National Research Centre for
GROWTH AND DEVELOPMENT

2010 Annual Report

He Timatanga ora

A healthy start for productive lives

Contents

Report from the Chair and Director

The National Research Centre for Growth and Development (NRCGD) has undertaken a significant process of self-assessment during 2010. This included the preparation of a mid-contract report to the Tertiary Education Commission (TEC) as we approach the mid-point of our six-year funding contract (2008–2014), and planning the process to determine the Centre's major research project investments for the 2012-2014 period.

The self-assessment necessary to evaluate our performance to date and to refine our future strategy included a review by our Scientific Advisory Board (SAB), chaired by Professor John Funder, and completion of our strategic plan for 2012–2014. We are grateful to the SAB for the time and effort put into this review, which highlighted our culture of collaboration, especially at the international level, and identified the NRCGD as a key enabler of cultural change through innovation. The SAB also endorsed our new approach to supporting postgraduate training, which involves the establishment of a fund to provide stand-alone premium scholarships to top students.

These features align well with the purpose of the Centres of Research Excellence (CoREs) Fund, which is to conduct excellent research as well as to contribute significantly to human capital development, including through training and leadership development. The CoRE model is now established in Government's thinking, but it is still maturing. Government remains focused on outcomes and the Centre's goals of optimising health outcomes and increasing agricultural productivity through a healthy start to life are highly relevant in difficult economic times.

The mid-term review by TEC has now been completed, and we are pleased to have had positive reports from TEC and their external reviewers and to have received confirmation of ongoing funding at the originally indicated levels. The TEC Board of Commissioners particularly noted how successful the CoREs are; the Board endorsed the direction of our Centre's research and the high value that we place on human capital development through provision of a diverse range of training and development activities for our investigators and students.

A new initiative for the Centre in this area was the establishment of a scientific writing retreat for postgraduate students, led by Professor David Lindsay, a new member of our SAB. This retreat was a great success, and we are sure it will become a regular and popular feature of the NRCGD annual calendar.

Another popular annual event is our Scientific Symposium. In 2010 this was held immediately following the SAB review and was attended by the majority of our members and students. Presentations were largely from postgraduate students and were of excellent quality, making judging the best presentation an unenviable task.

These events, plus the extensive inter-site travel which occurs throughout the year as investigators meet more informally to share ideas and findings, have demonstrated to us that NRCGD members are very positive in their approach to the Centre. It is clear that integration and participation continue to increase as members fully appreciate the benefits that membership of the Centre brings. The flexibility of the funding model allows CoREs to actively facilitate communication, interaction and collaboration across sites; this is a fundamental and essential feature of CoREs and is key to their success.

The positive, vibrant feel within the Centre, despite the lengthy process of appointing a permanent successor to Sir Peter Gluckman as Director, demonstrates that we are now a firmly established and robust virtual institute. Nevertheless, we fully appreciate the importance of the appointment of a permanent Director and are resolved that this should be the right appointment, even if this results in a relatively lengthy appointment process.

supported by Ministry for Science and Innovation funding, has been established to provide a national infrastructure to accelerate New Zealand's genomic research and technology. NZGL will provide the opportunity to access cutting edge technology and bioinformatics support at affordable rates and therefore presents a great opportunity for our investigators. We aim to increase our ties with our fellow CoREs, both through translational initiatives and also through new collaborative research projects. As our research matures we anticipate greater investment in clinically-focused research to translate some of our findings from more basic research into the clinical arena. We look forward to contributing to the ongoing development and maturation of the CoRE model and to responding to TEC's vision for CoREs after 2014.

Membership of the NRCGD presents an opportunity to be part of a body of investigators with commitment to a cohesive programme of activities encompassing excellence in research, collaboration, translation of knowledge to a wide audience

"As the Centre continues to mature we are seeing continued growth in the closeness of collaboration and the drawing together of different disciplines."

The Centre has also been building its international links and has well-developed collaborations around the world. For example, we continue to work with a large international collaboration, including researchers in the United States, Jamaica and South Asia, to investigate the economic benefits of a healthy start to life. Our research into how nutrition during early development may impact on later life encompasses a range of organisms from bees to large mammals and humans and has resulted in key publications with international collaborators.

As the Centre continues to mature we are seeing continued growth in the closeness of collaboration and the drawing together of different disciplines. A particular strength of the Centre is the breadth of expertise of its investigators, but we are also aware that this breadth necessitates constant focussing on our goals to ensure we deliver on our potential and continue to contribute effectively to maximising economic benefit and optimising health outcomes. This past year has seen translation of some of our basic research into clinical trials and extension of translation of knowledge through educational outreach to the farming sector. Our members are involved in a wide range of activities disseminating knowledge from our research programmes, including Ministry of Health working groups, industry interactions and regular dissemination to healthcare professionals.

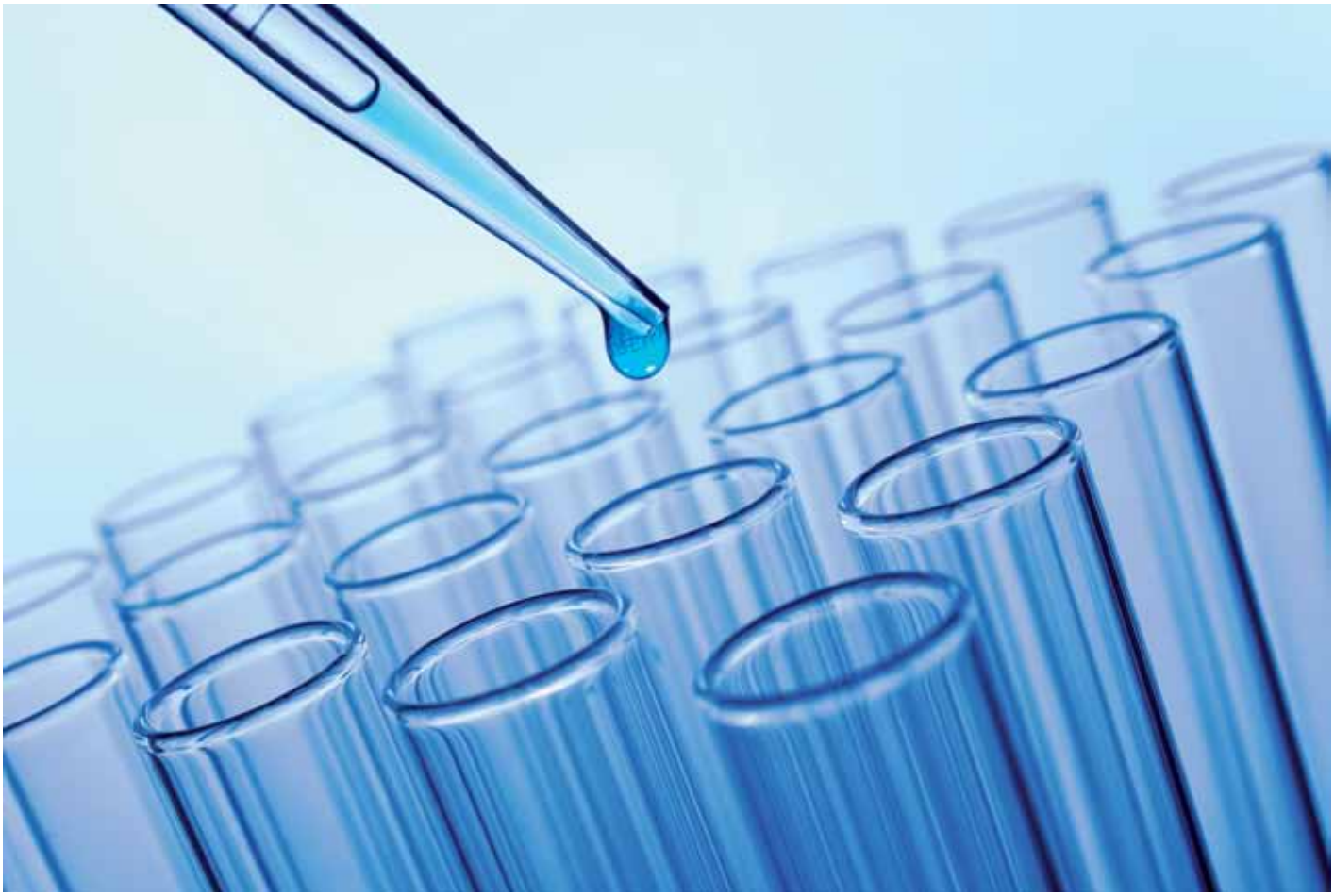
The next three-year period presents a variety of opportunities for the NRCGD. Molecular biological techniques are becoming ever more powerful, opening up new possibilities for research. New Zealand Genomics Limited (NZGL), a consortium of New Zealand universities and Crown Research Institutes

and the privilege of being involved in a variety of initiatives aimed at human capability development. We believe that the CoRE funding model, which favours flexibility and significant investment in infrastructure, is essential to CoREs' success. We are grateful to all the members of the NRCGD, our host and partner institutions, the SAB and the Board for their commitment to our vision. We look forward to continuing to mature as an organisation and to contributing to New Zealand's productivity, human health and development.

Alison Paterson
Chair, Board of Governance

Frank Bloomfield
Acting Director

A unique focus: the work of the Centre



The National Research Centre for Growth and Development (NRGCD) brings together leading scientists from across New Zealand to investigate how the conditions encountered in early life affect the way an individual grows and changes throughout the life-course.

Many of the underlying processes that govern the way an individual develops are common to all mammals. The NRCGD combines the research potential of clinical, biomedical and agricultural scientists to advance our understanding of these shared processes and to measure their implications both in human health and agricultural contexts. Through this work we aim to assist the development of new approaches both to improved human health and to increased productivity in our pastoral industries – issues of strategic importance to New Zealand that are linked by the biology of mammalian development.

The NRCGD receives Government funding as one of New Zealand's eight Centres of Research Excellence (CoREs). The CoRE model is based on collaboration to support excellent research in an area of national importance; CoRE funding allows the NRCGD to mobilise leading research expertise from The University of Auckland, Massey University, the University of Canterbury, the University of Otago and AgResearch to create a multi-disciplinary "virtual institute" investigating the biology of growth and development in both animals and humans, and to support active collaborations with world-class researchers across the globe.

The Centre's research effort is focused around the phenomenon of developmental plasticity – the ability of a developing organism to respond to environmental cues received early in life in subtle yet persistent ways, with implications throughout the life of the individual and perhaps throughout the life of the next generation as well. A growing body of research suggests plastic responses in early development contribute to the rising incidence in humans of obesity and its related diseases and influences growth potentials in lambs and calves. Thus, two apparently disparate areas of great importance for New Zealand society — human health and agricultural productivity — are fundamentally linked by the concept of plasticity and its implications for the mature human or animal. It is the appreciation of this link between early life and later health or productivity that drives the Centre's science.

