Riddet Review

December 2009 Issue 03

Riddet Institute
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New Zealand
www.riddet.ac.nz

Riddet Institute
FOOD | INNOVATION | HEALTH

Editorial

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"The event helped build bridges over several platforms and individual presentations showed an interesting diversity of work underpinning the development of future foods."

As the holiday season approaches, the Riddet Institute is preparing for its annual influx of visiting scientists and interns from around the world. The presence of students around the institute is always invigorating and adds vitality to what is otherwise a quiet time on a university campus.

The highlights over the past six months include the student colloquium in October, followed by our Riddet Foodlink workshop. The colloquium was held in Palmerston North and attended by an eager group of PhD scholars. The event helped build bridges over several platforms and individual presentations showed an interesting diversity of work underpinning the development of future foods. One of the presentations, on the 'chewing robot', is featured in this newsletter. The Riddet Foodlink one-day event brought together research and technical staff from New Zealand's major food processors and distributors and there were some interesting insights into the issues facing food innovation. Another workshop will be held early next year.

Visiting scientist Professor Doug Dalgleish from the University of Guelph in Canada will be running a workshop on Food Colloids in February. The workshop will be held in Palmerston North and is an in-depth three-day course. More details are on our website.

In April we are holding a one-day summit in Wellington focusing on New Zealand's research and development capability in the agri-foods sector. Professor Aalt Dijkhuizen, Executive Director of Wageningen University and Research Centre (UR) in the Netherlands, has agreed to be our keynote speaker. The Dutch model is very successful and the Food Valley in the Netherlands represents one of the largest clusters of food innovation capability in the world. There has been considerable debate this year about science and its potential to position New Zealand's economy for the future. This summit will attract key people in the sector and there will be vigorous debate about the organisation of our intellectual resources in this area.

In 2010, the Riddet Institute is embarking on a campaign to develop new business in south-east Asia. Led by Dr Shantanu Das, Product Development Manager at the institute, the campaign will focus on Malaysia, Singapore and Thailand.

Finally, it remains to wish all readers a happy festive season.

Paula McCool
Communications Officer,
Riddet Review Editor

Amy Van Wey

First recipient of Earle Food Research Fund scholarship

Amy Van Wey is the first recipient of a scholarship from the new Earle Food Research Fund. From Oregon, USA, Ms Van Wey is based at AgResearch in Hamilton and is undertaking a PhD through Massey University. She graduated with a BA in Mathematics with Honours from Willamette University in Oregon and an MA in Mathematics at Oregon State University.

She will develop a mathematical model integrating the physical and metabolic processes involved in the colonisation of food particles by bacteria in the human bowel. Ms Van Wey is being supervised by AgResearch's Professor Warren McNabb, Dr Tanya Soboleva and Dr Nicole Roy.

Cover image: False-colour scanning electron micrograph of a slice through a raw potato, Solanum tuberosum, showing starch grains, or amyloplasts (red), within their cellular compartments.

Researchers unlock secrets of baked beans

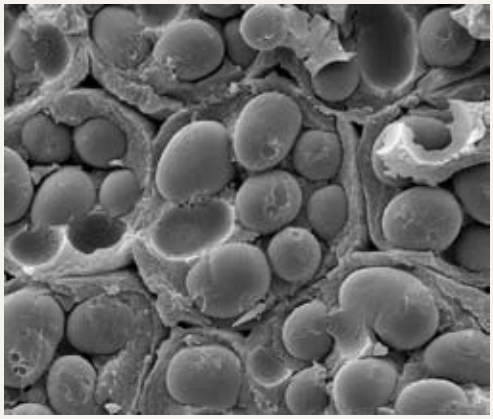


Figure 1: Starch granules in opened cotyledon cells of a raw navy bean.

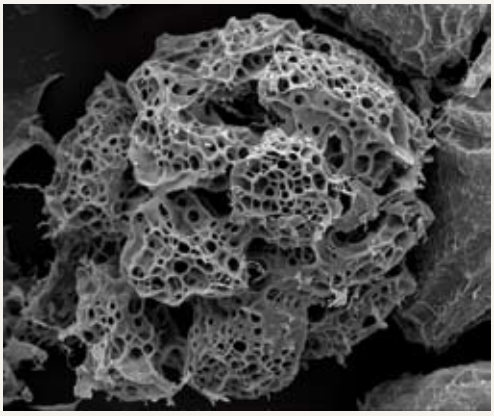


Figure 2: Scanning electron microscopy picture of bean cotyledon cells.

