that drive them. Several human gastric simulators are already being used in the Institute's research projects to investigate the breakdown and modification of food in the stomach. A second-generation mechanical gastric simulator in use is the latest iteration of this technology and employs a J-shaped, curved, soft-walled chamber to mimic the human stomach, with a series of mechanical rollers manipulating the chamber's gastric contractions.

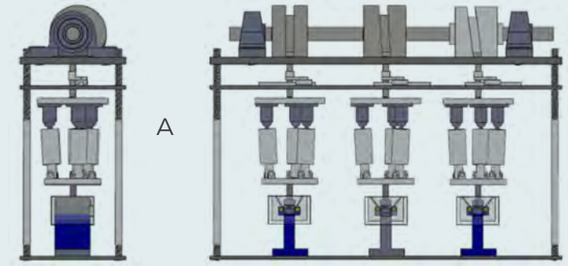
A prototype computer controlled gastrointestinal simulator.



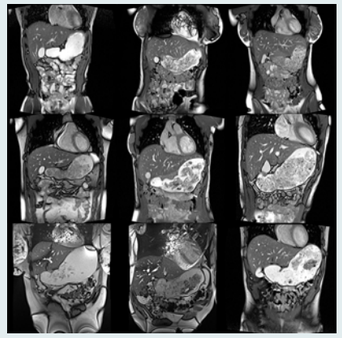
Mechanical rollers manipulate the soft-walled 'stomach' to digest couscous.



A new design currently in development features nylon coils and thin flexible cables to function as the muscles in a "stomach" made of elastic nylon fabric fused with silicone.



The multi-chamber Chewing Robot has three chambers that can run in unison.



MRI captures flow patterns in human digestion.

Other models in prototype stage employ pneumatic systems or controllable actuators to replicate the formidable muscular contractions that a human stomach employs in the digestion of food.

A new computer-controlled version being developed by Dr Gerald Olson is currently in the design phase. This innovative gastrointestinal simulator uses nylon coils and thin flexible cables to function as the muscles in a "stomach" made of elastic nylon fabric fused with silicone. The coils are worked by pulleys attached to motors that sit in the housing below and controlled by computer to replicate gastric motility compressions in line with the MRI contraction patterns recorded from the earlier study. Including an oesophagus section, this pliable stomach nests within mouldings of other internal organs that can be filled with water to control the temperature of the experiment or maintain the model at normal body temperature.

The next step is to integrate an intestinal model. Work has commenced on the design of this machine, and it is currently being built. The intestinal simulator section works on a pneumatic system with a semi-permeable membrane. Projects to simulate the work of the duodenum section of the small intestine are also underway. Research Fellow Nadun Palmada and Professor Leo Cheng have developed a computational modelling technique to simulate fluid flows in the duodenum and then validated these results using Dr Palmada's mechanical benchtop model. Aligned research projects are also using *in vitro* techniques to model another important aspect of digestion: the fermentation of food that occurs in the large intestine.

In the future the gastric simulators and intestinal models will be used in conjunction with the chewing and swallowing machines for an extended human digestive system and a whole-system approach to food studies.

THEME 01: FOOD STRUCTURE DESIGN AND NUTRIENT DELIVERY

Global project on protein nutrition now supplying useful data

Combinatorial proteins. A global project analysing sources of protein will create more accurate data and help feed vulnerable populations.

The Riddet Institute's protein characterisation work continued through 2022, with the major internationally funded Proteos Project now drawing to a close.

Proteos is a collaborative project undertaken by the Riddet Institute, the University of Illinois, Wageningen University, and AgroParisTech. The collaboration means research methods can be assessed in different laboratories around the world ensuring consistency and validity to results. The project is led by Distinguished Professor Paul Moughan and the scientific work coordinated by Dr Suzanne Hodgkinson of Riddet. The work, funded by global food sectors and with funding coordinated by the Global Dairy Platform, Chicago, aims to determine amino acid availability for all foods commonly consumed globally and to thus provide a repository of data to describe the protein quality of human dietary patterns.

The data generated by Proteos and other published data are now being collated by the Riddet Institute scientists. Already the data have been used in published studies in both India and China to assess the complementary effects on dietary protein quality of different mixtures of food proteins. Work in China has also investigated improving the protein quality of infant formulas by careful readjustment of constituent proteins, to better mimic breast milk composition.

Early in October, Dr Hodgkinson spoke at a technical meeting organised by the United Nations FAO and IAEA in Vienna on the current human nutritional guidelines on protein requirements and the work thus far towards turning new findings about the protein quality of different foods into the public database.

Another recent highlight for the group was an invitation extended to Dist. Prof Moughan to advise the Bill and Melinda Gates Foundation in London on approaches to determining amino acid availability, and the application of Linear Programming modelling to achieve targeted amino acid balances in food supplements to be used for maternal nutrition in developing countries.

Combination proteins on the way

Dr Arup Nag
Affiliated Researcher

Dr Sylvia Chungchunlam
Affiliated Researcher

Dr Lirong Cheng
Affiliated Researcher

Another project working on combining proteins is also entering exciting new stages.

The combinatorial protein project is about finding ways to combine multiple sources of proteins to deliver optimum nutrition, sensory experience and functionality.

Affiliated researchers Dr Arup Nag and Dr Lirong Cheng have carried out extensive physio-chemical characterisation studies of individual protein sources and are now in the process of combining them in the most optimised form. This is done by using an innovative algorithm developed in-house at the Riddet Institute by Dr Sylvia Chungchunlam.

Food design project looks at the assembly of lipids and proteins

Under Theme 01, the Fundamentals of Food Structures project is about working out the processes of food structure assembly, and how this assembly relates to food properties and performance. Ultimately, the goal is the design and development of enhanced and sustainable food materials.

Work continues on manipulating the assembly of plant proteins through molecular modifications to optimise protein functionality, by the team made up of Dr David Everett, Professor Matt Golding and Professor Geoff Jameson. Specifically, this project seeks to investigate how chemical or biochemical transformations of targeted amino acid side chains can modify native protein structure, and accordingly, the related aspects of technological function. In this regard, the project aims to explore the effects of phosphorylation of serine amino acids, seeking to develop reaction pathways that can control yield of conversion within the protein molecule. It is hypothesised that phosphorylation can enhance protein solubility, improve surface active properties, and enable design of macroscopic structure via molecular interactions. To this end, the development of a phosphorylation synthesis pathway has been established with trials using hemp protein as an example.

Research has also commenced on examining the formation of lipid structures containing phytosterols as replacements for cholesterol in milk products. The team is investigating how phytosterols and specific phytosterol-phospholipid interactions affect milk fat globule and liposome membrane fluidity in a pre-digested intact form, and after the imposition *in vitro* digestive conditions. This will have implications for lipid digestion and uptake of lipids into the circulatory system.

Uncovering objective biomarkers for assessing dietary intakes

Aysu Shahin
PhD student

This project aims to generate an objective method of measuring dietary intake using analysis of human tissue (blood and urine). Dietary intakes will be reflected using a novel 'all-in-one' mass spectrometry method to measure a panel of known metabolites.

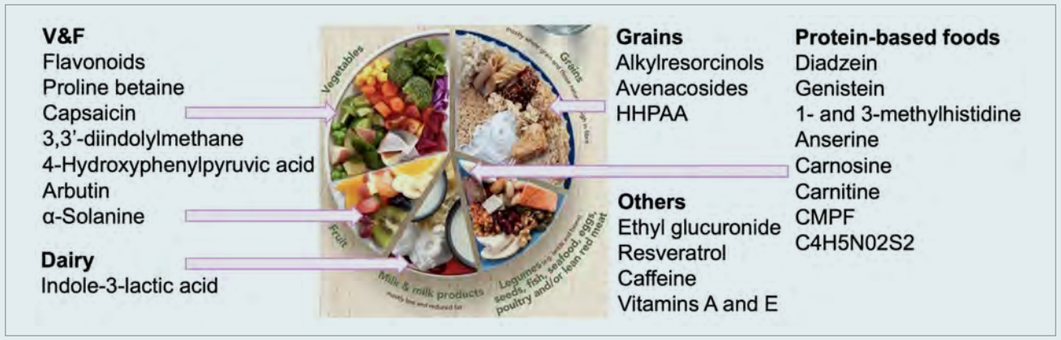
Fundamental to human health is what we eat. Reliable nutritional assessment, both at the individual and population level, is key for understanding diet-health interactions.

Under Theme 01, Riddet Institute scientists Professor Jim Mann, Dr Andrew Reynolds, and PhD student Aysu Shahin are setting out to challenge the biggest criticism of nutritional epidemiology: that it relies on self-reporting methods of data collection. Most of what we know about what people eat depends on self-reporting, which is prone to a range of bias that differ over the lifespan. With food being the number one modifiable factor in health improvement, dietary change is necessary on a large scale to support healthier and longer lives. Reliable nutritional assessment, both at the individual and population-level, is key to understanding diet-health interactions.

Preliminary results of a small trial show correlations between the change of food groups from baseline (a standard day of eating) to intervention (a day of monitored food provision) and the change of each metabolite from baseline to intervention.

Metabolite markers of dietary intake in whole blood and urine were measured via liquid chromatography LC-qToFMS and semi-quantified with known standards at AgResearch, Lincoln.

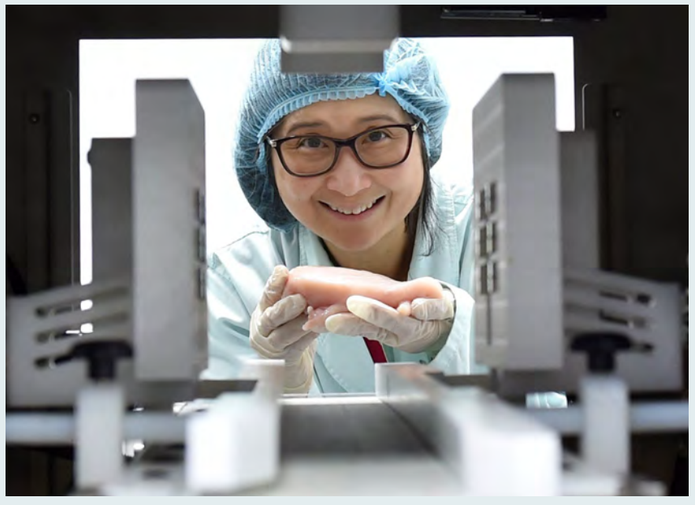
While still in the early stages, this project has the potential to provide clinicians and researchers with more reliable methods of assessing dietary intakes than the current self-reported method while also reducing participant burden. This research serves as a fundamental step in confronting a complex challenge. It is the promising start of a long and important journey to build a bigger picture that will enable the improvement of health communication, potentially benefiting the population as a whole.



