Igniting Potential

New Zealand's Science and Innovation Pathway

Igniting Potential – The Cover Story

For *Igniting Potential*, the Government wanted a cover that embodied the theme of science and innovation. Wellington design company Station Creative was tasked to produce this.

The white light in the image represents opportunity transformed through the potential of the mind and the power of science and innovation. The beam of light also reflects New Zealand's science and innovation pathway.

The cover uses lenticular printing: clear optical plastic is shaped into sheets with very thin parallel lenses on the surface. Several viewpoints of the same subject are then printed on the plastic. The lenticular material reveals a different view to each eye and the images shift depending on the viewing angle, creating the three-dimensional depth.

The panels were produced by Outer Aspect – an innovative New Zealand company internationally recognised as a leader in lenticular printing technology. Their list of clients includes American Express, Warner Bros. Studios, The J Paul Getty Museum, New Balance and United International Pictures.

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Foreword

New Zealand faces a very clear challenge. We need to substantially improve our economic, social and environmental performance to provide a secure future for upcoming generations.

Science and innovation are the main drivers of the modern economy. We need to nurture and retain our best and brightest. We must demonstrate that New Zealand can harness our deep culture of innovation to grow our own capabilities and attract fresh talent from across the world.

The Prime Minister has placed science at the heart of the Government's economic agenda. When opening Parliament he noted: "Our objective is a high-performing public science system which supports economic growth, and a wider innovation system that encourages firms to increase their investment in, take-up, and application of research".

It was evident to me as the incoming Minister that we had to do much better in our science capability. I undertook extensive consultation and found there was wide consensus on the problems. These included a lack of focus, conflicting priorities and an overly complex and competitive system. This stifled collaboration and innovation. We needed to better connect science with business and provide more opportunities for our most able science graduates.

Over the last 16 months the Government has been working hard to improve the system. The Prime Minister, the Chief Science Advisor Professor Sir Peter Gluckman and I have been working with officials, the science sector and the wider community to develop our science and innovation strategy. We have simplified the system, set clear priorities, reformed the Crown research institutes (CRIs) and improved business assistance.

The sum of these efforts is the greatest transformation of the science system since the CRIs were introduced in 1992. The goal is to unlock the potential of our science system. This will drive the innovation that will lift our economy and society in the decades ahead.

Hon Dr Wayne Mapp
Minister of Research, Science and Technology

Executive Summary

Science and innovation create new opportunities for economic growth, improve our quality of life and help us make sense of the world we live in.

For science and innovation to create these opportunities, a robust science and innovation system that is responsive to national needs and opportunities is necessary. The Government is taking steps to improve New Zealand's system, empower the people working within it, get better returns from public investment and direct government support where it can make the most difference. Igniting Potential describes the new, simpler and more direct system and other changes the Government is making in this area.

An important initiative has been to restructure government funding to clarify priorities and provide a more direct pathway for implementing them. The priority outcome areas are:

- high-value manufacturing and services
- biological industries
- energy and minerals
- hazards and infrastructure
- environment
- health and society.

There are also generic outcomes, such as excellent people, investigator-led research, national infrastructure, international relationships and Vision Mātauranga. The Government has also defined funding tools that focus on different kinds of activity within each outcome area – from science-led funding to technology transfer and commercialisation. This allows the Government to focus funding where it can make a difference.

Business research and development (R&D) are essential, both in their own right and because businesses performing their own research are better able to make use of public sector research. New Zealand ranks poorly on international benchmarks for business R&D. The Government is responding to this by increasing its support for business R&D and introducing changes to give business better access to public research and enable users of research, including business, to have a greater influence on Crown research institute (CRI) research strategies. Changes will take place in the delivery of business R&D support – rather than firms having to search out the most appropriate R&D programmes, government agencies will do this, as part of a one-stop-shop approach.

The CRIs occupy central positions within New Zealand's broader science and innovation system. The Government commissioned a taskforce to review the CRIs and has accepted its recommendations. As a result, all the CRIs will receive a greater proportion of non-contestable funding, will become accountable for outcomes defined in a statement of core purpose and will work more closely with the end-users of their work and other stakeholders. Together these changes will ensure CRIs work to achieve maximum benefits for New Zealand rather than increase their commercial return.