Navy beans are widely grown and consumed in various parts of the world and are a good source of protein (20-38%), carbohydrate (50-60%) and fibre. The Glycemic Index of beans is generally low (~30) so they are regarded as a preferred source of energy. After eating the beans, the postprandial glucose response is moderate therefore immediate, and chronic problems of hyperglycaemia can be avoided.

A team of researchers led by Drs Jaspreet Singh and Mike Boland through experiments with navy beans showed that their cotyledon cells remain stable in terms of shape and general cell integrity during cooking whereas in the raw state, milling disrupts the cotyledon cells of beans rendering the starch granules free in a mix of cell wall and protein body residues. The team further observed that the thick and mechanically resistant nature of the cotyledon cell wall prevents complete swelling of starch granules during cooking (gelatinisation) and restricts their interaction with human digestive enzymes.

The major objective of this work was to study the influence of cotyledon cell integrity on the extent and rate of digestibility of starch in navy beans in a system simulating the human digestive system (*in vitro*).

Techniques such as scanning electron microscopy and comparative particle size analysis were used as tools to observe changes to the surfaces and particle size of intact cotyledon cells during the simulated *in vitro* digestion.

Cotyledon cell walls of navy beans are very stable. They impose restrictions on the swelling and gelatinisation of bean starch granules during cooking at high temperatures (autoclaving). Once cooked the pectinaceous middle lamella which firmly connects cells in raw state is dissolved and the cells are separated rather than disrupted during chewing. It was observed that the incomplete gelatinisation of starch granules reduces the maximum extent of starch hydrolysis during *in vitro* digestion with simulated gastric and small intestinal fluids as measured by glucose release. The intactness of the cells retards the rate of hydrolysis and is therefore very likely to contribute towards the low Glycemic Index of beans. The small surface area of the starch granules, which are tightly packed inside the cells, presumably restricts the free access of enzymes during *in vitro* digestion.

In order to gain further insights, experiments with stored and reheated beans were also conducted. The project is supported by Heinz-Watties NZ and the results are expected to enhance the beneficial properties of the carbohydrates present in beans.

News bites

New post-doctoral researcher from Colombia

Dr Carlos Montoya joined the Riddet Institute in September as a post-doc fellow. He is based in Palmerston North. Originally from Colombia, Dr Montoya completed his PhD in Canada and is an expert in the application of proteomics to digestion. He is currently working on the digestibility of protein and its interface with the gastro-intestinal tract.

New Associate Investigators appointed

Associate Professor Matt Golding and Dr Duncan McGillivray have been appointed Associate Investigators at the Riddet Institute. Matt Golding is Associate Professor Food Formulation and Characterisation at the Institute of Food, Nutrition and Human Health at Massey in Palmerston North. Dr McGillivray is in the Department of Chemistry at the University of Auckland. He was a Rhodes Scholar and completed his PhD at the University of Oxford. His research involves looking at the surface structures of biological systems using surface sensitive methods, particularly neutron and X-ray scattering.

MOU with University of Shizuoka, Japan

In October the Riddet Institute and the University of Shizuoka in Japan signed a Memorandum of Understanding agreeing to collaborate for the next five years. The agreement is with the School of Food and Nutritional Sciences and the School of Pharmaceutical Sciences at the University of Shizuoka.

Cover story

A novel simple chewing robot for food evaluation

Food texture can be measured by either sensory methods or instrumental methods. Although sensory methods enable the direct release-perception tests, there are many limitations such as: they vary from person to person and from time to time; they are generally time consuming, expensive and not subject to absolute standards; they have only a limited capacity for daily sample throughput; and the food sample must be acceptable to panel members.

PhD student, Richard Sun

A number of instrumental testing techniques are available to overcome these difficulties in sensory methods. However, most instrumental measurements of food texture focus on initial food properties and rely on simple crushing. Some robotic devices have been proposed to simulate human mastication but they are either complex in structure or difficult to control.

PhD student Richard Sun and others have come up with a novel simple chewing robot to simulate human chewing behaviour in terms of kinematics and the force applied to the food. Fibrous materials promote a lateral motion to implement a cutting-scissor-like mechanism to break down the food. Brittle foods promote a more vertical crushing motion. Based on this, a 4-bar linkage mechanism reproduces a full range of chewing trajectories of first molar from lateral chewing to vertical chewing in the frontal plane. The chewing robot based on this linkage was able to match the human chewing velocity profile of any trajectory. The robot was able to apply a force up to 150N on the food within the range of measured chewing forces on a single tooth.