Above are the metabolite markers that this project measures in the trials.

THEME 02: SUSTAINABLE FUTURE PROTEINS

Pioneering study uses pulsed electric fields to make legumes better to eat



University of Otago food scientist Professor Indrawati Oey with the world's first pulsed electric field (PEF) machine. Photo: Otago Daily Times.

How important is the texture of beans in your daily food consumption experience? Do you prefer soft, hard, or chewy cooked beans? Undercooked beans can be difficult to chew and may not effectively inactivate undesirable antinutrients, thus affecting protein digestibility. Overcooked beans, on the other hand, may become too soft and unpleasant to chew.

Under Riddet programme Theme 2.1., Professor Indrawati Oey, Dr Leong Sze Ying and postgraduate student Marbie Alpos from the Department of Food Science, at the University of Otago, investigated how green technology such as pulsed electric field (PEF) can be used to manipulate the texture of beans during cooking. The research found the beans were not only more appealing to chew, but the protein from them more accessible to the human body.

In the study 22 human participants were recruited to chew (*in vivo* mastication) cooked black beans that had been pre-treated using PEF in the presence of calcium chloride ($CaCl_2$). Interestingly, the chewiness of beans was improved by using PEF treatment in calcium solution prior to long cooking at high temperature, with texture softening/degradation eliminated. But it did not make the cooked beans too hard to chew; the beans could be readily masticated to achieve a bolus for swallowing.

The oral bolus from the masticated cooked black beans were collected from each participant at differing time frames and high-resolution images captured. The images were used to calculate the particle size distribution, showing the outer seed coat of the cooked black beans with PEF pre-treatment could be broken down to smaller and more consistent particles after chewing than cooked beans without PEF pre-treatment.

The next step following mastication was putting the collected oral bolus into a 6-hour long simulated gastrointestinal environment (*in vitro* digestion) to estimate the rate of starch and protein digestibility. Overall, the results revealed that the processing conditions involving the PEF and addition of $CaCl_2$ of black beans appeared to significantly ($p < 0.05$) enhance the *in vitro* digestibility of protein (by two-fold compared to untreated samples) without stimulating a considerable increase in the starch digestibility. These findings clearly demonstrated that the chewy texture of cooked black beans created through PEF treatment, combined with masticatory action, had the potential to modulate a faster hydrolysis of protein during gastrointestinal digestion. This offers a new way to upgrade the quality of legume protein intake in the daily diet.

The use of *in vivo* mastication with human participants, followed by *in vitro* digestion, to explore the effects of cooking processes and green technologies on the texture and digestibility of black beans is a pioneering study that has not yet been conducted elsewhere. Prof Oey and her team anticipate that this innovative approach could be applied to other different food matrices in the future.

Importance of texture in food often overlooked

A project under Theme 02 takes a consumer-led approach to understand consumer engagement with foods of the future.

The Future Foods and Consumer Engagement project has started to examine the hurdles to consumer acceptance of future foods, and is endeavoring to understand, quantify and measure key elements of sensory appeal in these novel products. But taste and flavour are not the whole story. Texture is also key but is difficult for consumers to communicate.

Spearheaded by project leader Professor Joanne Hort, together with Dr Sara Jaeger (Plant & Food Research) and Dr Amanda Dupas (FEAST), work on understanding consumer response to a wide range of plant-based milk alternatives has begun, uncovering the role of texture and mouthfeel on acceptance. This aspect works on the basis that people are unlikely to consume food products if they do not enjoy eating them or drinking them, even if they perceive the nutritional benefits or environmental advantages of doing so.

The Food Experience and Sensory Testing (Feast) lab's digital immersive space.

Improved methodologies to understand the evolving consumer relationship with the sensory characteristics of future foods, are also being developed. Key among these is the Food Experience and Sensory Testing (FEAST) lab's digital immersive space, where the research can occur in a more realistic setting.

THEME 03: TRANSFORMATIONAL TECHNOLOGIES

Hamish Trlin
PhD student

Project looks at allergenic potential of lab-grown meat

A project under Theme 03 aims to define patterns of allergen expression in cultured mammalian muscle cells. The results of this research will be used to identify the relative allergenic potential of cell-based meat products, compared to traditional meat products.

Cell-based meats are a promising alternative to traditional meats, with the potential to significantly reduce the global impact of meat production. The impact of the culturing process on cultured cells, however, has yet to be thoroughly investigated.

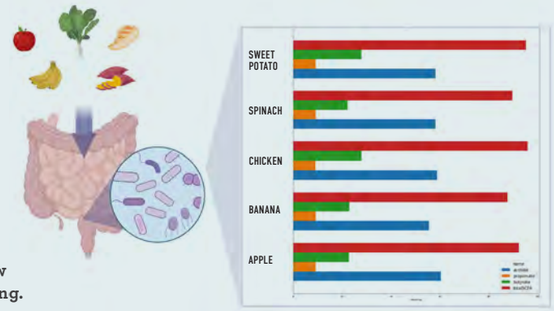
The primary objective of this project is to identify differences in the allergen expression patterns of traditional and cultured meat products. A significant proportion of meat allergies are caused by a hypersensitivity reaction to serum albumins, which are a type of protein produced by the liver and circulated throughout the organism via the bloodstream. As muscle cells do not produce serum albumins, Riddet Institute scientists Professor Renwick Dobson, Dr Olivia Ogilvie, and PhD student Hamish Trlin hypothesise that cell-based meats made with cultured muscle cells will not contain serum albumins. Therefore, cell-based meats should have a lower allergenic potential than traditional muscle tissue. This project aims to verify that serum albumins are absent in cultured cells, while also investigating the expression of other prospective allergenic proteins.

Because cell-based meats can, in theory, be more efficiently and cheaply produced than traditional meats, they have the potential to drastically reduce the footprint of the agriculture sector. In the face of a growing global population, reducing this footprint may be imperative. Before the benefits of cell-based meats can be realised, we must develop our understanding of the impacts of cell culture on food safety. This project aims to begin a dialogue that will improve consumer trust in cultured meat products and improve the general uptake of the technology.

STUDENT DISCOVERIES

VITOR GENISELLI DA SILVA

MICROBIOME-FEEDING FOODS EXPLORED IN PhD



Vitor Geniselli da Silva, based at Massey University, is investigating how food shapes our gut microbiome, and how this can be optimised to promote human health and wellbeing.

Our bodies are colonised by a complex microbiome community which has an influence on our health. An unbalanced gut microbiome affects the host's health, increasing the probability of chronic and psychological disease. Vitor's research explores which foods optimise the colonic microbiome for our lifelong health and wellbeing. He will use *in vitro* digestion, anaerobic fermentation, and mathematical models to understand how different food components affect the community of microorganisms that live in the human gut.

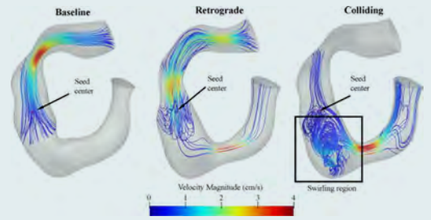
The use of mathematical modelling and lab experiments to mimic how food is digested, and then fermented by gut bacteria has been under-investigated. Using these tools could greatly accelerate understanding of the relationship between food, microbiome and health, leading to better dietary recommendations to improve quality of life.

Vitor has a particular interest in identifying foods to nourish the microbiome of infants during weaning.

STUDENT DISCOVERIES

NADUN PALMADA

COMPUTER MODELLING HELPS UNDERSTAND WORKINGS OF SMALL INTESTINE



The computer models developed within Nadun Palmada's research provide new tools for understanding the mixing and nutrient absorption taking place within the small intestine under both normal and diseased conditions.

Nadun, based at the University of Auckland, developed an anatomically realistic computer model of the first part of the small intestine, the duodenum. This model was used to predict the fluid flow and mixing patterns occurring within the duodenum and to investigate how these patterns are affected by different foods and different physiological states. The results from the computer model were validated with a benchtop duodenal setup.

The experimental benchtop setup was able to replicate the flow patterns found within the duodenum, and a corresponding computer model was also able to generate similar flow patterns. Increasing the strength of muscle contractions, led to better movement and mixing of digested substances. Simulations using thicker liquids resulted in lower levels of mixing compared to water. Colliding wavefronts significantly increase (up to 2.6 times) the amount of intestinal mixing relative to normal wave patterns travelling from the stomach towards the large intestine.

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COURTNEY JOHNSTON

NEW TECHNOLOGY BRINGS OUT THE BEST IN BEANS

Courtney Johnston, based at the University of Otago, investigated the use of pulsed electric field (PEF) technology and germination as pre-treatment processes for faba bean flour, and their effects on the quality, nutritional, and digestion properties of faba bean-enriched wheat bread.

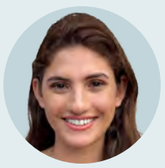
Faba bean is a popular legume in many countries, also known as broad bean, but is currently under-utilised in the food industry. By incorporating it into a staple food such as wheat bread, it may be promoted for consumption in the human diet. Faba bean-enriched wheat bread is a high-protein food that may be appealing to individuals such as health-conscious consumers, athletes, and the elderly with higher protein requirements.

Pre-treatment of faba beans with PEF and then germination improved the nutritional composition and *in vitro* protein digestibility of wheat bread while retaining more of its quality than soaking, germination, or PEF treatment alone.

This is the first study of its kind on the application of a germinated and/or PEF-treated legume flour in a food product formulation. It shows a promising means to improve *in vitro* starch digestibility and *in vitro* protein digestibility and should be considered to promote its use in the food industry.

AYSU SHAHIN

BODY'S RESPONSE TO FOODS USED TO ASSESS DIET



Reliable assessment of what you eat is fundamental to making necessary interventions in the prevention of disease at both an individual and population-wide level. But traditional methods of recording and self-reporting food intake are often inaccurate, biased, or incomplete.

PhD candidate Aysu Shahin from the University of Otago is researching a simple way to keep track of a patient's dietary intake via a blood or urine test. Using a novel 'all-in-one' mass spectrometry method to measure a panel of known metabolites, the research has the potential to provide clinicians and researchers with a panel of objective markers of actual food consumption.