The Government also recognises the importance of the other components of the research system, including universities and private research organisations. The Government will continue to develop initiatives to assist them to improve their contribution to New Zealand.

Infrastructure is crucial to science and innovation. The Government is working to refine its investment policy for infrastructure and maximise the returns from it. Large-scale research infrastructure is necessary for scientists to be productive and to attract and retain the best people. Major facilities are often too expensive for individual institutions, which may not be able to use them to their full capacity. A national approach is necessary to plan and invest in these facilities. Moreover, systems are needed to ensure maximum use of the data coming out of research and to promote effective data sharing and research collaboration.

The Government is also working to strengthen New Zealand's international scientific relationships and respond to new international opportunities. New Zealand can benefit from international scientific co-operation that builds on our strengths and creates new opportunities by providing access to complementary expertise and infrastructure overseas. New Zealand's status as an effective player in international science gives the country credibility and assists international negotiations that require strong scientific evidence.

The success of our science system ultimately depends on the excellence of the people involved. New Zealand has world-class people and an effective education system, from primary level, through universities to post-doctoral. We are also successful in attracting scientists from overseas. The Government is continuing to support the development of excellence and has moved to fill a major gap in career opportunities for early career researchers by establishing the Rutherford Discovery Fellowships.

Research done in the CRIs and by business is not an end in itself, so the Government is making it easier for this research to have impact. There are many ways that research delivers benefits, all of which are important. The Government is working to remove impediments to the better use of research, to make public research more accessible to end-users and to improve the effective transfer of technology from public research organisations to firms, government and the public.

The changes discussed in Igniting Potential are the most significant for the science and innovation system over the last 20 years, and will help lead to considerable improvements. However, the Government recognises these changes are the first stage of a longer journey. Work to improve and strengthen the system will continue to be a priority in the years to come.

1. Potential Unrealised: The Need for Change

Science and innovation – crucial to New Zealand's future

Science and innovation are the foundations of New Zealand society. They improve our quality of life, help us understand and manage our environment, and are essential to our jobs and our pastimes.

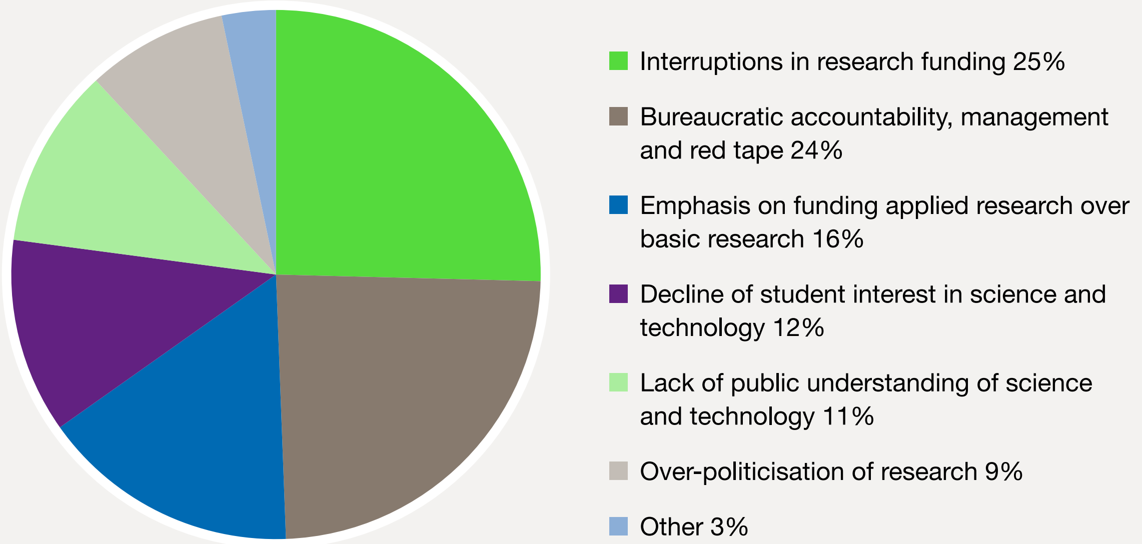
From a visit to the doctor to checking the weather forecast on a mobile phone to sitting down to watch a 3D movie, the fruits of science and innovation – new technologies and ways of doing things – are everywhere. Research has led to discoveries and inventions unimaginable a century ago and is continuously pushing the boundaries of knowledge.