The NRCGD's activities extend well beyond those of a traditional research institute. The multi-site and multi-disciplinary nature of our Centre enable us to provide a training environment for young and emerging scientists that is rich in the quality and breadth of opportunities that it provides. It also has enabled us to create an integrated suite of research activities that spans conceptual,

evolutionary, physiological and molecular studies of mammalian growth and development through to translational and evaluative research activities. These are linked to innovative science education and knowledge transfer initiatives that build scientific literacy and health awareness in our communities, and inform change in the health, agricultural, public policy and education sectors.

The insights gained through the NRCGD's work will lead to new therapeutic and public health policy approaches for improved health and well-being for all New Zealanders.

Focus on developmental plasticity

To fully understand plasticity and its implications we must understand its evolutionary origins and its fundamental biological mechanisms, which operate in many species. The Centre incorporates advanced conceptual and experimental studies to reveal the details of these underlying processes. These include studies in invertebrates that provide new insights into the origins and inner workings of plastic responses in humans and pastoral animals.

"At the heart of the Centre's approach is an unusual combination of agricultural and biomedical research expertise."

For farmers, the NRCGD's unique approach is contributing to better livestock management practices for improved productivity in the pastoral industries that are the cornerstone of New Zealand's economy.

As a CoRE we measure our success in terms of five fundamental indicators:

- the scientific quality and impact of the research we undertake;
- the Centre's standing and level of participation as an international collaborative network;
- the actual and potential application of our findings for improved human health and agricultural productivity;
- the impact of our education and outreach initiatives on scientific literacy and health awareness in New Zealand communities;
- the quality of the scientific training opportunities and new research capability we provide.

In the following pages we profile some of our research and activities to demonstrate the ways in which we are addressing these goals and the distinctive features that make the Centre's approach unique.

Collaboration across boundaries

At the heart of the Centre's approach are collaborations that cross the usual disciplinary boundaries. One strong partnership developed through CoRE funding is that between clinicians based at The University of Auckland and animal scientists at Massey University; both research teams study gestation in sheep in order to better understand fetal growth both in pastoral animals and humans. Other examples include collaborations between developmental geneticists and nutritional ecologists, between epidemiologists and economists, between chemists and physiologists, and between mathematicians and molecular biologists.

Communicating to the communities

We recognise that an important way we can contribute to health and agricultural performance outcomes is through supporting informed choice in a range of audiences (rural professionals, healthcare providers, educators, families and young people). The innovative outreach programmes we invest in, such as the LENScience programme at The University of Auckland, make our science and its key messages available to these groups and builds scientific literacy to empower future choices.

Influencing public health policy

The Centre advocates a fundamental shift in health policy emphasis – from responding to poor health outcomes in later life toward facilitating the best possible start to life. The NRCGD-funded "International Healthy Start to Life" project aims to support this position by providing robust data on the lifetime economic costs of a poor start to life, compared to the costs of mitigating the early-life factors that contribute to ill-health in later life.

Building new research capability

The NRCGD's research covers a complex area of biology and demands access to advanced infrastructure. As a collaborative network, the Centre has the capacity to pool resources across participating institutions and, through CoRE funding, to invest in unique new technology platforms. NRCGD resources have contributed to the development of distinctive new technology platforms and clusters of expertise to support our research.

Postgraduate incubator

The Centre provides a rich environment for postgraduate training and early-career development, thanks to the opportunities it offers scientists-in-training to become involved in high-quality collaborative projects. We provide dedicated funding to ensure that our young and emerging scientists gain the maximum benefit from their exposure to our international networks and advanced infrastructure.

Collaboration across boundaries

The size of an individual at birth makes a difference — and figuring out which factors affect this basic indicator, and when, is of keen interest to the health and agricultural sectors alike. NRCGD research addresses this question, as well as many others, through novel and complementary approaches.

Birth-weight is an important indicator of lifelong health. Low birth-weight due to restricted fetal growth affects a person throughout life — even if they attain normal weight levels after birth. It is associated with a greater risk of later-life diseases such as type 2 diabetes, obesity, and cardiovascular disease, and it may also affect cognitive function. Low birth-weight female babies may have smaller offspring when they themselves become mothers.

In the agricultural context, an improvement in lamb mortality by one percent would be worth millions of dollars to New Zealand. With small lambs most at risk of dying in the perinatal period, it follows that bigger lambs mean more money for the rural sector and greater GDP for New Zealand.

Currently two quite different studies supported by the NRCGD are endeavouring to discover signals that might lead to low birth-weight. One, led by Auckland neonatologist and NRCGD Acting Director Frank Bloomfield, considers birth-weight in twin- versus singleton-born lambs. There has been a common perception that the growth and gestation length of twins is limited by the capacity of the maternal womb, but Frank's work suggests that length of gestation and birth-weight are actually determined early in pregnancy, while the fetus is still very small.

A complementary study led by Massey University scientist Hugh Blair, the NRCGD's Associate Director, Animal Sciences, explores the effects of the physical size of the ewe on birth-weight. Hugh's work uses embryo transfer between different sheep breeds to examine fetal growth in a constrained environment by transferring embryos from large Suffolk ewes into small Cheviot ewes.

Both studies have relevance both to animal productivity and human health, because the incidence of twins is increasing in both the agricultural and human contexts. On the farm, a preference for twin lambs is driven by productivity targets because they offer a higher return from constrained resources. In the human setting, rising average maternal age and increasing demand for in vitro fertilisation means multiple births are becoming more frequent than in previous generations. Maternal size is also an important factor in common, whether due to different breeds in sheep or to dieting or obesity in women.

"Understanding the signals which may lead to lower birth-weight might mean we can discover ways to increase birth-weight," says Frank. "We might be able to send the ewe a signal that will improve the growth of the lamb in utero and therefore increase the likelihood of its survival. Similarly, in humans, there may be simple interventions or behaviours for women of child-bearing age that could optimise pregnancy outcomes with benefits for the health of the children throughout their lives."

This cross-discipline collaborative work by Hugh Blair and Frank Bloomfield illustrates the way in which the NRCGD brings together traditionally separate disciplines and research programmes that share common interests. "The underlying biology of early life in animals and humans is very similar. When you are look back toward the science – the physiology and gene expression completely overlap," says Hugh.

Hugh's messages are directed at rural professionals, and his team has built up strong connections with this sector. "We are closely linked to the agricultural community in New Zealand – it's very likely that one of us would be out talking to various industry groups at field days, workshops and conferences most weeks," says Hugh.

The Massey NRCGD team is now working on a programme establishing intensive farmlets which integrate component research into a production system with a few tens of sheep. These mini-farms will be used to support outreach courses with groups of rural professionals.

"There is some information out there which suggests that the traditional way of moving knowledge to farmers, such as posting a DVD or printed material, is inadequate," says Hugh.

"The underlying biology of early life in animals and humans is very similar. When you look back toward the science – the physiology and gene expression completely overlap."

"We can join forces to design experiments that answer questions for both animals and humans," says Frank. "Meanwhile the Centre's research into the fundamental mechanisms of plasticity, which brings to bear sophisticated molecular biology techniques to reveal the pathways through which nutritional signals in early life affect later outcomes, can help researchers such as Hugh and myself know where to look for changes in animals or humans. Some of the research might look disparate but it all dovetails together."

Sharing intellectual expertise and experimental design is only part of the interplay among the researchers. Optimising the use of specialist resources, such as the Liggins Research Farm at Ngapouri in the central north island and Massey's research farms and veterinary facilities, is also of critical advantage.

Findings about the implications of events in early life such as twinning, nutrition, exercise and maternal age are shared widely across networks. "It's here at the point of outreach that we start heading off in different directions," says Hugh.

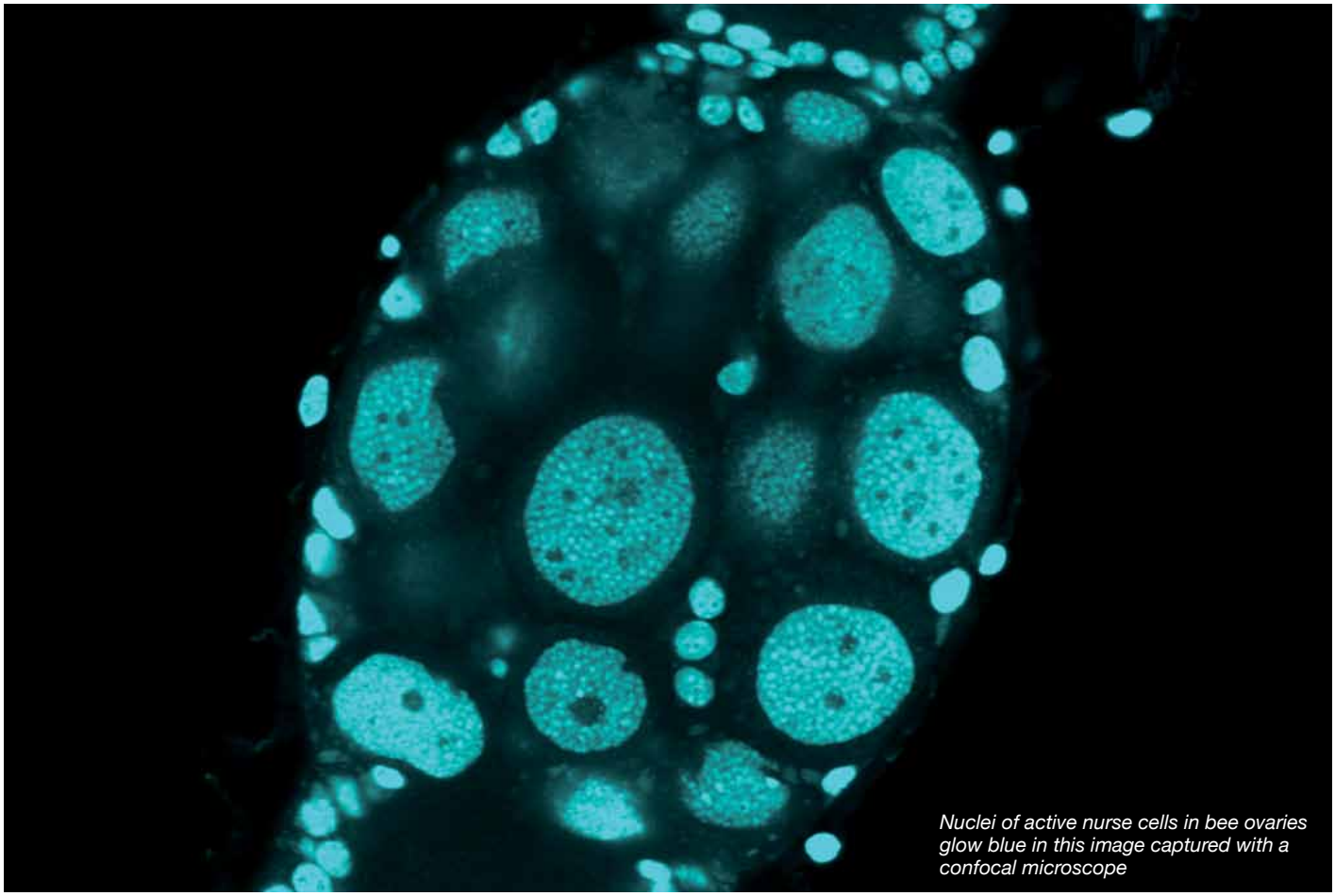
Frank's outreach targets the healthcare sector: medical professionals, midwives and policymakers. "NRCGD research points to the need for a re-think in antenatal care," he says. "It is clear that the nutritional state of a mother at the time of conception may have consequences for the pregnancy and for the health of the children. In practical terms, this means that women who become pregnant may benefit from contact with their lead maternity carer much earlier than currently happens; the early stages of pregnancy, and indeed the pre-pregnancy period, are very important."