The research involved 24 participants that were randomised into three intervention days with full food provision consumed under observation. Participants collected 24-hour urine samples on each standard and intervention day (six in total) and provided a fasted blood sample the morning after each day. Preliminary results have shown correlations between the change of food groups from baseline (standard day) to intervention (feeding day) and the change of each metabolite from baseline to intervention.

EJOVI ABAFE

PROJECT PUTS NUTRITION FIRST IN LAND-USE DECISION MAKING

If you looked at what land is being used for around the world, would producing food that supplies the necessary nutrition for human populations be top of the list?

PhD student Ejovi Abafe, based at Massey University, is working on understanding the significant inefficiencies that exist within global, regional, and national food systems within the Sustainable Nutrition Initiative (SNi®).

His research focuses on the relationship between the food use of agricultural land and the nutritional status of populations. Multiple factors dictate agricultural land suitability for food crops or livestock production, including climate, soil, and infrastructure. However, the ultimate purpose of food production is to deliver nutrition, which historically has been rarely considered in assessing the aptitude of primary production.

The project uses data science and complex systems modelling to integrate all relevant factors in assessing the suitability of agricultural land use into a computational framework that will allow the nutrition delivered from the land to be calculated. The data will help guide future land policies that are beneficial to global food and nutrition security and support the development of sustainable agricultural practices.

ZHONGHAN (SAM) DUANMU

NEXT-GEN OESOPHAGEAL SIMULATOR MIMICS MUSCLES

To combat the limitations of existing oesophageal simulators, Auckland University PhD student Zhonghan (Sam) Duanmu is investigating a new generation of oesophageal simulator.

The human oesophagus plays a vital role in the human digestive system, facilitating the movement of food and liquid into the stomach for further digestion. Its functioning affects the performance of the digestion process.

To aid further understanding of the swallowing process, the new simulator will be constructed with soft materials to accurately mimic the movements of the oesophagus as it contracts and pushes food from the upper oesophagus to the stomach. These elements mean the new oesophageal simulator will be more biomimetic than previous versions.

According to *in vivo* experiments, food transport is powered by both circular and longitudinal layers of oesophageal muscles. These can be simulated by separated pneumatic actuation systems in the new-gen simulator. A key challenge in the design of the simulator is replicating the wave-like motion of oesophageal peristalsis. The solution has been to employ a proper controller to coordinate two actuation systems.

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IMPACT

Future-proofing the Aotearoa New Zealand food sector:
developing capability, creating, and transferring knowledge
and addressing local and global sustainability challenges.

NATIONAL AND INTERNATIONAL CONFERENCES

The Riddet Institute team attending Foodomics in Auckland, from left, Natalie Ahlborn, Jacqueline Tonkie, Vitor Geniselli Da Silva, Anubhavi Singh, Alex Kanon, Simone Frame, Asher Brook, and Melanie Ruffell.

National and international conferences are an indicator of the Institute's standing in the international research community in its chosen fields. The Riddet Institute had a significance presence at international conferences in 2022, providing keynote and invited presentations as the world geared up again for hosting in-person events after the border closures of the Covid-19 pandemic.

In addition, the Institute was heavily involved in the following events:

Consumer Dimensions of Future Foods Symposium, online, 11-12 May 2022

The 1st Consumer Dimensions of Future Foods Symposium (Theme: Driving Change) was held in a collaboration between Massey University and A*STAR (Singapore) as part of the Future Foods Catalyst research programme Te Rangahau Taha Wheako mō ngā Kai o Āpōpō.

Riddet Institute/AgResearch International Symposium on Structural Nutrition, American Dairy Science Association Annual Meeting, Kansas City, 19-22 June 2022

The Riddet Institute and AgResearch were invited to jointly run a special symposium at the American Dairy Science Association Annual Meeting, Kansas City, on 23 June 2022. Several investigators and researchers presented at this symposium.

The NZ Institute of Food Science & Technology Conference (NZIFST), Rotorua, 5-7 July 2022

The Riddet Institute makes a significant contribution to this annual conference, including keynote speakers, session speakers and a special Riddet Institute session with selected speakers.

High Value Nutrition NSC Foodomics Conference, Auckland 8-9 September 2022

The Riddet Institute and its investigators contribute significantly to the HVN Foodomics Conference.

Food Structures, Digestion and Health (FSDH), Queenstown, 2023

The biennial international FSDH conference was initiated by the Riddet Institute in 2012 and is now held alternately in New Zealand and Australia in collaboration with CSIRO, Australia. Planning for the 7th International Food Structures, Digestion & Health Conference 2023 has started. This will be held in Queenstown, New Zealand, in November 2023 as a face-to-face event.

Dietary Protein for Human Health International Symposium, Utrecht, 2023

A three-day international symposium on Dietary Protein for Human Health, being held in the Netherlands, will cover a broad range of topics concerning the role of protein in human nutrition, health and well-being. The symposium is currently being organised by the Riddet Institute in cooperation with the Food and Agricultural Organisation of the United Nations (FAO), Wageningen University & Research, and the International Atomic Energy Agency (IAEA).

International Hydrocolloids Conference 2024, New Zealand

It was announced in 2022 that Riddet Institute has been selected by the International Hydrocolloids Conference Committee to host the 17th International Hydrocolloids Conference in New Zealand for the first time. This reflects the significant contributions of the Riddet Institute to the field of hydrocolloids over the past three decades.

New resources help scientists bridge policy divide

Riddet Institute researcher Dr Hannah McKerchar has been on a mission to help two worlds connect: **scientists and policy makers.**

Riddet Institute alumna **Dr Hannah McKerchar** has created resources to help scientists better share their research findings with government policy makers.

Riddet Institute investigations are at the forefront of food and nutritional sciences, generating research outputs that contribute to improving human health and reducing the impact of food production on the environment.

Dr McKerchar says Aotearoa New Zealand scientists are a massive resource for the country's policy makers looking to base their policies on directly relevant evidence, but building the links between the two communities is surprisingly difficult. The research world and the policy world are totally different.

Scientists can find it challenging to communicate their findings to the right people – the people in government who are making decisions about policies that affect New Zealanders.

In 2022 Dr McKerchar debuted as an intern in the Office of the Prime Minister's Chief Science Advisor to work on a Riddet Institute-funded project aimed at helping scientists better share their research findings with policy makers.

Over the year she has created a suite of engaging animations and print resources to help scientists prepare briefing documents and foster relationships with those working in policy development.

Dr McKerchar says navigating the complex interface of science and policy is most effective when researchers establish relationships with people working in policy.

"A good way to start is concisely saying 'I'm doing this science, this is what it means, and this is how it's relevant to policy. How can I help?'" Dr McKerchar says.

She has developed a Policy Brief template with animated guide and an animation aimed at young researchers starting their journey that highlights the challenges of connecting with policy.

The resources are designed to help researchers find solutions.

"A good way to start is concisely saying 'I'm doing this science, this is what it means, and this is how it's relevant to policy. How can I help?'"

Other outputs have quickly followed, including a booklet targeted at policy makers that profiles individual researchers and succinctly sets out how their research is relevant to policy.

Riddet Institute affiliated researchers working in nutritional science are leading and contributing to multiple influential bodies that inform policy every day. Impacting Policy is the working title of another booklet that Dr McKerchar has under way that details this contribution, as well as looking ahead to the Riddet Institute's science of the future and how scientists would like to capitalise on this to impact tomorrow's food policies.

The Riddet Institute works with key stakeholders to achieve impact, including its Strategic Industry Partners:

Zespri KIWIFRUIT · Fonterra · ALPHA GROUP · douglasnutrition · goodman fielder · WAKATU · NUKU kite PUKU

Riddet Institute science at the cutting-edge of global innovation

Ferri-Pro™ iron supplementation technology is now being used in an innovative new nutritional product called Bunyard Iron+ marketed by Nestlé.

The game-changing technology Ferri-Pro™ developed at the Riddet Institute continued to attract international acclaim in 2022, recognising its impact on addressing global iron deficiency.

More than 1.6 billion people suffer from iron deficiency anaemia around the world, particularly children and pregnant women. Ferri-Pro™ is a patented technology that allows iron fortification in food without adversely affecting taste and product quality.

The technology was developed at the Riddet Institute and is so spectacular because of its suitability for fortifying dairy products and easier absorption by the body than other comparable iron supplements.

Ferri-Pro™ was licenced to global food giant Nestlé in 2019 which represented the single biggest commercial deal to emerge from Massey University, both in terms of commercial impact and societal benefits. Nestlé and Riddet Institute teams worked together for more than three years on the scale up, manufacture, applications and regulatory aspects of Ferri-Pro™. The deal not only provided for a commercial return to the Riddet Institute but represented a huge opportunity to showcase New Zealand food science to the largest global food company. This generated widespread media coverage internationally.

A new product BUNYAD IRON+ using the technology was launched by Nestlé in Pakistan in May 2022, and quickly attracted notice around the world. It will continue to launch in other countries.

In September 2022 Ferri-Pro™ won two awards:

Massey Ventures Limited was awarded "Best Licensing Deal" at the 2022 KCA Australasian Research Commercialisation Awards in Melbourne for the sale of the technology to Nestlé.

Ferri-Pro™ technology used in Nestlé's new BUNYAD IRON+ milk powder won the "Innovation in Research & Development – Consumer Nutrition Award" at the International World Dairy Summit (organised by International Dairy Federation), held in New Delhi, India.

Ferri-Pro™ is a novel protein-iron complex using food-grade materials and a unique processing method. The complex has superior functionality compared with other products in the market. It provides advantages over other sources of iron present in foods, including ferrous sulphate, the recognised leading iron supplement. Riddet Institute Director, Distinguished Professor Harjinder Singh, led the research team that developed Ferri-Pro™ and says the Riddet Institute was immensely proud to have had a significant role in addressing one of the most important nutritional deficiencies in the world.

New start-up specialises in cell technology

Dr Laura Domigan (Associate Investigator), **Dr Olivia Ogilvie** (Riddet Institute PhD alumna) and **Dr Vaughan Feisst** successfully raised external funding and established a B2B spin-out company – Opo Bio Ltd.

This arises in part from research undertaken in the Riddet Institute CoRE programme in cell-based production of animal meat. The company specialises in cultivation of cell lines from disease-free non-GM New Zealand livestock. Dr Ogilvie has been appointed CEO.

BIO AOTEAROA

SPOTLIGHT ON

MĀORI AND PACIFIC SCHOLARS

Collaboration strengthens career pathways

The Riddet Institute strives to support Māori and Pacific aspirations through multiple strands.