Science and innovation are also important drivers of New Zealand's economic growth. Research improves productivity by creating ground-breaking technologies and new and better ways of doing things. It enables new industries to emerge and existing ones to become more competitive. The World Economic Forum has identified innovation and business sophistication as the most important drivers of the income of advanced economies.

Investments in science and innovation have a major impact on the international competitiveness of a country and the living standards of its people. At the same time, science unlocks understanding and the solutions to many of the global problems all nations face – such as climate change, food and energy security, and an ageing population.

New Zealand scientists' perceptions of major issues facing science

Source: NZAS (2010), *2008 Survey of New Zealand Scientists and Technologists*



This chart shows results from the New Zealand Association of Scientists 2008 Survey of New Zealand scientists and technologists, who were asked what the two most important issues they faced were. This chart shows that almost half the responses to this question related to interruptions in research funding or to bureaucratic accountability, management and red tape.

The need for change

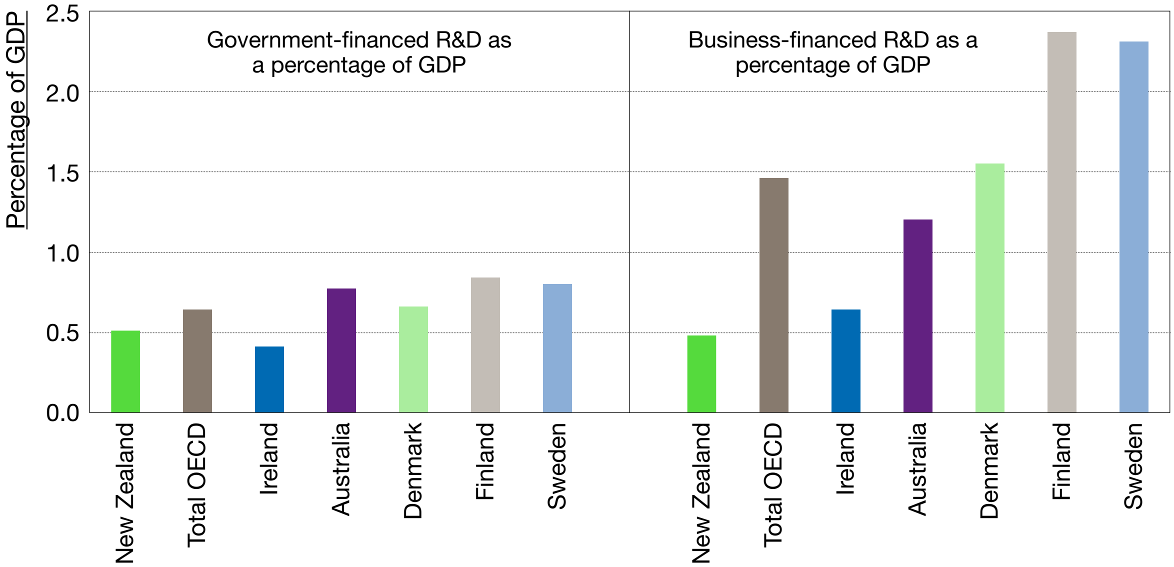
The Government recognises the critical importance of science and innovation to New Zealand, particularly in lifting our economic performance, and has made science and innovation a high priority. When the Government came to power in November 2008 it was clear there were a number of issues that were preventing science and innovation from delivering the best results for New Zealand. Changes needed to be made urgently.

These issues included:

- **An overly complex system.** Having a strong science system is essential for a developed country to grow and prosper. New Zealand's system was too bureaucratic, with complex government funding arrangements creating confusion for those working in and with the system.
- **Low business investment in research and development (R&D).** By OECD standards New Zealand businesses invest relatively little in R&D, a vital driver of innovation and growth. Creating more high-tech, high-value companies and diversifying our economy require this investment to increase.