"Those techniques are very poor at changing farmer behaviour. So we've invited the social scientists to watch what we do and to research the way in which these rural professionals learn. The ultimate quest is to change on-farm behaviour."

What we know:

- the individual's long-term growth pattern and developmental trajectory are set very early in pregnancy
- the nutritional state of a mother at the time of conception may have consequences for the pregnancy and for the health of the offspring

Focus on developmental plasticity



Nuclei of active nurse cells in bee ovaries glow blue in this image captured with a confocal microscope

While genes set the overall range of outcomes possible for an individual, the environment plays an enormous role in shaping what we actually become. The conditions the embryo or fetus encounters during development appear to cause persistent changes to the way an individual grows and responds to future environmental cues, and this has implications for health throughout life.

Most organisms exhibit developmental plasticity – the capacity to alter the way development proceeds in response to experiences during early life. One of the implications of developmental plasticity is that obesity and associated disease might be about more than diet and exercise. It may be that changes in our physiology, consequent upon experiences during pregnancy and early life, leave us less able to cope with the sedentary, food-rich lifestyles that at the same time are becoming more prevalent – a kind of "double whammy". If we can understand how plastic responses are triggered, how they work, and their later consequences, we might be able to predict, and perhaps change, our susceptibility to later ill-health.

To achieve this we need a deep understanding of plasticity: How is it triggered? Why does it occur? What molecular mechanisms are involved? How are plastic outcomes maintained? The answers to these questions will provide an enormous boost to our attempts to manipulate plasticity to improve animal production and human health. The bad news is that plasticity is complex and subtle and is thus very hard to study directly. The good news, however, is that plasticity is everywhere – so we can look to simpler life-forms that exhibit extreme cases of plasticity to learn about the shared genes and processes involved. In Peter Dearden's laboratory at the University of Otago, experiments with honey bees are shedding light into some of the complex puzzles of human reproduction and animal husbandry.

As a developmental geneticist, Peter's interests focus on the ways in which the actions of various genes together produce the characteristic physical and physiological features of an animal. Although the genetic code that a species carries sets the ground rules for development, honey bees provide a commonplace yet extreme example of plasticity in action. Honey bee queen and workers are both female, but one caste is long-lived and extremely fertile, while the other is short-lived and sterile – and these differences are entirely due to the diet the bees receive as larvae. Thus, a nutritional signal at the earliest stage of development has profound effects on the development of the organism.

Moreover, although these differences are persistent, they are not irreversible. "The really amazing thing is that if you take the queen out of the hive then workers will begin laying eggs. It's entirely due

to a pheromone that the queen produces which represses the reproduction activity of the worker bees. It's a huge plastic event," says Peter.

Although the effect of early-life nutrition on development of bees is an extreme example of developmental plasticity, the same principle appears to apply in more complex organisms such as mammals, including humans. NRCGD research has shown that nutritional signals around conception have lifelong effects in rats and in sheep; emerging evidence suggests that plastic responses with significant implications for health occur during the early-life period in humans as well. By studying other organisms, the Centre's researchers are able to ask questions about how the fetus responds to specific signals.

"We are beginning to understand what happens to the cells and what activates the ovaries to bring about the plastic response, which genes are involved, how they are changing and what the consequences are of those changes," says Peter. "It's the beginning of a process of looking at how we might overcome environmental factors that could affect human fertility and animal reproduction."

The Centre's research, combining work from bees, rats, sheep and humans, suggests that before birth a fetus responds to cues derived from its developing environment. Depending on the nature of these responses, permanent changes in an organism's postnatal physiology may result, leading to lifelong effects on growth, energy use and reproduction. "Both maternal undernutrition and high-fat intake during pregnancy and lactation advanced the age of puberty in our rat studies and was linked to signs of premature ovarian ageing," says Deborah. "Human studies also have shown a link between prenatal adversity and early puberty. Through our research, we hope to reveal the mechanisms underlying these changes."

"The cooperation between scientists working with quite different organisms is one of the most exciting and rewarding aspects of the NRCGD for me," says Peter. "Some of the mechanisms we study are present in all animals. They are of interest across the

"It's the beginning of a process of looking at how we might overcome environmental factors that could affect human fertility and animal reproduction."

The Centre aims to draw out general ideas of how plasticity works in order to identify and understand the corresponding mechanisms in humans. To this effect, collaboration with animal- and human-focused research teams across the NRCGD is happening constantly. Deborah Sloboda and Mark Vickers at the Liggins Institute, The University of Auckland, undertake research in small animals to study the effects of differing maternal nutritional intakes during gestation on the offsprings' metabolic and reproductive development. "We now know that rats born to maternally-compromised females are obese, insulin resistant and metabolically-compromised as adults," says Mark. "These changes are present during fetal life and are associated with changes in placental development, providing insight into how maternal nutritional compromise can affect offspring development." The Centre's research suggests that some aspects of metabolic dysfunction arising from plastic responses can be ameliorated via targeted intervention during early life; the mechanisms underlying these observations are now the focus of further investigation.

In addition, via collaboration with applied mathematicians Tony Pleasants (AgResearch) and Graeme Wake (Massey University), mathematical models of the patterns revealed through the Centre's research into plasticity have been developed. These provide further insights into the biological responses that underlie the changes observed.

CoRE so we can say, 'These are the things that are happening in insects…are the same things happening in other systems?' And the flow of information goes both ways – when animal researchers have evidence that particular genes are involved in a process, we can corroborate that or identify the most important sets of genes in our system and direct our colleagues to look in that direction."

The "wingless" development gene is active in precise locations on the torso of this honeybee embryo

What we know:

- dramatic differences in the characteristics of an individual can be generated through nutrition during early development
- the results of plastic responses are persistent but not irreversible

Influencing public health policy

A challenge for scientists and researchers is being able to speak the right language when it comes to communicating their research findings. This is especially true when the results are to be communicated to those capable of influencing policies that can improve population outcomes.

The NRCGD invests in the Auckland-based International Healthy Start to Life (IHSL) project, which aims to place an economic value on a healthy start to life. “It is the protective fence at the top of the cliff rather than an ambulance at the bottom of it,” says Susan Morton, Director of the IHSL programme.

“We’re looking to find a quantifiable way to demonstrate that children with a less than ideal start to life could potentially grow up to be less healthy and productive; this could very well translate on to their own children,” says Susan. “We know that it is more cost effective to prevent health and other issues occurring in the first place, than it is to treat them once they have happened.”

The IHSL programme was launched after an analysis undertaken by two economists at the World Bank (still with the IHSL project). By undertaking a literature review, they estimated the dollar benefits of moving an infant born in a developing country from a low birth-weight status (less than 2,500 grams at birth) to the normal birth-weight range. They found that the majority of the gains come from increased labour productivity in later life rather than from avoidance of infant illness. Aggregating these estimated benefits, they concluded that the economic benefit of moving an infant out of a low birth-weight status was $510 (US).

Any intervention that could achieve this outcome for less than $510 per infant would therefore be justified on economic grounds. The IHSL project builds on the extensive evidence from other NRCGD projects, especially the work led by Professor Sir Peter Gluckman, which indicates the importance of the intrauterine environment for shaping lifelong developmental outcomes and considers at which point, in the life course of a child, intervention would work best.

The challenge is being able to apply econometric modelling to longitudinal population information and then translate the results into the language of policy makers. “We are scientists, economists, researchers and epidemiologists so we don’t necessarily speak the language that politicians and lobbyists understand. We wish to put an economic cost on a poor start to life, by translating the scientific or biological evidence that suggested that early-life development was important for later-life health into a dollar value. This would demonstrate the risks and costs of not intervening at those early-life stages,” says Susan. “It’s about discovering where the resources available to us could be put to best use. For instance, should we put our resources into providing free health or other care services in a similar fashion to how the Whānau Ora system operates?”

The strength of the programme lies in the collaborations that it has managed to create with internationally respected research teams such as the one led by Nobel Laureate, economist James Heckman in Chicago.

"We have developed partnerships with international researchers and bodies with an interest in what we're doing and who have longitudinal population data available to assist with the modelling. These relationships have to be strong; we continue to develop them because we're asking them to provide us with intimate data unique to their own population," says Susan. The study now has agreements to utilise longitudinal data from Brazil, Jamaica, Pakistan, Singapore and Scotland.

The research process requires the development of economic models that account for the information available from the longitudinal studies – no small feat when you consider the breadth of data the team have available to them. These models will be more complex than simple supply and demand formulae. "This sort of cross-disciplinary work is very hard to explain conceptually because it doesn't just sit in one silo," says Susan. "It doesn't just sit in 'health', it recognises that health is just one of the considerations and has an effect on other contexts such as social surroundings, education or family and whānau networks.

"Trying to develop economic models that reflect the interplay of all these variables is a challenge. Many of the economists we approached struggled with the uncertainty that exists over causal relationships in epidemiology and public health. Establishing relationships with the individuals and the organisations that are on board has been a highlight for us. The next phase of the project will involve validating the economic models that we've created with the longitudinal population data that have been made available to us, and in particular making sure that they will be applicable for the current New Zealand population.

"The translational aspect of our work involves taking the scientific data that have been collected and making them into a more contextual scenario for the end-user, whether that is Members of Parliament, government departments, or people who have children or may have them one day."