One of these approaches is the Institute's work with its partner research organisations, such as the Pūhoro STEMM Academy, to support young Māori scientists in their education journeys and provide pathways towards a career in science with summer internships and postgraduate scholarships. The Riddet Institute also endeavours to embrace mātauranga (indigenous knowledge) and taonga (native resources) when it works with Māori food entities on food science projects.

For a number of years Māori and Pacific students have explored options for their future high-value careers and post-graduate academic study through the Riddet Institute and Pūhoro STEMM Academy's partnership and summer programme. The collaboration models the Māori concept of a "braided rivers" approach to facilitate shared learning.

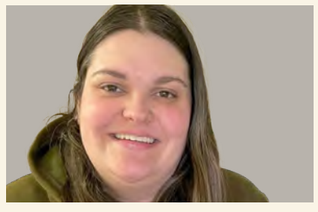
Pūhoro STEMM Academy students at the Massey University campus in Palmerston North for 2022/23 summer scholarships. From left, **Meg MacGregor-Dunn, Georgia Patching, Jade Rivers, Rubi Smith** and **Genevieve Bell.** For student research topics, see page 34.

The Pūhoro STEMM Academy is a programme focusing on science, technology, engineering, mathematics and mātauranga.

A national programme, it offers the Riddet Institute a rewarding partnership with Pūhoro tauira (students) working with Riddet supervisors on co-designed summer projects.

This highly successful internship programme supports Māori students from school into undergraduate food science and technology studies, and eventually into postgraduate study and beyond.

Māori post-graduate students working on food health themes



PhD candidate **Summer Wright,** left, and Master's students **Asher Brook,** and **Simone Frame.**

For her PhD research, **Summer Wright** *(Ngāti Maniapoto)* is exploring the unique value proposition of Māori plant-based foods through qualitative methods. She is investigating some of the key opportunities and challenges for strengthening Māori participation in the plant-based food sector in Aotearoa. **Asher Brook** *(Ngati Porou)* is carrying out the research component for her Massey University Master's thesis on the effects of milk oligosaccharides on the microbiota. **Simone Frame** *(Ngāti Maniapoto/Ngāti Kahungunu)* is a Riddet institute Master's student who is researching different New Zealand banana varieties and their impact on infant gut microbiota.

PhD research to help others live better and longer

The Riddet Institute's first PhD candidate from the Pacific is doing research that will directly help improve the lives of Pacific people.

Salanieta Naliva, known as Sala, is researching what adults aged 55-years and above in Fiji are eating, the social and health factors that put them at nutrition risk, and interventions that would help them, for her PhD.

Sala says the Asia-Pacific population is ageing more rapidly than any other region, especially in Fiji where she is from.

"This concerns me because there will be a time when there will be more older adults than younger people and this will have an impact on our health system," says Sala, who has a Master of Public Health from Fiji National University.

"Evidence has shown that nutrition plays an integral part in living better and longer in older adults."

She says parallel to an ageing population is an ongoing "crisis" of non-communicable diseases and premature deaths before 60 years of age.

"Older adults are also often left out in health research in Fiji. Thus, my passion is to investigate why and how nutrition can play a key role in the nutritional status of the younger-older age to the oldest-old adults in Fiji."

She hopes her research findings will make a real difference.

Salanieta Naliva receiving her prize for winning the three-minute research presentation competition from Riddet Institute board member and acting chair **Mark Piper** at the Riddet Institute Conference and Student Colloquium in Napier in November 2022.

"I am optimistic that my study will help with baseline information on what older people in Fiji are consuming, what dietary changes can be made to meet nutritional requirements and what factors affect their nutrition status."

She is hopeful this will lead to interventions that are sustainable, culturally relevant and cost effective.

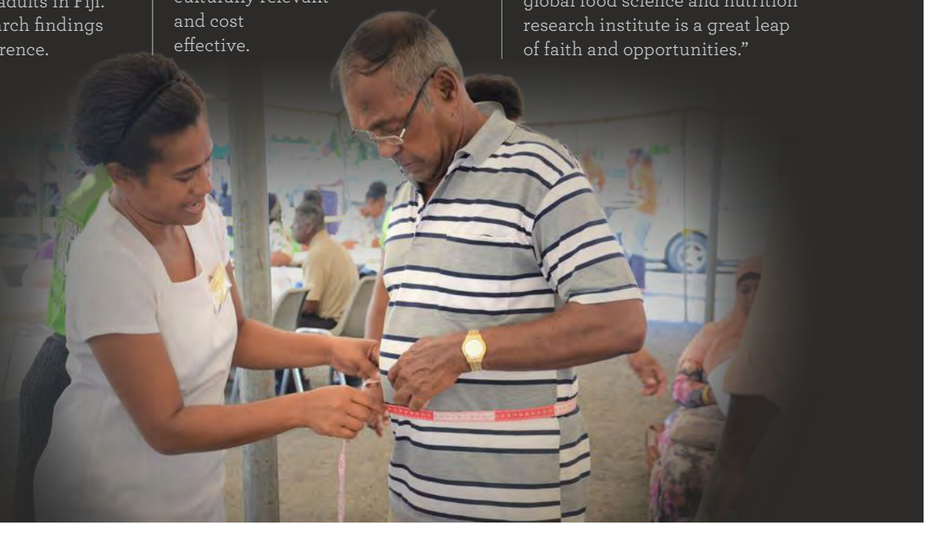
"Evidence has shown that nutrition plays an integral part in living better and longer in older adults."

Possibilities include being able to train and educate other health professionals on protocols and guidelines for nutritional needs assessment, and the introduction of effective policies to address nutrition and wellbeing in older people in Fiji.

Sala is a married mother of five children, ranging in age from nine to 15, whom she has had to leave in Fiji to study in New Zealand. She says it is a tough but worthwhile journey.

"I had to sacrifice leaving my family in Fiji, but I know others have walked this journey before me and they came through, so that motivates me to keep going and do what I am passionate about because it will be worth it one day.

"To come from the Pacific Islands where obtaining a PhD qualification is rare and where resources are limited, to securing a prestigious scholarship from a renowned global food science and nutrition research institute is a great leap of faith and opportunities."



Summer students get a taste of food and nutrition research

THE RIDDET INSTITUTE HOSTED 15 SUMMER INTERNS IN VARIOUS LOCATIONS.

Meg MacGregor-Dunn *(Māupoko)* researched seaweed and pea protein digestion (Massey University).

Peti Cooper-Slade *(Ngaati Tipa, Ngaati Amaru)* and **Tiaria Te Hau-Karaitiana** *(Ngāti Kahungunu, Ngāti Tūwharetoa, Ngāi Tahu)* worked on the methodology for visual interviewing (University of Otago).

Jade Rivers *(Ngāpuhi, Ngāti Kahungunu ki Wairarapa)* analysed United Nations FAO food data for mathematical modelling (Massey University).

Daniel Shippey tested the validity of the mathematical modelling of the DELTA Model® (Massey University).

Genevieve Bell and **Rubi Smith** *(Rangitāne)* worked on a project to investigate how Māori communicate their value propositions on food and beverage products (Massey University).

Pelenitina Vao *(Tongan)* looked at food behaviours in in-vitro digestion (Massey University).

Isaac Williams *(Samoan)* worked on the nutritional profiles of edible insects (University of Otago).

Georgia Patching *(Ngāti Kauwhata, Ngāti Kahungunu)* researched the health benefits and digestion of damson plums (AgResearch/ Massey University), and will commence a Master's Degree through the Riddet Institute to further this work in 2023.

Jacob Knight captured national food and nutrition data for the Sustainable Nutrition Initiative (SNi®) (Massey University).

Reuben Dodd analysed New Zealand native coffee varieties for bioactive compounds (Massey University).

Connor Ferguson worked on a project to extract protein from seeds for protein-enhanced beverages (Massey University).

Jeffery Fang looked at the extraction and characterisation of plant seed oil bodies for use in future products (Massey University).

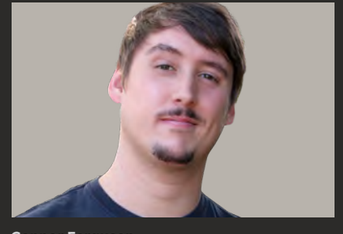
Rikki Tubman *(Ngāti Hauā/ Tainui)* investigated the native hebe plant's expected impact from climate change (University of Otago).

Reuben Dodd

Jacob Knight

Peti Cooper-Slade.

Jeffery Fang



Connor Ferguson

INTERNATIONAL SCIENCE EXCELLENCE

RESEARCH COLLABORATION AND CONSORTIA

The Riddet Institute's investigators routinely collaborate with world-leading international research groups. The following ongoing collaborations provided additional capability and strength to the Institute's research programme:

International University Consortium of Food Science & Nutrition (IUCoFSN)
This consortium is a formal food science research collaboration between The University of Leeds, Riddet Institute/Massey University, Wageningen University and Zhejiang Gongshang University of China.

Wageningen University and Research, The Netherlands
The Institute has had a long-term collaboration with Wageningen UR, the top ranked university in the world in the field of agriculture (QS Rankings 2020).

New Zealand Singapore Future Foods Research Programme
Riddet Institute investigators are involved in four collaborative projects exploring the potential for novel foods and food technologies, funded by the Ministry of Business, Innovation and Employment (MBIE) and the Agency for Science, Technology and Research (A*STAR) in Singapore.

INFOGEST
This programme involves researchers from around the globe and seeks to provide a focal point for research and methodologies in digestion models.

PROTEOS Research Consortium
Proteos is a collaboration between the Riddet Institute, Wageningen UR (Netherlands), the University of Illinois (USA) and AgroParisTech (France) to characterise the quality of food protein.

CSIRO
The Institute continues to collaborate with CSIRO in mounting the highly successful Food Structures Digestion and Health (FSDH) international conferences held alternately in New Zealand and Australia.

INRAE, France
Riddet Institute researchers were invited to join a new multi-partner European programme entitled DURATRANSFO investigating the sustainable global production of food and its distribution.

University College Cork, Ireland
PhD student Ethan Cain, funded through a Walsh Fellowship provided by Teagasc, is working on a joint project and spent most of 2022 on placement in Ireland.

DSM, The Netherlands
The Riddet Institute collaborates with DSM, Netherlands, for a study on the texture of plant protein-based meats.