New Zealand's financing of R&D: An international comparison

Source: OECD (2009), *Main Science and Technology Indicators*, Volume 2009 Issue 2 (2007 OECD Reference Year)



- **Poor connections across the science and innovation system.** New Zealanders are inventive people, but relatively few of our inventions make it into the marketplace. Improving this requires better links between firms and research organisations such as universities and CRIs, and new ways of thinking.
- **Too high a proportion of competitive funding.** Competition for funds can encourage more efficient, effective science that is targeted at the nation's top priorities. New Zealand's system has relied too much on competitive funding. Researchers and research organisations have spent too much time applying for funding and had too much of a focus on short-term results, to the detriment of work that might produce better results over a longer period.
- **Too much administration.** Linked to competitive funding and the complexity of the system, researchers have spent too much of their time on the paperwork involved in getting projects started and not enough on the work itself.

- **CRIs focused on commercial return, rather than economic benefit to New Zealand.** Crown research institutes (CRIs) are vital players in New Zealand science, but have not been delivering as well as they could. A major reason has been because CRIs were focused on their balance sheet, rather than on the betterment of New Zealand.

- **A low public profile for science and innovation.** Science and innovation have made and continue to make huge contributions to New Zealand's wellbeing, but they do not get the recognition they deserve. It is important to lift the profile of science and innovation. Getting the most out of new discoveries and insights requires a public that appreciates the value of science and innovation.

- **Talented scientists being lost.** Too many clever, motivated emerging scientists were being lost to New Zealand.

- **Gaps in important infrastructure.** New Zealand's research organisations are small by international standards and are often unable to afford large, expensive but important pieces of research equipment.

2. Potential Ignited: The New Science And Innovation Strategy

The Government's strategy

The Government needs the science and innovation system to function as well as possible. It has taken a strategic look at how the system can be improved. In doing this it has taken into account previous work such as the OECD review of New Zealand's innovation policy and the work going on in the OECD to develop an innovation strategy. It has consulted the science and innovation sector widely through the *New Zealand's Research, Science and Technology Priorities* feedback document; and through the commissioning of a taskforce to look at the CRIs, which reported in March 2010. The Government has also benefited from consultations conducted by the Prime Minister's Chief Science Advisor, Professor Sir Peter Gluckman.

Feedback has emphasised that past tinkering has not worked. An ad hoc approach has not achieved anything and it has been necessary to undertake a far more thorough reappraisal of the system. This means identifying the underlying issues and then tackling them in a strategic manner.

The overall goal has been a simpler, more transparent and more responsive system that operates without excessive government control and produces better benefits for New Zealand.

In considering the strategic direction of the science and innovation system, the Government first developed a set of strategic principles for publicly funded science. These were set out in its *New Zealand's Research, Science and Technology Priorities* feedback document and are included below.

Strategic principles for publicly funded science

New Zealand's approach to publicly funded science must be strategic. It needs to take into account size, geography, environment, sociology and economic structure. Accordingly, the science system should be underpinned by the following strategic principles.

General principles

1. The science system will be based on scientific excellence and impact.
2. It will invest where research can advance New Zealand's economic performance, productivity and future development, and assist in developing our social fabric and protecting our environment.
3. It will recognise New Zealand's particular sectoral and societal interests, which to some extent have been given definition by the shape of the CRIs.
4. It will recognise the need for New Zealand to develop a full scientific value chain from discovery to exploitation (domestically and internationally) with long-term returns and value for New Zealand.
5. It must be flexible and responsive, because science by its very nature is serendipitous, generates unexpected results, moves fast and results in new opportunities and disciplines.
6. Science that does not show promise and pathways to results will not continue to be publicly funded over time.

Principles underlying priority setting

1. Investment in the training, development and retention of outstanding scientific talent will ensure the capacity for the most innovative scientists to contribute to their fullest potential. This requires appropriate infrastructure and critical mass.
2. Priority will be given to investment where New Zealand has competitive advantage. That advantage is in part already defined sectorally, but beyond that New Zealand, as a small country with advanced science capabilities, has unique, but as yet untapped, potential for multidisciplinary research.
3. Priorities also have to reflect the different types of research providers and the need to sustain a balanced programme from discovery to exploitation.
4. Priority will be given to assisting international partnerships both in scientific research and in accessing science infrastructure in domains where clear advantage can be obtained for New Zealand.