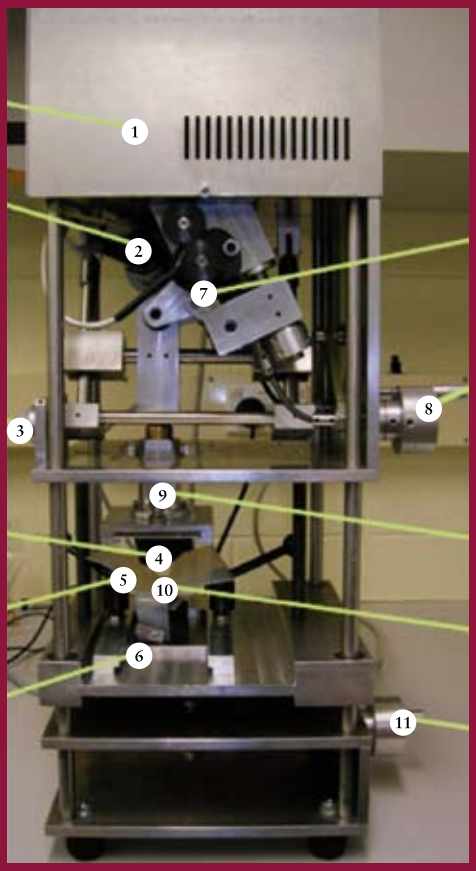
The chewing robot was built with mandible teeth up and the maxilla teeth down for convenience of collecting chewed food particles. Upper and lower teeth consist of two premolars and two molars made of hard durable plastic from a dentistry study model. A plastic enclosure around lower teeth was used to keep food on the occlusal surface during mastication.

An ATI Mini 40 force sensor was installed under the lower teeth to dynamically measure both force and torque in three dimensions.

A set of experiments on one gram of peanut was carried out to examine the reproducibility and sensitivity of the functional parameters of the chewing robot. Chewing velocity of the robot was controlled to match the human chewing velocity profile according to human measurements. 3D force profiles were recorded dynamically for entire chewing cycles and food particles were manually repositioned with a spatula on the occlusal surface to prevent particles from sticking to teeth.

These preliminary results illustrated that particle size distribution of the peanut bolus was more sensitive to chewing forces than shearing angle. It was also found that tongue movement during mastication is crucial for food particle reduction by comparing the results with food particles manually repositioned at various frequencies. The comparison with particle size distribution of peanut bolus from human mastication showed that human chewing results could be reproduced by the chewing robot.

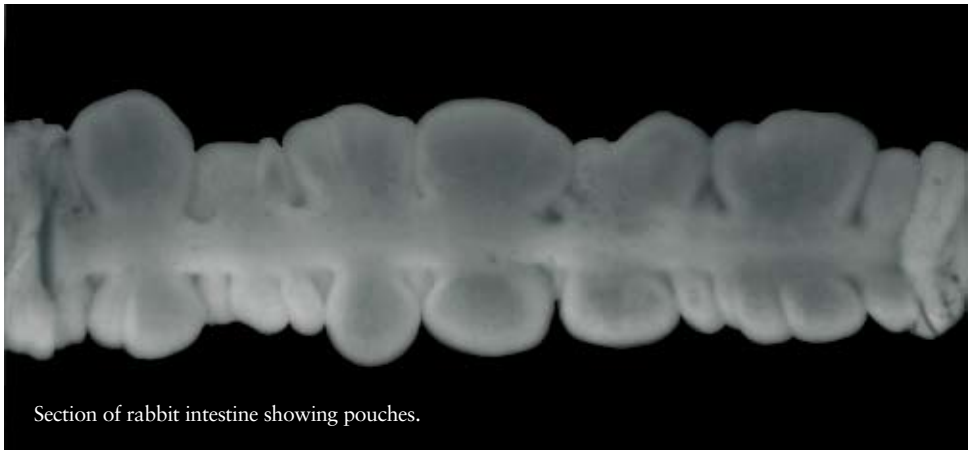
In the future, compliance force control will be implemented in the robot to simulate a human chewing force profile. A food manipulation device will be installed for future improvement to simulate the functions of the tongue during mastication.