Plant cells making milk proteins

Miruku's Dr Alejandra Acevedo-Fani and Akashdeep Beniwal with plant-grown dairy products

"Animal-free milk proteins" sounds like a contradiction, but new company Miruku is making the impossible possible. The alt dairy start-up uses molecular farming techniques with plant cells working as 'mini factories' to produce the proteins, fats, and sugars that combine to make dairy products.

Cows traditionally use plant proteins, via grasses, to convert plant energy into milk, so the breakthrough plant technology means Miruku is essentially cutting out this step. The oilseed crop-produced compounds developed in labs and greenhouses are also cost effective and efficient, with promising climate-friendly future aspirations.

Miruku's research and development programme involves strong collaboration between New Zealand's Riddet Institute, the Hebrew University of Jerusalem in Israel, and CSIRO, Australia.

The food applications team is based in the Riddet Institute in Palmerston North, led by Dr Alejandra Acevedo-Fani and postdoctoral researcher, Dr Akashdeep Beniwal.

mirüku™ Helping Nature Nurture.

The team is developing novel methodologies for characterisation and functionality of milk proteins expressed in plants.

The innovative technology will lead to the development of cheese and yoghurts, and novel food formats.

Miruku was founded in 2020 by CEO Amos Palfreyman, a leader in New Zealand's future foods landscape and a former dairy industry executive, Ira Bing, a technology and life science investor, Riddet Institute director Distinguished Professor Harjinder Singh, a leading expert in milk protein science and technology, and internationally renowned biotech and molecular agronomy innovator Professor Oded Shoseyov.

The game-changing technology means Miruku intersects future food, biotech and agriculture, a fast-emerging space placing sustainability and ecology at the forefront of its focus.

ALIGNED PROGRAMMES

Funding from industry shows confidence in research

Research funding from industry and government sources was more than $8 million for the second year in a row in 2022, indicating a high degree of confidence in Riddet Institute research.

Overall, there was a slight increase compared to 2021 on the back of higher funding from the High Value Nutrition National Science Challenge and from overseas industry. This funding has grown compared to previous years and is for projects that run until mid-2024. The original research in food science and nutrition being done at the Riddet Institute and its connections with food companies is making an impact in the New Zealand food sector. These research projects, listed below, and the connections made from them, will transfer advanced knowledge and innovation and build skills for New Zealand's economic benefit.

The Sustainable Nutrition Initiative

The Sustainable Nutrition Initiative (SNi®) is gaining recognition and continues to grow in influence, with new funding received from industry and government in New Zealand and internationally. The initiative is led from the Riddet Institute, in collaboration with other industry participants and experts. SNi® comprises data and modelling programs to enable better understanding of the food system and the opportunities to sustainably feed the global population, national populations, and individuals.

The SNi® team from left, Dr Andrew Fletcher, Dr Nick Smith, Laurette Batstone, Prof Jeremy Hill and Prof Warren McNabb.

It aims to generate new insights into sustainable food systems and diets based on best available evidence. It operates several mathematical models: The DELTA Model® is a tool that has been designed by the SNi® team to examine the consequences of choices around food production systems at a global level. This tool has continued to be developed and presented at various national and international forums; The iOTA Model® is an optimisation tool for sustainable, healthy diets, that allows the trade-offs and synergies between nutrition and environmental impact in the diet of an individual to be explored; Finally, the SNi® team are also engaged in national food system modelling efforts for multiple countries, including modelling the NZ food system to understand flows of nutrition from production, through trade, to consumption.

MBIE Catalyst programmes

In addition, the Riddet Institute contributes to several programmes funded by the Ministry of Business, Innovation and Employment (MBIE) in which there is significant industry involvement.

Examples include:

- Professor Joanne Hort (Principal Investigator, Massey University) leads Te Rangahau Taha Wheako mō ngā Kai o Āpōpō: The Consumer Dimension of Future Foods, which involves a number of NZ industry partners: NZ Algae Innovation, Goodman Fielder, Fonterra, Movers in Hemp Innovation (MiHI), Wakatū Incorporation, NUKU ki te Puku™, Vince and Food Nation.
- Dr Arup Nag and Dist. Prof Harjinder Singh collaborate with the Cawthron Institute-led programme to investigate the potential of the red seaweed, Karengo, and the microalga, Chlorella, as everyday alternative protein sources.
- Dr David Everett (Principal Investigator, AgResearch) is a senior investigator on the project co-led by Dr Linda Samuelsson (AgResearch) and Dr James Chan (A*STAR, Singapore) on the cooking and processing of seaweed to improve consumer acceptance, protein digestion and nutrient bioavailability.
- Dr Laura Domigan (Associate Investigator) leads a team exploring the development of successful hybrid foods using plant proteins (soy bean and pea) and cultured livestock cells (including cattle, sheep, deer and pig).

Milks Mean More

The New Zealand Milks Mean More programme (NZ3M), led by the Riddet Institute and funded by MBIE (2018-2022), involves multiple New Zealand dairy companies and most of the Riddet CoRE partners. NZ3M is an in-depth interdisciplinary research project to understand the key impacts of dairy components from different ruminant sources in providing better nutritional and health outcomes. The project is supported by the A2 Milk Company, Blue River Dairy, Cilantro Cheese, The Dairy Goat Cooperative, Fonterra, Goodman Fielder, Kingsmeade Cheese, Mataura Valley Milk, Pāmu (Landcorp Farming), Maui Milk, Miraka, NIG Nutritionals, Spring Sheep Milk Co, Synlait, Tatua and Waiu Dairy.

New products being investigated with High-Value Nutrition (HVN) National Science Challenge

The Riddet Institute is the lead research partner for the government's High-Value Nutrition (HVN) Science of Food programme. The programme is led by Distinguished Professor Harjinder Singh and supported by Research Scientist Dr Ali Rashidinejad. The Institute also supports the wider HVN programmes and HVN industry stakeholders with food science capability, knowledge sharing, and facilitating the development of new products for clinical evaluation.

PROJECTS CONTINUING OR COMPLETED IN 2022:

- With Calocurb Limited to develop a functional food ingredient from hops, for potential use in calorie control food products.
- In a Māori-led partnership with Wakatū Inc. and Chia Sisters on their 'Tūhauora' clinical research project, led by the University of Auckland, the Riddet Institute is involved in looking at developing a dried ingredient from the taonga species kawakawa and exploring products for the Japan market.
- With NIG Nutritionals, an investigation of powdered milk consumption (bovine, ovine, caprine) in an elderly cohort has begun, with recruitment of participants nearly completed. The clinical trial will be done at the University of Otago and some analysis of whole milk powders was carried out at the Riddet Institute in 2022. This research is in collaboration with the MBIE-funded NZ3M programme, led by the Riddet Institute, and also involves Miraka and Spring Sheep Dairy.
- In a Māori-led partnership with Te Taiao Innovations Limited, research into freeze-dried mamaku as a Smoothie ingredient with potential metabolic health benefits (aligned with a wider programme of research into mamaku led by Plant & Food Research with Nga Uri o te Ngahere Trust).
- With Zoffee Limited, exploring a Native New Zealand coffee alternative.
- With Cherri Global Health & Manufacturing Limited, research establishing the bioactive baseline for New Zealand cherries.
- With NewFish, a $50,000 research project to establish the quality of protein in paua.

The native New Zealand coffee variety Coprosma repens.

Proteos programme in second phase

The Riddet Institute leads an international collaborative research team in the Proteos programme. The second phase of the programme to develop a global database of protein quality from commonly consumed foods was funded in 2021. Proteos is funded by a consortium of international food companies led by the Global Dairy Platform and this phase involves US$1.5M in funding over two years.

OTHER RESEARCH PROJECTS

- Work is continuing on MBIE-funded research on "New Infant Formula Emulsions", by Associate Investigator Dr Simon Loveday and Affiliated Researcher Dr Caroline Thum.
- Also involving infant nutrition, a project with Inner Mongolia Dairy Technology Research Institute Co. Ltd is being led by Associate Investigator Dr Suzanne Hodgkinson to determine the content of digestible amino acids in breast milk collected from Chinese women and evaluate the protein quality of infant formulas.
- In its second year of four years, a project assessing the quality and nutritional potential of proteins extracted from Irish marine, meat and dairy sources is underway, with Dr Suzanne Hodgkinson the project leader for a Walsh Fellowship in collaboration with Teagasc, Ireland.
- A project examining the digestibility of different calcium sources is led Dr Suzanne Hodgkinson and funded by DSM International.

OUR PEOPLE

The Riddet Institute seeks to celebrate diversity at all levels of our organisation. We are committed to the proactive development of staff and students in the Institute and the inclusion of people from under-represented groups. We consider that a culture embracing equity and diversity is intrinsic to better science and innovation.

Early career scientists shine at international dairy award

Riddet Institute scientists won two of the four top prizes in the inaugural International Dairy Federation awards in July 2022.

Dr Debashree Roy came second equal, and Dr Nick Smith was third in the International Dairy Federation (IDF) Professor Pavel Jelen Early Career Scientist Prize. The pair received their prizes at the IDF World Dairy Summit, held in India in September 2022. Dr Roy and Dr Smith both completed their PhDs through the Riddet Institute.

Dr Debashree Roy was second equal for her entry titled, "Composition, structure, and dynamic digestion behaviour of milk from different species." Her entry focused on her research about how milk composition and structure impact the release of nutrients at various stages of gastric digestion of different mammalian milks, such as cow, goat, and sheep milks.

Dr Nick Smith's third-place entry on "Understanding dairy's contribution to a sustainable food system" used a data science and modelling approach to unpick the quantity of food nutrients that come from dairy in our current food system. Dr Smith is working on the Sustainable Nutrition Initiative (SNi®) and has been involved in the development of the DELTA Model®, a global food system mass balance capable of calculating the nutrition available globally from the food system today, and under various future scenarios.

The IDF Professor Pavel Jelen Early Career Scientist Prize was created to acknowledge the work of scientists and/or technologists in the dairy science and technology field and aimed toward early-career scientists, including graduate and postgraduate students, who are less than three years since graduation from their highest degree attained. It is in honour of Professor Pavel (Paul) Jelen, a Czech-born scientist and educator who has spent his career based in Canada and the United States. The International Dairy Foundation is the leading source of scientific and technical expertise for all stakeholders of the dairy sector.

Dr Roy also received an outstanding recognition in an international science competition in March 2022, when she was awarded second place in the Pieter Walstra award organised by the Dutch Dairy Organisation for her research into the digestion behaviour of milks of different species.