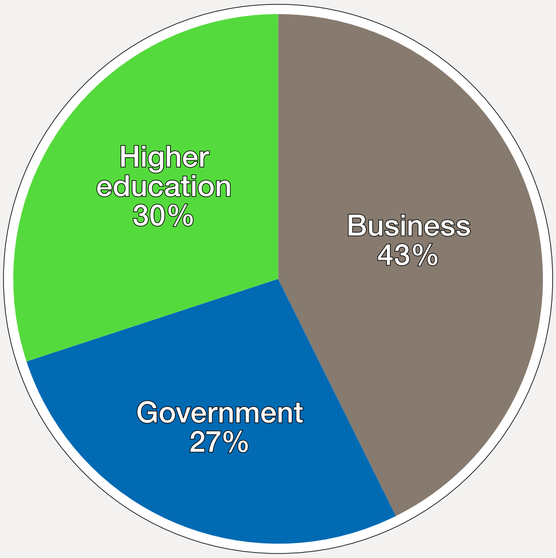
Operational principles

1. The science system must be transparent and responsive with minimal compliance costs. It has to be regulated by appropriate scientific evaluation and accountability, allowing effective oversight and outcome focus.
2. It will comprise a mix of competitive and strategic funding tools and a balance of basic, applied and translational research appropriate to an overall strategy and appropriate to national size.
3. To foster efficiency, emphasis should be given to where a multi-organisational approach is possible so that critical mass can be achieved, duplication is avoided, advanced infrastructure can be developed, and latent and real synergies across partners can be exploited.

A Snapshot of New Zealand Science

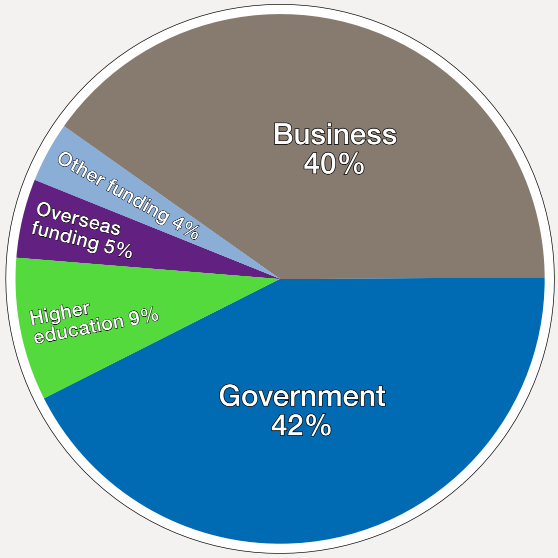
Who undertakes R&D in New Zealand

Source: Statistics New Zealand, *Research and Development in New Zealand 2008*



Who invests in R&D in New Zealand

Source: Statistics New Zealand, *Research and Development in New Zealand 2008*



'Government' in these graphs includes CRIs, local government, funding agencies and government departments, Crown entities and Crown-owned companies, but not state-owned enterprises.

The Changes Taking Place

Having set out a strategy, the Government began to make changes to the science and innovation system – the most significant it has seen in two decades. In 2009 it also increased its investment in science and innovation, despite the difficult fiscal environment and the need to control government spending. The Government's major initiatives include:

Setting new priorities

Because resources are always in short supply, it is necessary to set priorities. A country of four million people cannot support a broad canvas of research and has to focus on what is important. An important initiative has been to provide the tools that allow the government to set priorities explicitly and in a way that will clearly lead to action.

Supporting fundamental research

The Government recognises the importance of fundamental research, such as the investigator-led work carried out in universities in particular. This research improves our knowledge of the universe and can lead to major benefits for New Zealand's economy, society and environment. Today's fundamental research can turn into tomorrow's applied research. An effective science system has an appropriate balance of both types of research. It also has systems that recognise when fundamental discoveries have potential for commercialisation or other uses.

Increasing business investment

New Zealand's business sector invests relatively little in research and development (R&D), by OECD standards. This is important because business concentrates on the applied research and development that translates knowledge directly to commercial opportunities. The Government is increasing funding support for business R&D, to help overcome the low level of business investment.

Reforming CRIs

The Government is introducing major reforms of CRIs. By providing stable, certain funding associated with a clear statement of purpose for each CRI, the Government is empowering the CRI boards and management to operate strategically, co-operatively and in a way that will maximise the benefits they produce for New Zealand.