The project is international and will provide a modelling framework applicable across different countries and population contexts. Results will be tailored to each of the participating countries. For New Zealand, it is the same – the output will be referred to in conversations with those who hold influence over policy.

These have already begun with the Ministry of Health and the Ministry of Social Development, both of which are keen to follow the progress of the research.

The desired outcome is to have policies in place that recognise the importance of investing in early-life development, whether this be ensuring that the health of the mother is at an optimal level before the birth of their child or making sure there is a supportive environment in the early stages of the child's development.

"The challenge is being able to apply econometric modelling to longitudinal population information and then translate the results into the language of policy makers."

"We're trying to develop an integrated policy context informed by robust scientific evidence to ensure that kids have the best possible start to life because that's what's going to give them the best possible future," says Susan. One approach to reducing the costs identified by the IHSL project may be through adolescent education intervention; the potential of this approach is currently being investigated through the LENScience Adolescent Education project.

What we know:

- A poor start to life results in impacts throughout the life-course
- Early intervention is more effective than later response to ill-health (both in economic and well-being terms)

Communicating to the communities

The NRCGD takes a "bottom-up" approach to communicating its researchers' findings to healthcare providers, rural professionals, educators and families. We recognise the importance of building scientific literacy in our audiences to empower informed choices.

One of the last things you would expect from a young teenage boy would be for him to seat himself at the dinner table and say, "Mum, I'm not eating that for dinner – it's rubbish! Our family's eating habits aren't healthy and I'll show you why." But this type of dialogue is just what the LENScience team would like to hear more of – because it is indicative of both their purpose and their successes to date.

A University of Auckland initiative, LENScience aims to improve the scientific literacy of Year 7–13 school students by giving them exposure to current scientific thinking and to New Zealand scientists. It consists of seven interrelated educational programmes available to students across the country in a variety of formats. The NRCGD is the largest single funder of the initiative, directly funding three programmes; many of the Centre's academics also contribute to its success.

One of the more notable projects that has arisen through an NRCGD-funded seeding grant is the Māori and Pacific Initiative (MPI). This programme, now funded by Te Puni Kōkiri with support from the NRCGD, aims to address the underrepresentation of Māori and Pacific Island students in science or health science-related degrees and the over-representation of Māori and Pacific Island peoples in poor health statistics.

From 2007 to 2009 the NRCGD funded the MPI pilot programme targeting low-decile secondary schools, mainly in South Auckland, with high proportions of Māori and Pacific Island students.

"When we launched the programme we were hoping to find twenty schools to be a part of it," says Jacquie Bay, Director of LENScience. "The programme received such a great profile that we had to restrict the intake to twenty-five actively engaged schools – we could easily have had more if we had the facilities and resources to accommodate them."

The NRCGD-funded Healthy Start to Life Adolescent Education project is exploring ways of implementing change that will improve human health through a better start to life. Underpinning this project is an understanding of the importance of scientific literacy for 21st century society, the need for contexts to be made accessible to schools by scientists, and the need for specialist education expertise in the development of contextualised resources. The project aims to provide learning experiences that will support understanding of science and how science works, to enable lifelong learning that will support health and well-being.

Evidence that the early-life environment influences health and well-being throughout life, and specifically the risk of non-communicable disease in adulthood, underpins the contexts that have been selected. It is known that adult diet and lifestyle are influenced by the adolescent experience; therefore we suggest that adolescence is one stage in the life-course where appropriate educational intervention could potentially influence future health for the student and their potential future offspring. The learning resources provided within the project have evolved from work that started in 2006 at the Liggins Institute, The University of Auckland. Trials with students from Year 7 – Year 13 in a range of schools in New Zealand led to the development of the current learning resources. NRCGD-funded research is now evaulating the effectiveness of these resources in assisting the development of understanding of the nature of science, and key life competencies (as defined by the OECD DeSeCo project), and in assisting students in using scientific understanding in personal decision-making related to health and well-being.

At first glance, the simple benefit and purpose of the LENScience initiative is more students studying science or health science-related programmes at a tertiary level – but that isn't the sole objective. It is about changing perceptions of science, effectively communicating the relevance of scientific findings and developing a trust of scientific process, thereby enabling the future generation to make informed decisions about issues that may affect their health and well-being.

"We're enabling students to see the relevance of science; the results of our studies are starting to show that, by continuously exposing children to science from Year 7 through to Year 13, they will develop an understanding of the nature of science and perhaps even an appreciation of science," says Jacquie. "When they get to the stage of considering higher-level learning, science or health science will become a viable option for them. If they do continue studies, we know they will have a solid foundation of science education behind them. If they don't, we've managed

"We're enabling students to see the relevance of science...by continuously exposing children to science from Year 7 through to Year 13, they will develop an understanding of the nature of science..."

This project is about encouraging the developing attitudes, behaviours and knowledge that will enable students to ask questions and make decisions about their health and well-being, based on scientific evidence. "We teach these kids the scientific process in a way that doesn't involve analyses or judgement but encourages scientific questioning," explains Jacquie. "We engage them by saying, 'Why would scientists want to know about the diet of mothers before their babies are born?' We ask them to tell us what sorts of questions they would ask."

The NRCGD also contributes to the LENScience Face-to-Face programme, which takes place in the Sir John Logan Campbell Classroom and gives secondary school students and teachers the chance to interact with University researchers and learn about current academic research in a way that is tailored to suit the education curriculum. Many NRCGD scientists are involved in the 'meet a scientist' small discussion groups that form part of the Face-to-Face experience. Research carried out by the LENScience team shows that this interaction is having a positive impact on the students' perceptions of science and scientists.

LENScience's award-winning Connect programme, which receives funding from the NRCGD, telecommunications services provider Kordia, and The University of Auckland Information Technology Service, utilises Web2.0 technology alongside satellite television to connect scientists and researchers with intermediate and secondary schools around the country. In 2010 we welcomed the participation of the Bio-Protection Research Centre and the Allan Wilson Centre in delivering the Connect programme.

to increase their scientific literacy, a very important aspect of education to equip children for the lifelong learning that they need to engage as 21st century adults."

What we know:

- Educational intervention increased the proportion of 11-14 year-olds showing high levels of awareness of the link between the maternal diet and lifelong health
- Follow-up studies suggest an increased discussion of diet, lifestyle and health concepts in the families of participants 6-12 weeks after intervention

Building new research capability

Building the infrastructural base necessary to support the Centre's research programmes is a task we take very seriously – and thanks to CoRE funding, and to the benefits of collaboration across institutions, the NRCGD has been able to develop the new technology platforms and clusters of expertise that underpin our scientific success.

Epigenetic capability

An example of the Centre's focus on capability is the development of an advanced facility at the Liggins Institute to support epigenetic biology, which is a key area of focus for the Centre. Epigenetic processes are those which modify the DNA molecule or its attendant proteins without altering the genetic code itself; they can affect whether genes are active or inactive, and are likely to be particularly important during early development. CoRE funding has enabled the Centre to invest heavily in the infrastructure and human capital necessary to undertake credible research in epigenetic biology, and this investment has resulted in several nutrition companies contracting work via the Liggins-based platform. The epigenetic team is working on both human and animal projects to understand how these processes in early life may be linked to later phenotype and to determine whether epigenetic marks can be reliably identified in tissues that are readily available through non-invasive techniques. To do this, the facility has extensive international linkages, particularly with the United Kingdom and Singapore, and makes extensive use of the mathematical and systems biology capability within our Centre to enhance the robustness of its data analysis in a very complex field.

Ngapouri Research Farm

A further, highly novel capability development that builds on New Zealand's strengths is a purpose-built sheep research facility established in collaboration with NRCGD partners Landcorp Farming Ltd and The University of Auckland.

Within the NRCGD, sheep are studied both to inform better on-farm practices for improved production and to generate new insights into the corresponding stages of human reproduction and development. These two themes come together at the Ngapouri facility, which has unique international capability, including an intensive care unit for the study of novel interventions for the treatment of complications of preterm birth, a Dual Energy X-ray Absorptiometer for the measurement of body composition, and extensive capabilities for both pasture-based and intensive physiological research.

Using this facility, NRCGD scientists are able to closely monitor sheep throughout pregnancy and the neonatal period and can accurately measure the effects of particular complications or interventions. Working in close collaboration with the sheep research centre at Massey University, the Ngapouri team is

uniquely equipped to investigate subtle processes that occur during pregnancy and have long-term implications for the growth and health of the offspring. The extensive capabilities of the facility have led to collaborations and contracts with international and commercial partners.

The Discovery-1 Platform

Another important piece of NRCGD-funded equipment is the Discovery-1 microscope, an automated microscopy technology that is almost limitless in potential and is shaping new pathways in scientific analyses, according to Mike Dragunow, an NRCGD scientist at The University of Auckland's Faculty of Medical and Health Sciences.

"The great thing about this area of work is that it has opened up a lot of research areas that we wouldn't ordinarily be involved with. It's exciting because the software allows us to create new ways to solve research problems, particularly those for researchers in the NRCGD," says Mike. "A major 'by-product' of helping to solve research problems or developing the tools and programmes to do an automated analyses of hundreds or thousands of images has meant publication in respected scientific journals such as *Science* and *Nature Neuroscience*.

Discovery-1 has its strength in its objectivity, presenting an automated and standardised way of analysing complex cellular imagery at rates that are unparalleled and are as accurate, if not more so, than counting by human sight. "The NRCGD has played an important role not only in the acquisition of Discovery-1 but the personnel to maintain and operate it. The sheer cost of the machine, which is heavily influenced by exchange rates, means that it was highly unlikely that we would have received funding to purchase this machine – without the NRCGD, it's unlikely any of this would have been possible."

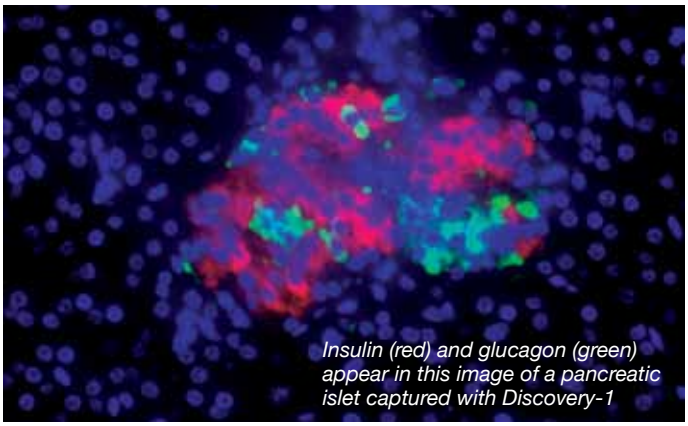
"The NRCGD has played an important role not only in the acquisition of Discovery-1 but the personnel to maintain and operate it...without the NRCGD, it's unlikely any of this would have been possible."