Research Officer Dr Nick Smith and Postdoctoral Fellow Dr Debashree Roy.

Student award named after former staff member

The inaugural Ansley Te Hiwi Student Communicator Award was won by Aylin Sen at this year's Riddet Institute Conference and Student Colloquium 2022 in Napier in November.

Aylin won the competition with an entertaining 10-minute student oral presentation that was a snapshot into her coconut oil body membranes research for her PhD.

The Award was named in memory of Riddet Institute administrator Ansley Te Hiwi, who sadly passed away earlier in April 2022. Ansley was a great friend to the Riddet Institute, and especially its students. Until she retired in 2021, Ansley was an important part of the Riddet Institute and a driving force behind the Annual Student Colloquium, organising the event for several years. Ansley's widower, Tana, presented the Student Communicator prize to Aylin in a poignant awards ceremony to close the three-day conference.

Ansley Te Hiwi Student Communicator Award winner Aylin Sen pictured with Ansley's widower Tana Te Hiwi.

Graduates head to a wide range of careers

Many of our students and emerging scientists go on to a career in food research or the food industry. We prepare our young scientists for this through industry-ready training. Some students and staff who have recently started careers in industry and research are highlighted below.

Isuri Jayawardana
Senior Lecturer – Food & Nutritional Sciences, Rajarata University of Sri Lanka

Isuri Jayawardana's PhD focused on the effect of kiwifruit actinidin on the digestion of gluten proteins, and her outstanding thesis was included in the 2022 University Dean's list of Exceptional Doctoral Theses. After completing her PhD in 2022, Isuri has continued her research on in vitro human oro-gastrointestinal digestion models and preclinical (animal) digestion models. She has published four research papers on her work. Isuri is now a Senior Lecturer in the Department of Animal and Food Sciences in the Faculty of Agriculture at Rajarata University of Sri Lanka. In this role, Isuri delivers lectures and conducts research in the field of food and nutritional sciences. She is also the Head of Department, overseeing its activities and responsibilities, and supervising undergraduate and postgraduate students in their own research.

Patrick Tai
Research Scientist - Hilmar Cheese Co Inc., US

Patrick Tai's PhD research focused on the release of nutrients from dairy food matrices under in vitro gastrointestinal digestive conditions. Patrick is now employed as a Research Scientist for the Technical Services team at Hilmar Cheese Company, California, USA. Hilmar was founded in 1984 by 12 local dairy families and is a world-leading manufacturer of cheese and whey products. Hilmar produces a variety of cheese for private label, wholesale, and food service customers. Patrick's team works closely with the Operations and R&D teams to develop methods, optimise processes, and investigate potential new products. Patrick is mainly involved with the Hilmar Ingredients division, which was established in 2004 to focus on producing whey protein for infant formula, sports nutrition, and healthy aging, as well as lactose. Patrick is currently working on projects closely related to his PhD topic on the milk fat globule membrane and its bioactive properties in his role at Hilmar.

Tung Thanh Diep
Lab Analyst, AssureQuality, New Zealand

Tung Thanh Diep graduated in 2022 with a PhD that studied tamarillos as a high value nutrition ingredient, exploring how the addition of tamarillo powder affects the digestibility of yoghurt. Tung now works as a Lab Analyst at AssureQuality, testing and interpreting the nutrient composition of food products such as vitamins (A, C, E, K1, K2), minerals, carnitine, and nucleotides in infant formulas. Tung also processes, analyses, and authorises data and applies quality control requirements to comply with international standards. Tung's PhD research and international industry experience has given him expertise with a diverse range of equipment and analytical software, and he now also trains new technicians in the safe use of appropriate techniques and the continual quality assurance of equipment, tests, and reporting of results. His work at AssureQuality delivers impact to the field of food science and nutrition as well as adding value to the New Zealand food economy.

Xin Wang
Research Scientist - Fonterra

Xin Wang recently graduated with her PhD, which focused on the digestive behaviour of non-dairy milk alternatives in her thesis titled "Studies on the gastric digestion of plant-based alternative milks". Following her graduation, Xin joined the Fonterra Research and Development Centre, where she continues to utilise her expertise in projects related to UHT cream and other relevant developments. Xin's time at the Riddet Institute proved to be immensely valuable, shaping her academic journey and establishing the groundwork for her current position. She holds cherished memories of her experience at Riddet, where she refined her research skills and gained a comprehensive understanding of the intricacies of food science. One of Xin's highlights of studying at Riddet was her encouraging and supportive supervisors. Their mentorship provided Xin with the valuable guidance and constructive feedback she needed to navigate her research projects and academic challenges, building the skills she now utilises in her role as a research scientist.

Student Success

Our students and postdoctoral fellows achieve at the highest level. Some outstanding student achievements from 2022 are:

Isuri Jayawardana Sunandita Ghosh Sherine Jesna

Three outstanding in their field

Three recently completed PhD students were included in the University Dean's list of Exceptional Doctoral Theses in June: Sunandita Ghosh (University of Auckland), Isuri Jayawardana (Massey University), Sherine Jesna (University of Auckland).

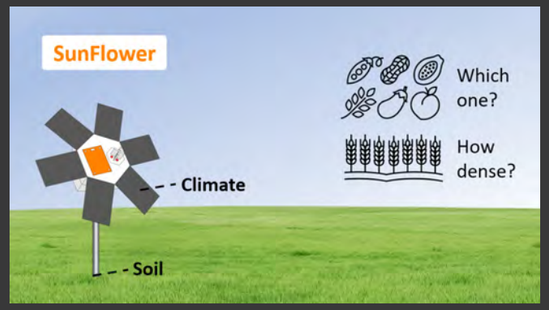
Poster winners impress

- **Patrick Tai** (PhD student) – came 3rd place in the three-minute thesis competition at the American Dairy Science Association Conference, Kansas City, 19-22 June 2022.
- **Haroon Qazi** (PhD student) – awarded 1st Place in the Poster competition at the NZIFST Conference, Rotorua, 5-7 July 2022.
- **Catherine Maidment** (PhD student) – came 3rd place in the 3MT competition at the NZIFST Conference, Rotorua, 5-7 July 2022.
- **Simone Frame** (Master's student; Ngāti Maniapoto/ Ngāti Kahungunu) – awarded 'People's Choice Award' in the Poster Competition, Foodomics Conference, Auckland, 8-9 September 2022.

Scholar shows she means business

Riddet Institute PhD student Aylin Sen was $500 richer after winning an elevator-style business pitching competition at Massey University.

The Pitch.ME 60-second video pitch challenge was open to all Massey University students and staff with a unique and innovative idea. Aylin's 60-second animation, with voice over, featured a mechanical sunflower that analyses soil and climate conditions for farmers. The product prototype is being developed by Aylin and her brother Aydin in Turkey. The mechanical sunflower is 'planted' into the soil and its self-charging 'head' rotates with the sun to collect data on everything from soil conditions to sunlight hours.



Aylin, whose PhD research is in plant-based oil body membrane materials, also won the 2022 Student Communicator award at the Riddet Institute Conference and Student Colloquium in November. In 2021 she was runner up and people's choice in the Massey University Visualise Your Thesis Competition.

Other student appointments and awards

Summer Wright (PhD student; Ngāti Maniapoto) was appointed as co-convenor for OraTaiao: NZ Climate & Health Council. Summer has been an active member of the council for a few years and recently took a leadership role. The group comprises health professionals who advocate for equitable action on climate change.

Alex Kanon (PhD) was awarded a FoodHQ scholarship to attend the International Food and Agribusiness Management Association (IFAMA) Conference in Costa Rica (June 2022).

AWARDS AND ACHIEVEMENTS

Our investigators are high-achieving researchers in their fields. The following investigators, students and other personnel gained recognition during 2022.

Session speakers at NZIFST 2022 conference from left Dr Ali Rashidinejad, Dr Bangxiang Chen, Dr Amber Milan, Prof Indrawati Oey, Dr Nick Smith

NAME	AWARD/APPOINTMENT
Dr Alejandra Acevedo-Fani (Associate Investigator)	→ Appointed as Review Editor in *Frontiers in Sustainable Food Systems* journal. → Appointed to the Topical Advisory Panel of *Applied Biosciences* journal. → Appointed to the Editorial Advisory Board of *Sustainable Food Proteins* journal. → Appointed as Guest Editor for the *Foods* journal Special Issue 'Recombinant proteins for food applications'. → Promoted to Senior Research Officer (effective 1 January 2023). → Appointed as Chair of the Technical Committee for the Food Structures, Digestion and Health International Conference 2023.
Dr Skelte Anema (Associate Investigator)	→ Elected a Fellow of the Institute of Food Science and Technology at the NZIFST Conference, 5-7 July 2022, Rotorua.
Dr Gail Bornhorst (Associate Investigator)	→ Promoted to the rank of full Professor at the University of California Davis, USA. → Appointed to the Editorial Advisory Board of *Sustainable Food Proteins* journal.
Dr Barbara Burlingame (Adjunct Professor)	→ Appointed to a newly formed IUFoST Task Force on food classification systems for diet and health. → Appointed to the UN Food Systems Coordination Hub Scientific Advisory Committee. → Elected to the IUNS Council and given the award of Fellow of the International Union of Nutritional Sciences.
Dr Lirong Cheng (Postdoctoral Fellow)	→ Appointed as Guest Editor to the Special Issue 'Recent Advance in Food Gels' in *Gels*.
Prof Clive Davies (Associate Investigator)	→ Invited to membership of the Engineering Sciences and Technology (EST) assessment panel for the 2022 James Cook Research Fellowship funding round.
Dr Laura Domigan (Associate Investigator)	→ Appointed to the Ministry of Business Innovation and Employment Science Board for a three-year term.
Dr Amanda Dupas de Matos (Research Officer)	→ Appointed as Guest Editor to the Special Issue 'Novel Research on Aroma Interactions of Alcoholic Beverages' in *Foods*.
Dr David Everett (Principal Investigator)	→ Appointed Fellow of Food Standards Australia New Zealand (FSANZ). → Appointed Session Chair and presented on 'Dairy: Where's the cheese? Nature's strategy for better nutrition', at NZIFST Conference, Rotorua, 5-7 July 2022. → Appointed Chair of the Organising Committee of the Food Structures, Digestion and Health International Conference 2023.
Prof Manohar Garg (Principal Investigator)	→ Appointed as Guest Editor of the *Nutrients* journal Special Issue: "Food Structure and Human Health – Need for a New Approach to Dietary Guidelines".
Dr Janice Lim (Postdoctoral Fellow)	→ Awarded an International Union of Nutritional Sciences Early Career Travel Grant to attend the IUNS Conference in Tokyo, December 2022.