Simplifying the system

New Zealand's science and innovation system needs simplifying to reduce bureaucracy, make it more efficient and better for those involved with it. The Government is working to reduce the amount of time scientists spend applying for funding so that they can spend more time doing research.

Supporting sharp minds

People are at the heart of science and innovation. Human creativity, imagination, skills, expertise and team work create, test, develop and use the ideas and technologies that come out of research. The Government's strategy for science and innovation recognises this. The Government's restructuring of its support in this area will lift public recognition of the importance of science and particularly direct help at the early to mid-career researcher level, where support has been lacking. The Government will continue work on how New Zealand can best attract and maintain the best entrepreneurial people, the people the country needs to carry science and technology forward to serious commercial outcomes.

Improving infrastructure

New Zealand needs adequate infrastructure to maintain and attract highly talented scientists, as well as to enable them to work productively. The Government has agreed to develop a national research infrastructure strategy, given the importance of major research infrastructure and its rapidly rising cost.

Increasing international connections

Science has always been an international activity, and it is becoming more so. In part this is because technology has made it easier for scientists in different countries to work together; in part it reflects the global problems science is addressing. The high cost of infrastructure also provides a focus for international collaboration. Because New Zealand is such a small country and accounts for a small proportion of global effort, we stand to benefit more than many countries from developing effective international links. For example, the route to taking our science to commercial scale will often require partnerships at every stage from discovery through to capital raising and marketing. The reforms the Government is making in this area will allow us to do this better. They will also enhance New Zealand's reputation as a producer of excellent science, better positioning us globally, not just within the science community but within the global community where scientific diplomacy is important.

Capturing the benefits of research

Putting together all the elements of a science and innovation system is necessary but not sufficient to release all of the potential benefits of investing in research. It is also necessary to encourage the transfer of technology and knowledge from those who invent it to those who can commercialise or apply it to benefit New Zealand.

Igniting Potential expands on these initiatives in the pages that follow.

3. 2009: Strategic Priorities and Boosting Science

Setting New Priorities

Before making major changes to the science and innovation system, Government focused on setting new priorities for its science and innovation investment. Before setting these priorities, it consulted the sector through the *New Zealand's Research, Science and Technology Priorities* feedback document.

The need for priorities and a priority-setting system

Research, science and technology encompass a wide range of activities directed to many different ends, from the basic, investigator-led research performed in universities to the advanced development work performed by industry.

Government has limited resources and must make choices about what is funded. We are a country of only four million people and cannot realistically fully encompass every aspect of the development of knowledge. Like other small countries we must prioritise. This is not easy, because:

- there are many different kinds of science and innovation contributing to New Zealand in many different ways
- these different kinds of science and innovation are often interdependent
- the time over which research projects deliver benefits and the chance of success differ, and are not always predictable
- New Zealand is better able to make use of some research results than others, depending on the sophistication of end-users
- the investment necessary to make effective use of research can vary significantly and is often much greater than the cost of the research itself.

The Government recognises that priorities need to be identified in an open, transparent way that sends clear signals about its intentions to stakeholders. One aim of the priority-setting exercise is to simplify the system, making it easier for stakeholders to use. A simpler system also provides a more direct path from the Government's priority setting to its funding decisions.

Scale

Setting priorities is particularly important for a small country such as New Zealand. If science is to have impact, research has to have sufficient scale. New Zealand's total private and public spend on science and innovation is less than that of many multinational companies' R&D spending, let alone that of research giants like the US, Germany and China. As a country we cannot and should not try to compete with this level of effort. We must identify niche opportunities, build on our natural and human resources, and then fund these opportunities at a level that will make a difference.

Outcomes

In setting priorities the Government has identified the outcomes it is trying to achieve. Focusing on outcomes is important as science becomes more interlinked, with disciplines blurring into each other in areas such as nanotechnology, and as science tackles complex global challenges such as climate change. Support for outcomes also encourages co-operation and emphasises achievements rather than processes.

Defined outcomes have advantages for research management, making it easier to assess the effectiveness and value of the support that government provides. For some kinds of research, managing for impact means considering more than scientific excellence.

For example, measures of success have to go beyond advancing knowledge to take into account whether potential users of that knowledge can and want to take up those advances.