"A major part of the NRCGD's work involves studying cells and tissues using microscopes and taking high-powered images of cells, or of structures within cells," he explains. "Our eyes can scan this type of imaging data relatively easily, working out which cell might have a mutant protein, for example. Our eyes are capable of pointing them out and counting the presence or absence of an effect.

"The problem comes when the number of images to process gets into the hundreds or, as is often the case in modern biomedical research, the thousands. Issues of reliability and standardisation then become a concern; this is where the Discovery-1 microscope and a process called High Content Analysis comes in," says Mike.

"Using the software that came with Discovery-1 we can use different techniques, writing different programmes to instruct the system to automatically detect and analyse the desired abnormalities in the images," says Mike. "You can easily create rules so that the instrument runs through an enormous number of images performing your chosen analysis automatically and with high reliability – it's basically analysing complex features of cells and tissues at high throughput."

This combination of automated microscopy and image analysis has led to the use of the Discovery-1 platform in a number of NRCGD research projects. For example, the technology has been used to study pancreatic islet beta cells in research looking at the biology of diabetes, a disease that is a major area of interest for the NRCGD. It has also been used to measure the shape and the function of a type of brain cell called microglia which are prime cellular candidates linking early-life events in humans to the development of a number of later-life brain disorders such as schizophrenia, and perhaps even Alzheimer's disease. It has also been used to quantify the effect of maternal nutrition on the mammary gland ductal area in sheep.



Insulin (red) and glucagon (green) appear in this image of a pancreatic islet captured with Discovery-1

Postgraduate incubator

A primary goal of the Centre is training excellent people to become the next generation of outstanding New Zealand scientists and science leaders. Since 2003, the NRCGD has funded 44 PhD students and 25 postdoctoral fellows, most of whom have gone on to further positions at research institutes in New Zealand and around the world.

The CoRE model enables us to offer our trainees an enhanced training experience, and we encourage them to develop a wide range of skills making use of the environment that the Centre provides. For example, PhD students are involved in multi-site projects and we help them to take maximum advantage of the opportunities that this provides by supporting costs associated with spending time in partner institutions' laboratories, by encouraging involvement in the development of collaborations and by facilitating the culture of a larger, multi-institutional student body.

Most of the postgraduate work is linked into the NRCGD's major studies, giving students the chance to gain valuable experience in laboratories across institutions by working with top scientists, using the Centre's cutting-edge infrastructure, and linking into international networks. Projects currently underway include: looking at moderate maternal exercise on fetal growth and development in rats; examining the impact of early and late pregnancy stresses such as children born to mothers with severe vomiting in early pregnancy and children born post-term; looking at the effects a lamb's sex has on the strength of the ewe-lamb bond following birth; investigating epigenetic changes in the honey bee ovary; investigating, in lambs, the long-term effects of a novel intrauterine treatment for poor fetal growth; and working on lifespan versus reproduction trade-offs in fruitflies and honey bees.

Growing children

Paediatrician Tim Savage is doing tertiary training in paediatric endocrinology and diabetes at Starship Children's Hospital as well as studying for a PhD at the Liggins Institute. His thesis, supervised by Wayne Cutfield (a senior researcher in the NRCGD and member of the Directorate), investigates the influence of fertility treatment and maternal age on the growth and metabolism of children.

Tim has two studies underway for his PhD, both of which are NRCGD–funded. The first is an evaluation of the growth and metabolism of children conceived with the help of fertility medications. "It is based on the hypothesis that fertility medications may alter the epigenetic make-up of the ovary and hence influence the growth and metabolism of the child," explains Tim.

"To date, I have assessed 80 children conceived following fertility medication and am in the process of comparing their growth and metabolic profile to naturally conceived children. Results will be available later in 2011."

Tim's second study is investigating the impact of maternal age on the growth and metabolism of children. It is a groundbreaking, world-first study which is looking at whether the age of a mother, at the time of giving birth, makes a difference to her child's health later on.

"We do not know if having a child when a mother is younger or older makes a difference to her child's growth and physical development. New Zealand first-time mothers are the oldest in the world. The age of mothers having their first child has increased by more than a decade over the past 50 years or so, yet the question, 'What does this mean for the health and well being of these infants?' has never been asked." To date, more than 200 children of mothers aged from 20 to 45 years have been assessed, with recruitment nearing completion.

DNA methylation and oxidative stress

Helena Koltai is a paediatrician and NRCGD PhD candidate based at the University of Otago where she is supervised by Ian Morison (Head of the Department of Pathology). As part of her study into the effects of acquisition and loss of DNA methylation, she is collaborating with Christchurch-based Mark Hampton (Department of Pathology), building on discussions held at the NRCGD symposium in August last year.

"Acquisition and loss of DNA methylation is a key feature of human development, and also of ageing and cancer. But no one really understands the mechanisms by which methylation is modified in developing cells or in tumour cells," says Helena.

By experimenting on Jurkat cell lines (an immortalised line of T lymphocyte cells) which have been exposed to oxidative stress in Mark Hampton's laboratory, she is hoping to understand the role oxidative stress plays in abnormal development and ageing as well as the process by which changes in methylation occur in response to the environment. Her work also involves a new and exciting technique called DNA hairpin bisulfite sequencing – this can assess the two methylated complementary strands of DNA simultaneously.

Lifespan vs fertility trade-offs

PhD student Sarah Morgan is based in Peter Dearden's Laboratory for Evolution and Development at the University of Otago, where she is studying the molecular mechanisms behind the trade-off between lifespan and fertility that is apparent across many species: long-lived organisms tend to reproduce at a lower rate than do short-lived organisms. Honey bees are an important exception to this trend, since queen bees are both long-lived and highly fecund. Nutrition appears to play a crucial role here, and for this reason Sarah is also being supervised by David Raubenheimer, a Nutritional Ecologist based at Massey University's Albany campus.

"My work is supervised by two people to cover the major, but very different, aspects of the project," she explains. "Peter Dearden has expertise with regards both to the experimental animals we use (Drosophila and honey bees) and to the evolutionary context of the project, while the original aim of the project (and the underlying theory) has arisen from David Raubenheimer's work in nutritional ecology." When she began her study, Sarah spent two months in Sydney working with David's collaborator Professor Steve Simpson in his Behaviour and Physiology Research Laboratory. The flies Sarah has been using for her work were raised on specific macronutrient controlled diets, the procedure for which was developed in that lab.

Sarah is actively involved in several areas of the NRCGD's work: she has worked on the LENScience programme, hosts its Dunedin hub and coordinates its Otago-based alumni, and last year she presented a seminar with Peter Dearden for the LENScience Connect series. She has supervised several senior high school students on fruit fly projects and had ongoing contact with other CoRE-funded PhD and MSc students through symposia, scientific reviews and a recent NRCGD-funded writing retreat.

Other research highlights

Nutrition transitions

NRCGD investigators are involved in an international collaborative nutrition project currently underway at the Tropical Medicine Research Institute (TMRI) at the University of the West Indies. This project, co-led by Sir Peter Gluckman, is investigating changes in food intake patterns in adult survivors of childhood malnutrition. Children suffering from malnutrition usually exhibit the symptoms of one of two distinct conditions known as marasmus and kwashiorkor; children suffering from marasmus being twice as likely to survive as those with kwashiorkor.

The study found that marasmus survivors tended to have had low birth-weights, reflecting poor fetal nutrition during late pregnancy. Thus the capacity for a marasmus-style response to malnutrition may be an example of developmental plasticity – a persistent change to the developing individual's physiology in response to conditions experienced during pregnancy.

Moreover, the study found differences in the eating preferences of the two groups of participants: those who had survived marasmus seemed to require greater levels of protein in their food. When the available diet was low in protein, marasmus survivors ate more food in order to satisfy their demand for protein, consuming as much as 500 calories a day more than normal in the process. These individuals exhibited 'Protein Leverage' – a phenomenon identified by NRCGD investigator David Raubenheimer with collaborators in Australia. NRCGD-led research has previously shown that in fruit flies, changing the proportions of protein to carbohydrate in the diet caused changes in lifespan, possibly due to changes in the organism's ability to respond to disease. The TMRI study suggests that similar mechanisms may also operate in humans, with important implications given the trend toward higher levels of fats and sugars in Western diets.

More information:

Slim pickings: evidence that the problem of obesity starts in the womb. Economist 2010 Nov 13; 397 (8708): 96.

Brooks RC, Simpson SJ, Raubenheimer D. The Price of Protein: Combining Evolutionary and Economic Analysis to Understand Excessive Energy Consumption. Obesity Reviews. 2010; 11: 887-94.

Exercise during pregnancy

In many cases, the conditions experienced by the developing fetus during pregnacy are not under the control of the mother, but diet and exercise during pregnancy are two important exceptions. Of these, relatively little information is available to support healthy choices relating to exercise during pregnancy.

An NRCGD-funded project is currently investigating the effects of voluntary exercise during pregnancy in rats. The first stage of the project, led by Massey-based investigators Elwyn Firth and Brielle Rosa, has examined whether adult female rats respond to mild but regular voluntary exercise over a 21-day period – the same length of time as a normal rat pregnancy. The results were encouraging: the exercising female rats exhibited bone and muscle strengthening over the three-week period. The second stage of this research – involving pregnant female rats – showed that voluntary exercise during pregnancy positively influences fetal growth. A follow-up study, examining the long-term effects of maternal exercise on offspring, is now in progress.

NRCGD investigators Wayne Cutfield and Paul Hofman, with PhD student Sarah Hopkins, have been investigating the effects of moderate exercise in pregnant women on the outcomes of their pregnancies. Pregnant women were randomised to two groups, one of which undertook low-impact stationary cycling exercise from 20 weeks gestation to delivery. The babies of the exercising group were born with lower (but normal) birth-weights and different levels of growth hormone in their blood. This suggests that moderate exercise can influence pregnancy outcome in humans as well. The potential long-term benefits of exercise during pregnancy for the children continues to be assessed.

More information:

Hopkins SA, Baldi JC, Cutfield WS, McCowan L, Hofman PL. Exercise Training in Pregnancy Reduces Offspring Size without Changes in Maternal Insulin Sensitivity. Journal of Clinical Endocrinology & Metabolism. 2010; 95 (5): 2080-8.

Rosa BV, Firth EC, Blair HT, Vickers MH, Morel PC, Cockrem JF. Short-term voluntary exercise in the rat causes bone modeling without initiating a physiological stress response. American Journal of Physiology - Regulatory Integrative and Comparative Physiology. 2010 Oct; 299 (4): R1037-43.