The chewing robot using the 4-bar linkage (above)

1. Motor control unit
2. Motor for actuating the mandible teeth
3. Handle for adjusting the trajectory in sagittal plane
4. Mandible molar
5. Food retention system
6. Maxilla molar repositioning table
7. Linkage mechanism
8. Handle for varying the length of ground link
9. Spring-mass system
10. Maxilla molar
11. Handle for the adjustable maxilla

Inside knowledge for better health



Section of rabbit intestine showing pouches.

Professor Roger Lentle is investigating how to physically interfere with the process of digestion so as to slow down the rates of absorption of nutrients and drugs and reduce problems such as excessive pressure in the bowel. As he says, "We would be a lot healthier if we found a way to create foods that look and taste good but are digested slowly, absorbed slowly and processed properly just like the foods our ancestors lived on."

Work on cutting down digestion and nutrient absorption has focused on slowing the rate of emptying of the stomach and impairing the mixing of enzymes with food in the small intestine. Work on the pressure problem has focused on the effects of different types of fibre.

Most foods have insoluble indigestible components which get concentrated as the nutrients get digested and the residue moves down the bowel. Professor Lentle says, "It gets stodgy and thick and paste-like. The problem is that the residues of natural higher fibre and roughage containing foods seem to flow through the lower bowel more easily than our modern day diet which often causes the pressure to go up and the wall of the bowel to blow out. This leads to a condition called diverticulosis, where pouches form – 30 percent of people over 50 have this, which can in turn cause diverticulitis, infection of the bowel. Other symptoms are haemorrhaging and scarring of the bowel. The current work is showing that not all fibres work in the same way to influence flow and pressure, and the jury is still out on which is best. Surprisingly, the work so far suggests there may be big winners and big losers. It might be that not all fibre is good for you.

The work on nutrient absorption and digestion started with studying the rheology and the permeability of different digesta from the stomach and the large and small intestine.

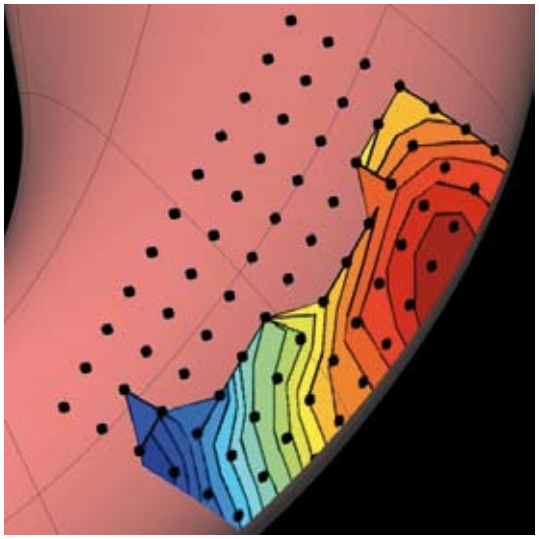
The research moved on to study how animal stomachs and intestines handle changes in the viscosity of digesta. Professor Lentle and his colleague Dr Janssen kept the organs in working condition in tanks, video filmed them and analysed their movements using state-of-the-art spatio-temporal mapping techniques. "This enabled us to see at an organ level how viscous foods are handled," he said, adding "this information is vital for the design of food products that impede flow and for the digestion."

More recently Professor Lentle's team in conjunction with Dr Gordon Reynolds have used a technique called EGG (electrogastrography) for monitoring stomach behaviour in humans. This involved placing electrodes on the belly and picking up the tiny electrical signals that the stomach makes when it contracts. This is making it possible to assess whether a particular food causes the stomach to mix less, work harder, or empty faster.

Further work on the intestine is studying how much mixing takes place alongside villi, the finger-like projections that cover the inner wall of the of the small intestine. "We are using micro-rheometry and other techniques to look at the flows between the villi. If we can interfere with how the nutrients get between the villi, then that will give us a whole new way of changing how much absorption takes place."

Professor Lentle was promoted to Professor at Massey University in October this year. He qualified in Biochemistry at University College London, in Medicine at University College Hospital and obtained his PhD in Ecophysiology at Massey. He spent the early part of his career in the UK Scientific Civil Service working in biochemistry and microbiology at Porton Down (MRE) and in Diving Physiology at the Royal Naval Physiological Lab, Alverstoke, before coming to New Zealand in the early 1970s. A book by Professor Lentle, *The Physics of Digestion* will be published in December next year and is the first review of what is known on the subject. He is also editor-in-chief of the journal *Food Digestion*.