NAME	AWARD/APPOINTMENT
Prof Jim Mann (Principal Investigator)	→ Appointed as a Knight Companion of the New Zealand Order of Merit for services to Health.[1]
Prof Warren McNabb (Principal Investigator)	→ Appointed by the International Dairy Federation (IDF) to be a member of the Dairy Matrix Roadmap Working Group. → Invited to join The Paul G. Allen Frontiers Group (USA) selection panel for the 2022 Allen Distinguished Investigator awards for technological innovation for nutrient sensing research.
Dist. Prof Paul Moughan (Principal Investigator)	→ Appointed as Chair of Organising Committee and Chair of Science Committee for FAO-sponsored International Symposium on 'Dietary Protein for Human Health' to be held in Utrecht in September 2023. → Appointed to the Editorial Advisory Board of *Sustainable Food Proteins* journal.
Dr Tony Mutukumira (Associate Investigator)	→ Appointed to the China Ministry of Science and Technology Overseas Experts Supporting Programme. → Requested by Mekong Institute Thailand to facilitate sessions on Food Processing and Preservation at the Regional Training Programme for participants from Myanmar, Laos, Vietnam and Cambodia, 9-13 May 2022. → Appointed as Session Chair: Application of Effective Food Safety Management Systems to Promote Better Health and Sustainable Global Food Trade. The XX CIGR Congress, Kyoto, Japan: International Commission and Biosystems Engineering, Japan, 5-10 December 2022.
Dr Noha Nasef (Affiliated Researcher)	→ Appointed to the Manawatu Branch of the Royal Society Te Apārangi committee, and as a Professional ECR member of the Royal Society Te Apārangi (MRSNZ).
Prof Indra Oey (Principal Investigator)	→ Appointed Fellow of Food Standards Australia New Zealand (FSANZ). → Appointed to the Scientific Programme Committee for the 4th World Congress on Electroporation and Pulsed Electric Fields in Biology, Medicine and Food & Environmental Technologies, Copenhagen, 9-13 October 2022. → Appointed as Guest Editor for *Applied Sciences* Special Issue 'Non-Thermal Technologies for Food Processing', MDPI.
Dr Ali Rashidinejad (Research Officer)	→ Appointed as Guest Editor for *Molecules* journal Special Issue: Bioactive Ingredients in the Food Matrix.
Dr Debashree Roy (Postdoctoral Fellow)	→ Awarded 2nd place overall in the international Pieter Walstra Award 2022 based on her PhD thesis on the digestion behaviour of milks of different species. → Awarded 2nd place in the inaugural International Dairy Federation (IDF) Professor Pavel Jelen Early Career Scientist Prize 2022 for a submission on 'Composition, structure, and dynamic digestion behaviour of milk from different species'.
Prof Elaine Rush (Associate Investigator)	→ Appointed as a life-long Honorary Member of the Nutrition Society of New Zealand in recognition of an outstanding contribution to nutrition science and the community.
Dist. Prof Harjinder Singh (Director)	→ Appointed by American Oil Chemists Society (USA) as Inaugural Editor in Chief for a new open access journal *Sustainable Food Proteins* in partnership with Wiley publishing company. → Invited to serve on the American Dairy Science Association (ADSA) Awards Program as chair for the Award of Honour and Distinguished Service Awards for 2022. → Invited to judge the inaugural International Dairy Federation (IDF) Dairy Innovation Awards (Innovation in Research & Development Category), July 2022.
Dr Nick Smith (Postdoctoral Fellow)	→ Awarded 3rd place in the inaugural International Dairy Federation (IDF) Professor Pavel Jelen Early Career Scientist Prize 2022 for a submission on 'Understanding dairy's contribution to a sustainable food system'. → Invited by Wageningen University to lecture for this year's 2022 Summer School-Dairy Nutrition and Health to be held in July via virtual class. Lecture Title: "Exploring the future: the DELTA model".
Assoc. Prof Lisa Te Morenga (Principal Investigator)	→ Appointed as Co-Chair of Health Coalition Aotearoa.
Dr Aiqian Ye (Associate Investigator)	→ Promoted to the rank of full Professor at Massey University.

[1] Also reported in 2021

NAME	UNIVERSITY	AWARD/APPOINTMENT NAME
Natalie Ahlborn **Summer Wright** **Akashdeep Beniwal** **Giovanna Castillo-Fernandez** **Dian Muñoz Lintz**	Massey University Massey University Massey University Massey University University of Canterbury	→ All make up Team Melt who, following their success in 2021 winning the international QING Innovation Track competition at Wageningen University, were selected as finalists for the Innovation Challenge in Partnership with Danone North America, at Future Food-Tech, San Francisco on 25 March 2022. The team was also invited to a dinner hosted by The Ambassador of the Kingdom of the Netherlands to New Zealand, on the occasion of the visit of a delegation from Wageningen University and Research visiting Aotearoa New Zealand, held in Palmerston North, 31 October 2022. In addition, the PhD students were invited by the Ambassador to attend an evening reception at the Embassy in Wellington on 1 November 2022.
Simone Frame	Massey University	→ Won 'People's Choice Award' in the Poster Competition, Foodomics Conference, Auckland, 8-9 September 2022. Poster entitled: "New Zealand bananas feeding the infant gut microbiota".
Sunandita Ghosh	University of Auckland	→ Included in University of Auckland's List of Exceptional Doctoral Theses.
Isuri Jayawardana	Massey University	→ Included in Massey University's List of Exceptional Doctoral Theses.
Sherine Jesna	University of Auckland	→ Included in University of Auckland's List of Exceptional Doctoral Theses.
Alex Kanon	Massey University	→ Awarded a FoodHQ scholarship to attend the International Food and Agribusiness Management Association (IFAMA) Conference in Costa Rica (June 2022).
Janice Lim	Massey University	→ Awarded an IUNS Early Career Travel Grant to enable her to present at the International Union of Nutritional Sciences – International Congress of Nutrition (IUNS-ICN) Conference, Tokyo, Japan, 6-11 December 2022.
Haroon Qazi	Massey University	→ Won 'People's Choice Award' in the Massey 3 Minute Thesis Competition, held September 2022. → Awarded 1st Place in the Poster competition at the NZIFST Conference, Rotorua, 5-7 July 2022.
Catherine Maidment	Massey University/ AgResearch	→ Awarded 3rd place in the 3MT competition at the NZIFST Conference, Rotorua, 5-7 July 2022.
Salanieta Naliva	Massey University	→ Awarded 1st place in Student Poster Presentation at Riddet Institute Conference and Student Colloquium in November 2022.
Linda Nezbedova	Massey University	→ A finalist in 'People's Choice Award' in the Massey 3 Minute Thesis Competition, held September 2022.
Aylin Sen	Massey University	→ Was one of the winners in the Massey University Ecentre Pitch.Me competition. → Won the Ansley Te Hiwi student communicator award for her winning Student Oral Presentation at the Riddet Institute Conference and Student Colloquium in November 2022.
Patrick Tai	Massey University	→ Awarded 3rd place in the three-minute thesis competition at the American Dairy Science Association Conference, Kansas City, 19-22 June 2022.
Summer Wright	Massey University	→ Appointed as co-convenor for OraTaiao: NZ Climate & Health Council.

Keynote and invited presentations at conferences

Investigators gave several keynote and invited presentations at international and domestic conferences and events, as follows:

NAME	TITLE	EVENT	VENUE/DATE
Dr Sara Jaeger, Dr Catriona Hay, Dr Caroline Giezenaar and Summer Wright		Annual NZOZ Sensory and Consumer Science Virtual Symposium	Online, 5-7 February 2022
Dist. Prof Harjinder Singh	Designing Food Structures for Optimal Functionality and Nutrition	University of British Columbia's Scholarly Series	Online, Vancouver, 25 March 2022
Dist. Prof Harjinder Singh	Biopolymer Interactions during Gastric Digestion: implications for Nutrient Delivery	International Mini-Symposium on Food Hydrocolloids	Online, Japan, 30 March 2022
Dr Ali Rashidinejad	High-pressure liquid chromatography for the quantification of phytochemicals in food	Guest Lecturer at Universiti Teknologi Mara, Malaysia	Online, 4 April 2022
Prof Aiqian Ye	Gastric behaviour of milk protein as a tool for manipulating nutrient digestion	International University Consortium of Food Science and Nutrition conference on Food Proteins	Online, April 2022
Dist. Prof Paul Moughan	Food sustainability and protein: Debunking the myths	INFOGEST Webinar Series on Food Digestion	Online, 6 April 2022
Dr Suzanne Hodgkinson	Digestible indispensable amino acid score (DIAAS) for the evaluation of protein quality	7th International Conference on Food Digestion	Cork, 3–5 May 2022
Prof Gail Bornhorst	Carbohydrate Digestion: The importance of the proximal and distal stomach during digestion in growing pigs	International Symposium on Digestive Physiological of Pigs	Rotterdam, 17-20 May 2022
Prof Barbara Burlingame	Food and health security	Guest lecture University of New South Wales	15 June 2022
Drs Nick Smith and Andrew Fletcher	Sustainable Nutrition Initiative	Meeting of international dairy bodies	Utrecht, 15-16 June 2022
Dist. Prof Paul Moughan	Food Sustainability and Protein: Debunking the myths – Why the Metrics Matter	American Dairy Science Association Annual Meeting	Kansas City, 19-22 June 2022
Adjunct Prof David Everett Session Chair	Dairy: "Where's the cheese? Nature's strategy for better nutrition"	NZIFST Conference	Rotorua, 5-7 July 2022
Prof Tasa Havea	Plenary Session: "A Personal Story"	NZIFST Conference	Rotorua, 5-7 July 2022
Dr Lovedeep Kaur	Alternate Protein Session: "Animal proteins versus alternate proteins: Achieving optimum digestion characteristics through processing"	NZIFST Conference	Rotorua, 5-7 July 2022
Dr Jaspreet Singh	Circular Economy Session: "Sustainable food processing: Role of innovative technologies and ingredients"	NZIFST Conference	Rotorua, 5-7 July 2022
Dist. Prof Paul Moughan	Protein quality and Sustainable Food Systems – the Metrics Matter	IFT Multi-Session Conversation	Online 13 July 2022
Dist. Prof Harjinder Singh	Panel discussion on Preserving nutritional goodness from farm to fork	Nestlé International Nutrition Symposium	Lausanne, Switzerland, 31 August - 1 September 2022
Prof Barbara Burlingame	Mediterranean Diet informing global policies and actions in food security and nutrition	International Centre for Advanced Mediterranean Agronomic Studies.	Bari, Italy, 28 September 2022
Dist. Prof Harjinder Singh	Structures and Interactions of Plant Proteins in Food Systems	AOCS Sustainable Protein	Chicago/Online, 4-6 October 2022