High-sugar vs high-fat diets

The fat and sugar content of diets in the Western world are increasing. NRCGD-led research has shown that when pregnant rats eat a high-fat diet during gestation, the offspring exhibit a number of metabolic differences. Comparatively little is known about the physiological effects of a high-sugar diet during pregnancy.

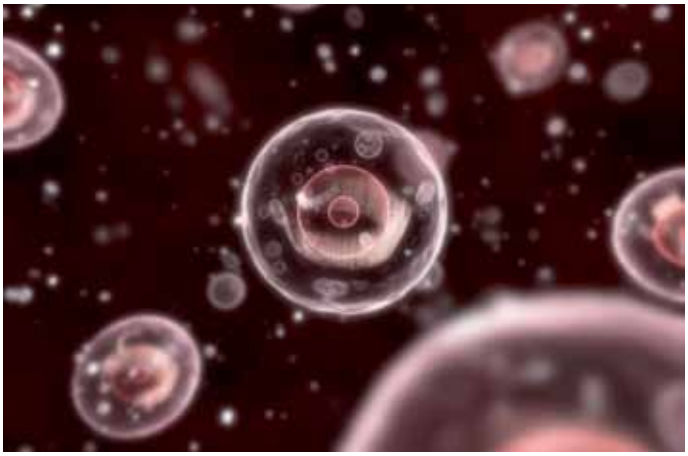
In the human context, obesity is now the leading cause of pregnancy complications. Here again, while the effects of maternal high-fat diets on offspring have been well investigated, very little is known about the effects of consuming high levels of sugars during pregnancy. However, refined sugars are increasingly present as sweeteners in processed foods and soft drinks and may be a major contributor to obesity.

In a new NRCGD-funded study led by Mark Vickers and Deborah Sloboda, feeding a diet high in fructose to pregnant rats caused changes in placental development and affected key metabolic hormone levels in both fetuses and newborn offspring. Intriguingly, these changes were sex-specific, with female offspring females appearing to be more vulnerable to metabolic compromise. Male fetuses appear able to compensate for the altered gestational environment, at least in the short term, by increasing their blood levels of the amino acid taurine. But by 10 days of neonatal life, males and females were equally metabolically-compromised.

Further work in rats is now underway to establish the long-term effects of maternal fructose intake on the metabolic health of offspring. It is not known whether the corresponding responses might occur in human pregnancy, but with Western diets becoming increasingly high in refined sugars, it will be important to find out.

More information:

Vickers MH, Clayton ZE, Yap C, Sloboda DM. Maternal Fructose Intake during Pregnancy and Lactation Alters Placental Growth and Leads to Sex-Specific Changes in Fetal and Neonatal Endocrine Function. Endocrinology. 2011. In press.



Oxidative stress

Normal metabolic processes produce high-energy oxygen species which can be destructive to biological systems. In humans, oxidative stress – caused when the production of these molecules exceeds the body's ability to remove them – is believed to be involved in many diseases. NRCGD-led research suggests that oxidative stress, and the body's responses to it, may be involved in plastic responses to conditions encountered during pregnancy. In rats, for instance, undernutrition during pregnancy caused changes in the development of the ovaries in female offspring, and these changes were associated with increased evidence of oxidative stress in these tissues.

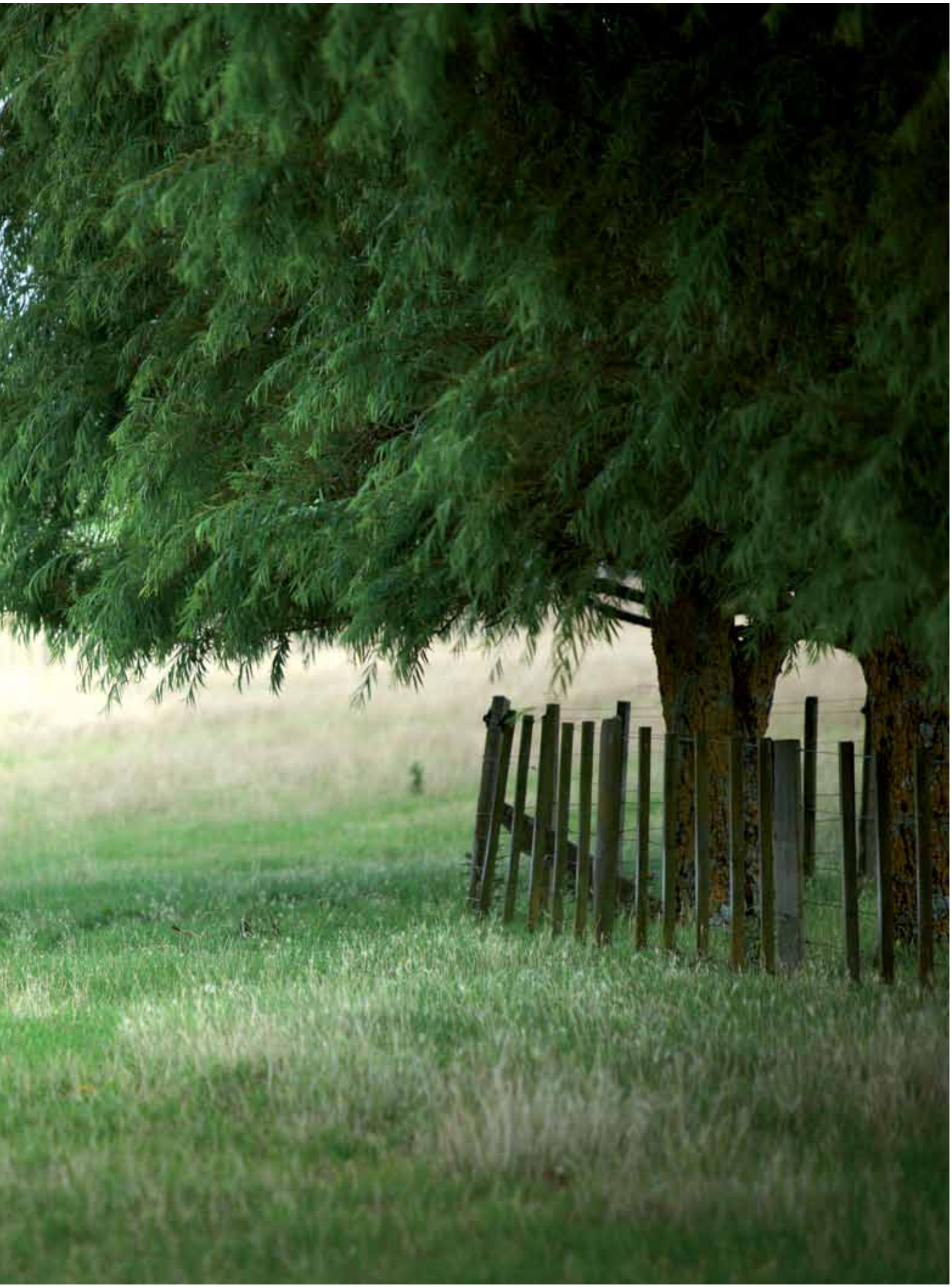
At the University of Otago's Christchurch campus, NRCGD investigators Christine Winterbourn and Mark Hampton have used specialised equipment to investigate the molecular pathways that might link these effects. Their research has focused on peroxiredoxins, a family of proteins that are extremely effective at detoxifying high-energy oxygen species. Peroxiredoxins exhibit a number of intriguing properties that have led to speculation that they might function as 'redox sensors', transmitting signals as part of the cellular response to oxidative stress.

In mammals, two important forms of peroxiredoxin are found in mitochondria, which are the sites in cells where nutrients are converted to energy – and where the majority of oxidising molecules are generated. Changes in fetal development that have their origin in altered nutrition during pregnancy may involve changes in mitochondrial function; and it now appears that oxidative stress responses, and the signaling roles of proteins such as peroxiredoxins, may play a major role here.

More information:

Cox AG, Winterbourn CC, Hampton MB. Mitochondrial Peroxiredoxin Involvement in Antioxidant Defence and Redox Signalling. Biochemical Journal. 2010; 425 (2): 313-25.

Bernal AB, Vickers MH, Hampton MB, Poynton R, Sloboda DM. Maternal nutrition significantly impacts ovarian follicle numbers and increases ovarian oxidative stress in adult rat offspring. PLoS One 2010; 5(12): e15558.



Financial statements

NATIONAL RESEARCH CENTRE FOR GROWTH AND DEVELOPMENT

INCOME STATEMENT

for the year ended 31 December 2010

	Notes	2010 $	2009 $
Operating Income			
Tertiary Education Commission grant	3a, 3b	**7,156,677**	7,809,513
Increase in unallocated funds at end of year	1b, 3c	**(559,306)**	(1,237,002)
Total Operating Income (Total grant income applied during year)		**6,597,371**	6,572,511
Expenditure			
Research Projects			
Salary and salary related costs		**1,337,172**	1,420,123
Overheads		**1,408,273**	1,448,054
Consumables		**960,665**	1,037,671
Postgrad student stipends and fees		**429,298**	526,794
Equipment hire		**433,887**	469,050
Pilot projects		**135,784**	179,279
Site discretionary fund		**0**	35,000
Other		**56,201**	175,055
Total Research Projects		**4,761,280**	5,291,026
Capability and Translation			
LENScience		**429,007**	178,646
Emerging scientists development fund		**27,075**	0
Ngapouri research farm		**70,000**	0
Epigenetics technology platform		**138,874**	0
Total Capability and Translation		**664,956**	178,646
Other Expenditure			
Māori initiatives		**13,618**	39,952
Directorate and administration	4, 8	**822,940**	758,883
Community liaison / profile development	8	**93,164**	56,489
International relationship development		**36,786**	27,349
Centre development	8	**155,466**	73,390
Travel		**49,161**	146,776
Total Other Expenditure		**1,171,135**	1,102,839
Total Operating Expenditure	4	**6,597,371**	6,572,511
Total Operating Income less Expenditure		**0**	0

NATIONAL RESEARCH CENTRE FOR GROWTH AND DEVELOPMENT

BALANCE SHEET

at 31 December 2010

	Notes	2010 $	2009 $
Assets			
Current Assets			
Current account balances with NZ Universities	5	**3,900,428**	3,846,512
Accounts receivable and accruals		**0**	6,316
Total Current Assets		**3,900,428**	3,852,828
Total Assets		**3,900,428**	3,852,828
Equity and Liabilities			
Current Liabilities			
Accounts payable and accruals		**42,176**	20,277
Research funds unallocated at end of year	3c	**1,966,042**	1,406,736
Capital fund	6	**1,892,210**	2,425,815
Total Current Liabilities		**3,900,428**	3,852,828
Equity	7	**0**	0
Total Equity and Liabilities		**3,900,428**	3,852,828

The accompanying notes form part of these financial statements

Signed on behalf of the Board

Alison Paterson
Chair, Board of Governance
28 March 2011

Frank Bloomfield
Acting Director
28 March 2011

NOTES TO THE FINANCIAL STATEMENTS

for the year ended 31 December 2010

1. Statement of Accounting Policies

(a) Basis of Preparation

These financial statements are Special Purpose Financial Statements comprising: an income statement, a balance sheet and notes to the financial statements. The financial statements are presented in New Zealand currency, rounded to the nearest dollar, and they have been prepared on an historical cost basis. The following accounting policies have been applied in preparing these financial statements:

(b) Revenue

Research contract revenue by way of grant from the Tertiary Education Commission is reduced by funds received but not allocated to research at balance date (see note 3(c)).