World-leading research on stomach's electrical activity may prevent obesity



Left: Stomach model showing the placement of the electrodes on the stomach and the electrical activity. Right: Dr Greg O'Grady looking at the flexible electrodes, with Peng Du in background.

Peng Du, a PhD student from The University of Auckland, won the top student award at the IEEE Engineering in Medicine and Biology conference in Minnesota, United States for his study using custom-made electrodes to measure the stomach's electrical activity.

The flexible electrodes, which cover about 70 percent of the top side of the stomach, were placed directly on the surface of patients' stomachs while they were undergoing open abdominal surgery.

"Electrical activity in the stomach is very important because it helps control how the stomach contracts and empties," says Mr Du. "This study aims to define what normal and abnormal electrical activity in the stomach is. Once we know this, we hope to develop new tools to better diagnose conditions where the stomach fails to work properly."

Mr Du's research colleague, PhD student and surgical trainee Dr Greg O'Grady, won Best Young Investigator and Best Abstract for his part in the study at the Joint International Neurogastroenterology and Motility meeting in Chicago, Illinois.

"We've been able to show for the first time what the characteristics of the stomach's 'natural pacemaker' are. This information may help plan for the design of new artificial pacemakers for the stomach."

Mr Du says electrocardiograms are routinely used in clinical practice to record electrical events in the heart, but not much is known about the stomach.

"Many people have heard about electrocardiograms and artificial heart pacemakers, but there's been relatively little attention paid to the electrical activity in stomachs. Our study aims to apply the same techniques that have been used to understand cardiac electrical activity to the stomach."

Dr O'Grady says some companies are beginning to develop the equivalent of artificial pacemakers for the heart to stimulate the stomach, but the technology is still in its infancy. He says these companies have shown great interest in this new method of measuring the stomach's electrical activity.

"We've been able to show for the first time what the characteristics of the stomach's 'natural pacemaker' are. This information may help plan for the design of new artificial pacemakers for the stomach."

Dr O'Grady says there are two main reasons for wanting to stimulate the stomach. "One is to restore the stomach's normal rhythm, such as for patients who have diabetic gastroparesis, in which dysfunction of the stomach muscles delays the passage of food through the stomach. The other is to slow down the rhythm of the stomach to make people feel full for longer, and possibly offering a treatment for obesity."

Mr Du and Dr O'Grady travelled to Mississippi in the United States in October to record the stomach's electrical activity in patients with serious stomach problems.

The research is being supervised by University of Auckland Professors Andrew Pullan and John Windsor. Professor Andrew Pullan is a Principal Investigator at the Riddet Institute.

Foods that increase the feeling of fullness

Sylvia Chung

Sylvia Chung is from Mauritius and is studying for her PhD supervised by Professor Paul Moughan at the Riddet Institute, Massey University, Palmerston North. She earned her Bachelor's in Bio-medicine from the University of East Anglia in the United Kingdom and began her PhD study in NZ in 2005. Mrs Chung is working on energetics and satiety in humans and is investigating the effect of milk proteins on food intake and satiety in human subjects.

Protein is often considered the most satiating macronutrient and a recent study by PhD scholar Sylvia Chung explored whether whey proteins enhanced satiety compared with carbohydrate. The study (Mrs Chung's first paper) was published this year in the *Journal of Physiology & Behaviour* and entitled "The influence of whey protein and glycomacropeptide on satiety in adult humans".

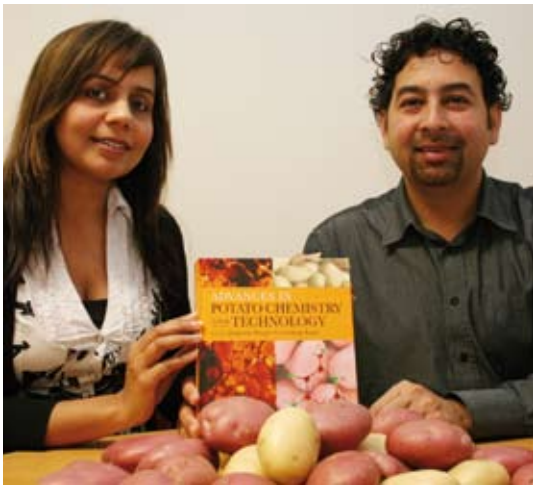
The paper covers Mrs Chung's first human trial to determine the short-term effects of mixtures of whey protein and glycomacro-peptide (GMP) versus a carbohydrate control on satiety in healthy adult humans.