Distinguished Professor Harjinder Singh

Dr Nick Smith

Dr Debashree Roy

NAME	TITLE	EVENT	VENUE/DATE
Dr Suzanne Hodgkinson	Protein digestibility issues	Joint IAEA-FAO Technical Meeting on the "Development of a Protein Database and the Way Forward for Reviewing Protein Requirements".	Vienna, Austria, October 2022
Prof Aiqian Ye	Gastric colloidal behaviour of milk protein as a tool for manipulating nutrient digestion	16th International Hydrocolloids Conference	Guelph, Canada, 23-26 October 2022
Adjunct Prof Jeremy Hill	Narratives for Nourishment: What can the Sustainable Nutrition Initiative® teach us?	21st IUFoST World Congress of Food Science and Technology	Singapore, 31 October-3 November 2022
Dist. Prof Harjinder Singh	Milk protein complexes for protection and delivery of sensitive nutrients and bioactive compounds. Effects of processing on milk digestibility	21st IUFoST World Congress of Food Science and Technology	Singapore, 31 October-3 November 2022
Dist. Prof Harjinder Singh	i) New perspectives on the delivery of bioactive compounds through food structure design ii) High value nutrition to address public health concerns such as micronutrient deficiencies	International Union of Nutritional Sciences – International Congress of Nutrition (IUNS-ICN)	Tokyo, Japan, 6-11 December 2022
Dist. Prof Paul Moughan	The importance of protein quality in a sustainable diet	International Union of Nutritional Sciences – International Congress of Nutrition (IUNS-ICN)	Tokyo, Japan, 6-11 December 2022
Prof Nicole Roy	Unlocking the puzzle of functional gut disorders, assessing novel biomarkers targeting gut comfort	International Union of Nutritional Sciences – International Congress of Nutrition (IUNS-ICN)	Tokyo, Japan, 6-11 December 2022
Prof Barbara Burlingame	i) Sustainable diet and global policies and actions in food security and nutrition ii) Highlights from the HLPE of the Committee on World Food Security iii) How Indigenous Peoples can inform the global debate on sustainable food systems and sustainable diets	International Union of Nutritional Sciences – International Congress of Nutrition (IUNS-ICN)	Tokyo, Japan, 6-11 December 2022

Staff were also asked to contribute to other overseas events such as:

The National Agricultural Higher Education Project (NAHEP) on-line international webinars, organized by the ICAR-National Dairy Research Institute, India, as follows:

DAIRY AND FOOD PROCESSING, 22 JUNE 2022

→ **Dr Ali Rashidinejad** (Research Officer) "Delivery of bioactive compounds via functional foods and their release in simulated gastrointestinal tract".

→ **Dr Partha Subramanian** (Research Officer) "Design and fabrication of in vitro digestion models".

STABILITY OF PROBIOTICS DURING LONG-TERM STORAGE & DAIRY PROTEINS AS EMULSIFIERS, 22 JULY 2022

→ **Dr Lirong Cheng** (Junior Research Officer and PhD Student) "Nanodroplets coated with dairy protein particles as emulsifiers for O/W emulsions".

→ **Dr Arup Nag** (Food Innovation Manager) "What causes probiotics to lose viability over long-term ambient storage?"

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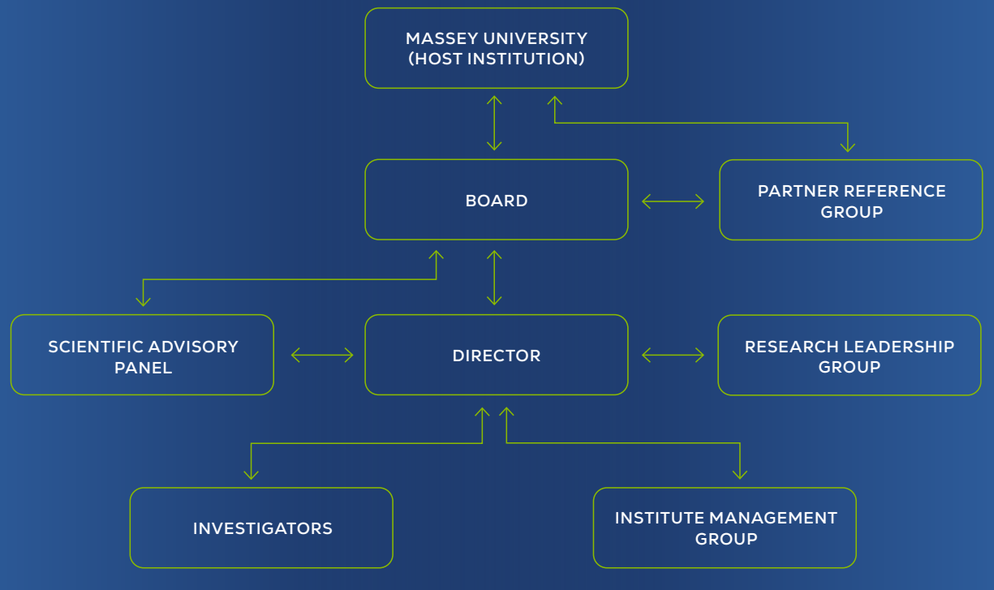

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Footnotes: **1** Appointed 2022 **2** Changed employment 2022 **3** Riddet Fellows are senior researchers who have been Riddet Institute investigators and whose contribution to the Institute is recognised through this special status. They may retain involvement in the CoRE programme through advisory or supervisory roles. **4** While holding Fellow status Prof Gerrard does not act as project leader or participate in any funding applications **5** Affiliated Researchers contribute significantly to the CoRE research programme and other aligned research programmes but do not hold Investigator status. **6** Contract ended/resigned 2022.

Footnotes: **1** Appointed 2022 **2** Contract ended/resigned 2022.

Financial Report

INCOME AND EXPENDITURE OF CORE FUNDS

		BUDGET 2022 $000	ACTUAL 2022 $000
Income			
	CoRE Funding	5,100	5,100
	Surplus/Deficit carried forward	964	1,679
	Funds contributed by collaborative partners	0	108
	Total Income	**6,064**	**6,887**
Expenditure			
Salaries	**Total Salaries & Salary-related costs**	**1,224**	**1,125**
	as % of Total Expenditure	*31*	*37*
Other Costs			
Indirect Costs	Overheads	1,399	1,016
	as % of Total Expenditure	*35*	*34*
Direct Costs	Project Costs	554	131
	as % of Total Expenditure	*14*	*4*
	Travel	256	197
	as % of Total Expenditure	*7*	*7*
	Postgraduate students	512	459
	as % of Total Expenditure	*13*	*15*
	Equipment depreciation/rental	0	0
	as % of Total Expenditure	*0*	*0*
	Subcontractor(s) specified	17	105
	as % of Total Expenditure	*0*	*4*
	Extraordinary Expenditure	0	0
	as % of Total Expenditure	*0*	*0*
	Total Other Costs	**2,738**	**1,908**
	as % of Total Expenditure	*69*	*63*
Total CoRE Expenditure	**Total Expenses**	**3,962**	**3,033**
Net Surplus/(Deficit) - annual		1,138	2,067
Net Surplus/(Deficit) - cumulative		2,102	3,854

CO-FUNDING

		2022 ($000)
Government Funding	National Science Challenges	2,009
	Other MBIE	3,437
	Callaghan Innovation	-
	Health Research Council	-
	Marsden	-
	Non-vote	10
Non-Government Funding	Domestic	1,612
	International - Private Sector	1,031
	International - Public Sector	74
	University/Host/Partner support	-
	Total	**8,173**

SUMMARY DATA

VALUE OF CoRE FUNDING FROM TEC		$5.1 MILLION
FTEs by category	Principal Investigators	1.5
	Associate Investigators	0.6
	Postdoctoral Fellows	3.2
	Research technicians	2.3
	Administrative/support	2.4
	Research students	30 (approx.)
	TOTAL	**40**
Headcounts by category	Principal Investigators	23
	Associate Investigators	52
	Postdoctoral Fellows	22
	Research technicians	Not collected
	Administrative/support	8
	Research students	99
	Research students	115
	TOTAL	**232**
Peer-reviewed research outputs by type	Books	3
	Book chapters	14
	Journal articles	176
	Invited conference/keynote presentations	26
	Prizes and distinctions	See pgs 42 and 43
Commercial activities	Number of licences	-
	Income from licences	-
	Patent applications	-
	Patents granted	-
	Invention disclosures	-
	Spinouts (cumulative or actual)	-
	Capitalisation value of spinouts	-
Students studying at CoRE by level	Doctoral degree	84
	Other	15
	TOTAL	**99**
Number of students completing qualifications by category	Doctoral degree	17
	Master's degree	7
	Other	0
	TOTAL	**24**
Number of graduates by immediate post-study destination	Further study in NZ	0
	Further study overseas	0
	Employed in NZ in Māori organisation	0
	Employed in NZ other	11
	Employed overseas	8
	Unknown	3
	Other	2
	TOTAL	**24**

SCIENTIFIC PUBLICATIONS AND OTHER RESEARCH OUTPUTS

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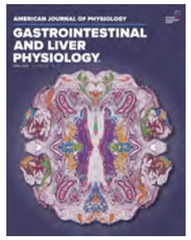
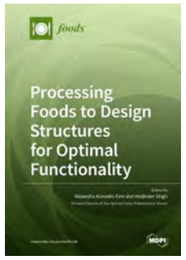


A paper by Associate Investigator Dr. Tim Angeli-Gordon was featured on the cover of the *American Journal of Physiology - Gastrointestinal and Liver Physiology* (April 2022). The cover art, titled The Enchanted Forest of the Gut-brain, is an artistic rendition of histology images illustrating the stomach as a 'second brain' created by the lead PhD student on the project, Zahra Aghababaie.



A Special Issue of *Foods* journal was published as a book, edited by Dr. Alejandra Acevedo-Fani and Dist. Prof. Harjinder Singh, titled *Processing Foods to Design Structures for Optimal Functionality.*

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