(c) Taxation

NRCGD income is exempt from income tax. All amounts are shown exclusive of Goods and Services Tax (GST). The University of Auckland as host institution accounts for GST outside NRCGD financial statements.

(d) Changes in Accounting Policy

Uniform accounting policies have been applied on a basis consistent with those of the previous year, except for a change in the allocation of salary costs for the Communications Officer as detailed in note 10.

2. Audit

These unaudited financial statements have been extracted from NRCGD transactions incorporated in the audited financial statements of The University of Auckland.

3. Tertiary Education Commission Operational Grants

(a) Funding Levels

NRCGD is primarily funded by the Tertiary Education Commission. Operational grant funding has been approved to 30 June 2014.

(b) Current Year Grant

	2010 $	2009 $
Income received in advance and held at beginning of year	**0**	2,522,757
Grant for year	**6,856,677**	4,333,919
Additional grant income arising from adjustment to grant period start date	**0**	52,837
Additional grant income received during the year	**300,000**	900,000
Current Year Grant	**7,156,677**	7,809,513

(c) Unallocated Funds

Research funds unallocated at beginning of year	**1,406,736**	169,734
Increase (decrease) in unallocated research funds at end of year	**559,306**	1,237,002
Research Funds Unallocated at End of Year	**1,966,042**	1,406,736

NOTES TO THE FINANCIAL STATEMENTS

for the year ended 31 December 2010

	2010 $	2009 $
4. Operating Expenditure		
Remuneration paid to Directors	**34,561**	36,014
5. Current Account Balances		
Current account balances are held for NRCGD by:		
The University of Auckland - research funds	**2,008,218**	1,420,697
The University of Auckland - capital grant	**1,892,210**	2,425,815
Total Current Account Balances	**3,900,428**	3,846,512

6. Capital Fund

Capital fund grants from the Tertiary Education Commission are for acquisition of capital equipment mainly for NRCGD work. Equipment purchased is vested in the research partners holding the equipment.

Capital fund at beginning of year	**2,425,815**	3,079,478
Assets purchased and vested in:		
The University of Auckland	**(321,729)**	(558,462)
Massey University	**0**	(16,925)
University of Otago	**(211,876)**	(78,276)
Capital Fund at End of Period	**1,892,210**	2,425,815

7. Equity

The NRCGD has no equity. Accordingly there were no equity movements during the year.

8. Change in Salary Cost Allocation

In the financial statements for the year ended 31 December 2010, salary costs for the Communications Officer have been allocated on a 50:50 basis between centre development and community liaison, whereas in previous periods it was allocated in full to Directorate and administration. If the same allocation had have been made for the year ended 31 December 2009, the reported amounts for that year would have been:

Directorate and administration	724,713
Community liaison / profile development	73,574
Centre development	90,475

Selected research outputs

Measuring our scientific impact

The NRCGD is first and foremost a Centre of Research Excellence. The NRCGD's membership comprises some of New Zealand's best scientists and specialist investigators who carry out the internationally competitive work on which the Centre's success is built. In 2010 our members published 82 peer-reviewed articles aligning with NRCGD goals, nearly three-quarters of which appeared in journals ranked in the top 20% of journals by the Australian Research Council (Figure 1).

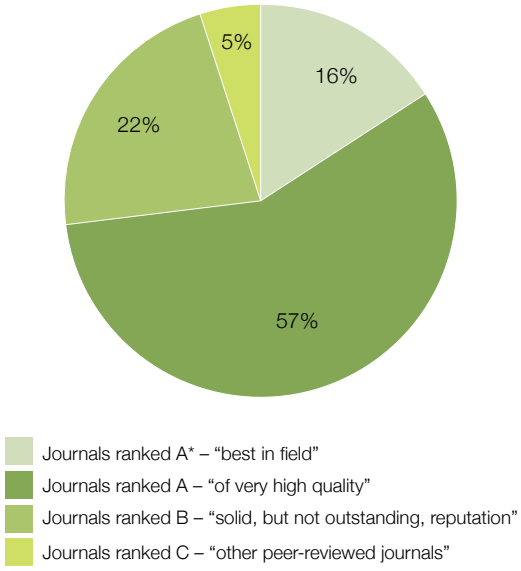


Figure 1 – 2010 NRCGD publications by ARC quality tier

The quality and impact of NRCGD research is based in no small measure on the extent and quality of the Centre's collaborative networks – both within the NRCGD and international. The impact of these linkages is apparent in the NRCGD's publications record, with over a third of NRCGD publications having international co-authors.

The contribution made by early-career scientists to NRCGD outputs is reflected in the numbers of NRCGD publications with students co-authors – over a quarter of all publications in 2010 (Figure 2).

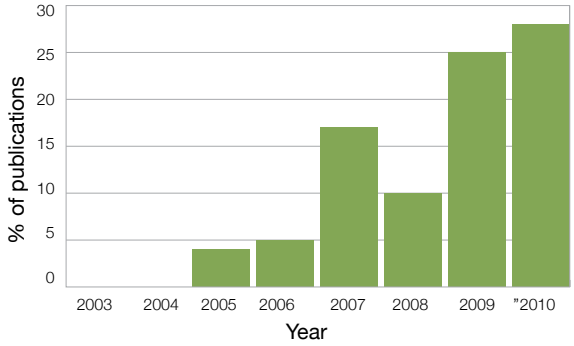


Figure 2 – in 2010 a quarter of all NRCGD academic publications have NRCGD students as co-authors

Books and book chapters

Bay JL, Mora HAA. Me, myself, my environment: nutrition. Auckland: Liggins Institute, 2010

Bay JL, Mora HAA. Me, Myself, my environment: nutrition, New Zealand curriculum level 4 Teacher Resource. Auckland: Liggins Institute, 2010

Bay JL, Mora HAA. Me, myself, my environment: puberty, New Zealand Curriculum level 5 Teacher Resource. Auckland: Liggins Institute, 2010

Dearden PK, Duncan EJ, Wilson MJ. The Honeybee Apis mellifera. In: Crotty DA, Gann A, editors. Emerging model organisms: a laboratory manual 2. New York: Cold Spring Harbor Laboratory Press, 2010

Morison IM, Reik W. Nutrition, environment and epigenetics. In: Symonds M, Ramsay M, editors. Maternal-fetal nutrition during pregnancy and lactation. Cambridge: Cambridge University Press, 2010

Raubenheimer D. Chapter 209: Foraging modes. In: Breed M, Moore J, editors. Encyclopedia of animal behavior. Oxford: Academic Press, 2010: 749-58.

Raubenheimer D, Simpson SJ. Chapter: Hunger and satiety. In: Breed M, Moore J, editors. Encyclopedia of animal behavior. Oxford: Academic Press, 2010: 117-26.

Vickers M, Krechowec S, Gluckman P, BH B. The role of leptin during early life in imprinting later metabolic responses. In: Gertler A, editor. Leptin and leptin antagonists. Austin (TX): Landes Bioscience, 2009

Vickers MH. Epigenetic or programming effects on physical activity level (Chapter 18). In: Bouchard C, Katzmarzyk PT, editors. Physical activity and obesity. 2nd ed. Champaign (IL): Human Kinetics, 2010: 77-80

Papers in academic journals

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Board of Governance

Alison Paterson (Chair) CNZM QSO

Alison has a wealth of experience in corporate governance and leadership in the service and health industries. She is currently Chair of Abano Healthcare Ltd, BPAC NZ Ltd, FarmIQ Systems Ltd and the Oversight Committee (Ambulance NZ). She is a director of Vector Ltd, Metrowater Ltd, Ngā Pae o te Māramatanga, and a councillor at Massey University. She was previously Chair of Waitemata Health Ltd and DHBNZ Inc., and Deputy Chair of Health Waikato Ltd and the Reserve Bank of New Zealand. Alison has the professional qualification of FCA.

Dr Dwayne Crombie

Dwayne is the Chief Executive Officer of Bupa Care Services. He has been the CEO since 2006, with leadership responsibility for one of New Zealand's largest aged residential care providers which employs approximately 3,300 staff and has 46 facilities nationally. He is also the Chair of the Repromed NZ Board and Rodney Surgical Services Board, and a board member of the NZ Guidelines Group. Dwayne was previously CEO of Waitemata District Health and then the Waitemata District Health Board from 2001 onwards. Dwayne has a current annual practising certificate and is on the Specialist Register in Public Health. He also holds an Executive MBA from The University of Auckland.

Dr Peter Fennessy

Following a highly successful career in scientific research and management, Peter has been in private business in the fields of technology strategy and evaluation, intellectual property development and project management since 1997. He is or has been a member of numerous task groups and specialist committees around R&D strategy and technology development in New Zealand, Australia and Europe. Peter is a senior consultant with, and Managing Director of, AbacusBio Ltd (Dunedin), a privately-held consultancy and new venture development business with a focus in the agricultural, agri-bio and biotechnology sectors. He is also Chair of Blis Technologies Limited and of the Advisory Board of the University of Otago Applied Science Programme. He is a director of a number of private companies.

Trudie McNaughton QSM

Representative for Deputy Vice-Chancellor (Research),
The University of Auckland

Trudie is a graduate of The University of Auckland and has worked previously at the University as a researcher and as the inaugural Equal Employment Opportunities Officer. She has worked in equity since the late 1980s, including as the Chief Executive of the EEO Trust (1992-2003). There she led research and communications projects on issues including cultural and ethnic diversity, disability, age, gender and work life balance. Trudie is the Pro Vice-Chancellor (Equity) at The University of Auckland. She is a former member of the Career Services Board, the National Advisory Council on the Employment of Women and the Human Rights Review Tribunal.