In the trial 50 subjects received a preload drink with either carbohydrate or whey protein isolate.

The results of the study suggest that whey with GMP had an effect on the feeling of fullness but this did not translate into a lower food intake at the lunch meal. Further work is required understanding dose of protein, delivery mode of preload and timing between preload and subsequent test meal. The pattern of release of cholecystokinin and other signals of satiety would also assist in understanding the satiety response of protein.

This paper has led to an invitation for Mrs Chung to prepare a review article for the book *The Handbook of Behavior, Diet and Nutrition* to be published by Springer, one of the world's leading academic book publishers. It will cover all aspects of neurology, behaviour, nutrition and diet, and will be published in early 2010. Mrs Chung's chapter is entitled "Whey protein and satiety: implications for diet and behaviour".

New book tackles potato chemistry



A new book brings together leading research on the chemistry and technology of the potato.

Advances in Potato Chemistry and Technology edited by Dr Jaspreet Singh and Dr Lovedeep Kaur covers the role and importance of chemistry in determining the processing quality and nutritional value of potatoes.

Dr Singh says that until now there has been a gap in the literature relating to potatoes. "Other books have focused on biology or agronomy, but this book collects the latest work on the technology and chemistry of the potato," he says.

Its major focus is on recent information related to carbohydrate and non-carbohydrate composition, cell wall chemistry, analysis of glycoalkaloids, phenolics and anthocyanins, thermal processing and quality optimisation, new and sophisticated methods of quality determination of potatoes and their products, potato starch characteristics and its modification and nutritional value of potatoes.

One chapter is written by a scientist from NASA that explores the potential of potatoes in space exploration.

The book was published by Elsevier-Academic Press (USA).

This newsletter is produced twice a year and is available from our website **www.riddet.ac.nz**

If you would like to be on our mailing list please contact:
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Awards and achievements

Dr Aiqian Ye was awarded the Massey University Research Medal – Early Career. The presentation was made at the university's annual research medals ceremony in October. His research includes the behaviour of food structure during digestive processes and the relationship between the physical properties of food components and nutrition.

Principal Investigator **Professor Andrew Pullan** of the University of Auckland has been elected a Fellow of the Royal Society of New Zealand.

PhD scholar **Anwesha Sarkar** received the 6th NIZO Elsevier Young Scientist Award for the best presentation at the NIZO Conference in The Netherlands held in October. Ms Sarkar received 1,000 Euro from Elsevier Publications, a one year *International Dairy Journal* subscription and free entry to an NIZO course. NIZO food research is one of the most advanced, independent contract research companies in the world.

Associate Investigator **Roger Lentle** has been promoted to Professor. Professor Lentle is based at the Institute of Food, Nutrition and Human Health at Massey University in Palmerston North.

Professor Paul Moughan has been appointed co-chair of the Organising Committee for a scientific symposium on protein hydrolysates to be held by the Association of Official Analytical Chemists, Orlando, Florida in 2010.

In November **Professor Harjinder Singh** completed a series of lectures on food science at Kumamoto University in Japan. He has been appointed a Guest Professor at the University's Graduate School of Science and Technology.

What's on

Food Colloids Workshop 15-17 February 2010

Riddet Institute, Palmerston North.
Tutor: Professor Douglas Dalgleish
University of Guelph, Canada.
For more details go to **www.riddet.ac.nz**

The Riddet Institute Scientific Advisory Panel will make its first official visit to the institute between 8 and 11 February 2010

The Riddet Institute is hosting four visiting scientists over the summer months

Professor Emeritus Jim Harper, Ohio State University, USA
Professor Emeritus Andy Rao, Cornell University, USA
Dr Devinder Kaur, Punjab Agricultural University, India
Professor Emeritus Douglas Dalgleish, University of Guelph, Canada

Agri-Food Summit 14 April 2010

Positioning New Zealand's Resources in Education and Research
Massey University, Wellington

Riddet CoRE Researchers Conference 28-29 June 2010

Sports and Rugby Institute
Massey University, Palmerston North

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