Jim Peters MNZM

Jim (Ngati Wai, Ngati Hine, Nga Puhi) is the Pro Vice-Chancellor (Māori) at The University of Auckland. He has taught in a number of schools, was Principal of Northland College (1987-2002), and has been involved in farming and forestry. He was a Member of Parliament (2002-2005), a long standing member of the Vice-Chancellor's Community Advisory Group, a member of the Northland Regional Council from 1989 to 2007, and its Chair from 1995 to 2001.

Jeff Todd CBE

Jeff is a company director and chartered accountant. Jeff was Managing Partner of accounting firm Price Waterhouse until 1998, where he provided business and taxation advice to national and international corporations. Since 1985 he has worked with both Labour- and National-led governments in the development and implementation of public policy in taxation, retirement income and tertiary education funding. From 2001 to 2005 he served on the Council of Massey University. He has also served on the boards of the ANZ Banking Group, Southern Cross Healthcare, the Earthquake Commission and the Reserve Bank of New Zealand. Currently, he is Chair of Dynasty Hotel Group Ltd, Deputy Chair of Sanford Ltd, and is a director of Watercare Services Ltd. He also holds other board positions, many of which are charitable.

Directorate

Associate Professor Frank Bloomfield

NRCGD Director (Acting)

Frank is a neonatal paediatrician whose research interests focus on fetal and neonatal nutrition and growth, including long-term consequences of altered growth trajectories, fetal development in twins, development of the fetal hypothalamic-pituitary-adrenal axis and consequences of perinatal care. He carries out his clinical duties in the newborn nursery at National Women's Hospital and is the leader of the fetal and neonatal physiology research group at the Liggins Institute. He also has an appointment in the Department of Paediatrics, The University of Auckland.

Dr Deborah Sloboda

Deputy Director

Associate Director, Experimental Physiology

Deborah is a fetal physiologist whose primary research interest is the effect of maternal nutrition during pregnancy on reproductive development in the offspring. She is a member of the Developmental Origins of Health and Disease (DOHaD) Council and an Associate Editor of the Journal of *Developmental Origins of Health and Disease*. Deborah leads an NRCGD Major Project employing an animal model to investigate the effects of a high-fat maternal diet during pregnancy on growth and reproductive function in the offspring.

Dr Roger Lins

Chief Operating Officer

Roger is a biological chemist by training with a background in research management and a keen interest in scientific communication and outreach. He held research positions in England, Scotland and New Zealand before moving into research management. Roger joined the Liggins Institute as an academic writer in 2007 and was appointed to the NRCGD Directorate in mid-2008. He is responsible for the operational management and administration of the Centre.

Jacquie Bay

Associate Director, Outreach Programmes

Jacquie, an experienced secondary school biology teacher, is the Director of LENScience, a programme bringing schools and scientists together to promote scientific literacy and capability. Her research investigates public perceptions of the relationship between nutrition and disease risk, and the use of e-learning strategies to connect school students and scientists. She is Chair of the New Zealand Biology Educators' Association and a member of the NZ Association of Science Educators Council.

Professor Hugh Blair

Associate Director, Animal Sciences
Site Representative, Massey University

Hugh's research interests are in animal genetics and epigenetics, and the inheritance of disease. Hugh is currently Deputy Head and Director of Research and Commercialisation for the Institute of Veterinary, Animal and Biomedical Sciences at Massey University, Palmerston North. He holds several industry consulting positions. Hugh leads an NRCGD Major Project investigating the effects of fetal programming on later-life productivity in sheep and cattle.

Professor Wayne Cutfield

Associate Director, Clinical Sciences
Site Representative, Liggins Institute

Wayne is a paediatric endocrinologist and an expert on insulin sensitivity and action in children. He is the Director of the Liggins Institute and Director of Endocrinology at Auckland's Starship Hospital. At the Liggins Institute's Maurice and Nessie Paykel Clinical Research Unit, he leads clinical research investigating how environmental influences early in life affect childhood growth and development. Wayne's NRCGD Major Project is focused on the growth and metabolism of children born through assisted reproduction or to older mothers.

Associate Professor Peter Dearden

Associate Director, Molecular Sciences
Site Representative, University of Otago

Peter is an evolutionary geneticist whose research interests are in evolution and development, with a particular focus on how morphology evolves at the molecular level, and in identifying ancient and conserved developmental programmes. He established the Laboratory for Evolution and Development at the University of Otago, is the Scientific Director of Genetics Otago, and in 2009 was appointed to the Science Advisory Board of the New Zealand Science Media Centre. He leads an NRCGD Major Project investigating the phenomenon of developmental plasticity in invertebrate model organisms.

Dr Susan Morton

Associate Director, Public Policy

Susan is an epidemiologist and specialist in public health medicine with a general interest in life-course epidemiology, particularly as it pertains to reproductive outcomes, growth throughout the life-course, and women's adult health. Susan is the Director and Principal Investigator for the longitudinal study 'Growing Up in New Zealand', which is following the lives of 7,800 children born in the Auckland and Waikato regions in 2008–2010 for approximately twenty years. She leads an NRCGD Major Project which aims to provide policy-makers with a robust economic model of the costs of a poor start to life.

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AgResearch Ltd, Palmerston North

Dr Mark Vickers
The University of Auckland, Auckland

Professor Graeme Wake
Massey University, Auckland

Professor Christine Winterbourn
University of Otago, Christchurch

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The University of Auckland, Auckland

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The University of Auckland, Auckland

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The University of Auckland, Auckland

Ms Angelica Bernal
The University of Auckland, Auckland

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The University of Auckland, Auckland

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University of Otago, Dunedin

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Massey University, Palmerston North

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Massey University, Palmerston North

Ms Natalia Martin
Massey University, Palmerston North

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The University of Auckland, Auckland

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The University of Auckland, Auckland

Ms Phuong Nguyen
AgResearch Ltd, Hamilton

Ms Meaghan O'Neill
University of Otago, Dunedin

Ms Rachna Patel
The University of Auckland, Auckland

Ms Amy Paten
Massey University, Palmerston North

Ms Rebecca Poynton
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University of Otago, Dunedin

Ms Brielle Rosa
Massey University, Palmerston North

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The University of Auckland, Auckland

Ms Cassandra Yap
The University of Auckland, Auckland

NRCGD-supported FTEs

Investigators	3.55
Research Fellows	9.20
Technicians	7.55
Postgraduate Students	13.33
Directorate and Administration	4.60
Total	**38.23**

Contacts

Acting Director

Associate Professor Frank Bloomfield
f.bloomfield@auckland.ac.nz

Chief Operating Officer

Dr Roger Lins
rj.lins@auckland.ac.nz

Communications Officer

Jane Duffy
j.duffy@auckland.ac.nz

Postal address

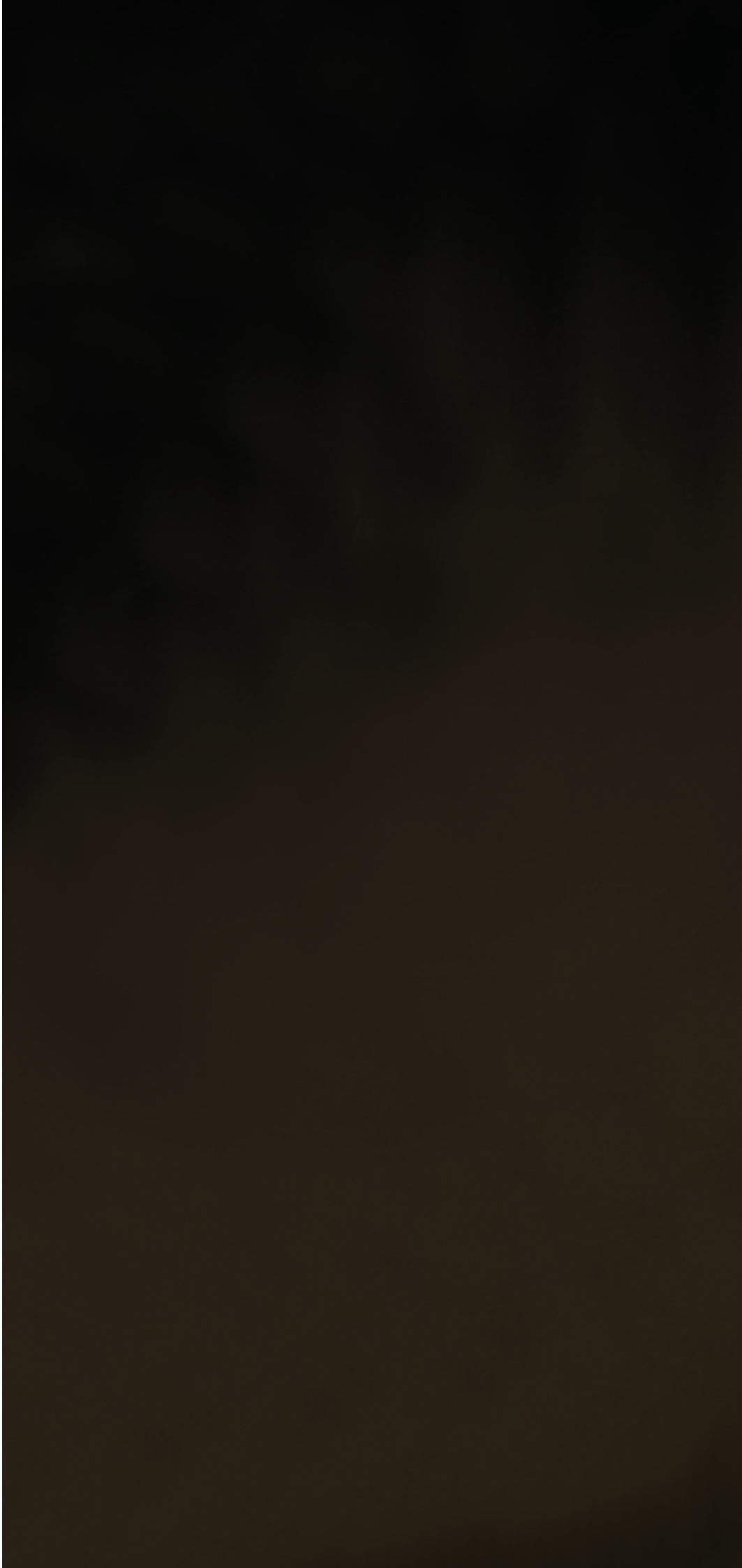
c/- The Liggins Institute
The University of Auckland
Private Bag 92019
Auckland 1142
New Zealand

Physical address

c/- The Liggins Institute
The University of Auckland
2-6 Park Avenue, Grafton
Auckland 1023
New Zealand

Email: info@nrcgd.org.nz
Telephone: +64 9 923 1637
Fax: +64 9 373 8763

www.nrcgd.org.nz



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