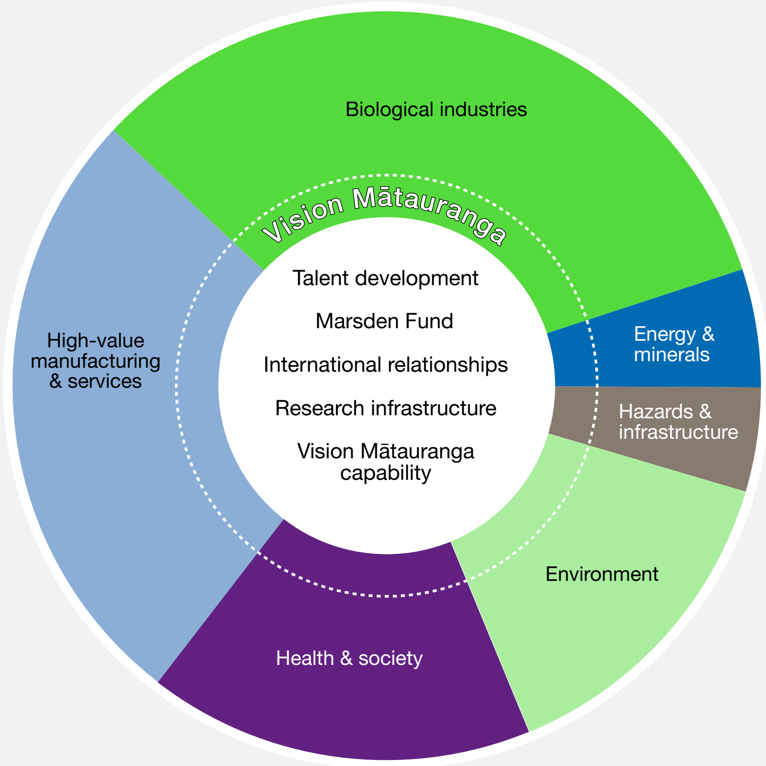
Priority areas for research

Because innovation is central to the Government's economic growth agenda, this agenda was an important driver in setting the priorities. In addition, the Government recognises that funding is necessary to support other areas and that improvement in areas such as environmental management can provide significant economic benefit, even if they do not always produce direct commercial returns. Firms can be affected by problems relating to health, social services, environmental degradation and hazards management. Much of New Zealand's wealth is built on natural resources and it is important to perform the research needed to maintain them.

It is also important to recognise the wide range of impacts that research can have – from the advancement of knowledge through to improved health and an enhanced national reputation. Commercial and economic impacts are very important but are only a partial indicator of the quality of research and its impacts.

The Government has identified priority outcome areas. It has also recognised there are underlying generic investment requirements, which support the outcome areas. These are all described below.

The diagram on the following page shows the priority outcome areas in the outer circle and the supporting priorities at the centre of the circle. The proportions are based on Budget 2010 investment.



Sector outcome areas

This section provides information about each of the outcome areas the Government identified following the consultation process it ran on its proposed priorities.

HIGH-VALUE MANUFACTURING AND SERVICES

Support for this outcome area will accelerate the growth and development of a vibrant, high-value, technology-based products and services sector. This will help diversify New Zealand's economy by growing existing businesses, supporting emerging industries, and developing new industries that do not depend on our natural resource base. Priority areas for investment include novel materials, manufacturing and applications; agri-technologies; health and medical technologies; and information, communication and digital technologies.

BIOLOGICAL INDUSTRIES

Science and innovation under this outcome area will improve the international competitiveness of New Zealand's biological industries and help diversify them. The Government is seeking sustainable productivity growth from the primary producing sectors and the development of premium products in response to global consumer preferences. Effort will go into producing higher-margin food and industrial products, processes and technologies derived from biological raw materials. This might include functional and manufactured food products and ingredients, nutraceuticals and supplements, as well as non-food natural products such as renewable industrial biomaterials and biosensing and bioprocessing technologies.

ENERGY AND MINERALS

Work supported by this outcome area will help unlock the potential of New Zealand's plentiful energy resources and lead to a future where the country uses more diverse, more dispersed and more sustainable energy resources, technologies and systems. It will also increase our understanding of the resource base and assist commercial decisions about extracting minerals from the ground and seabed in environmentally responsible ways.

HAZARDS AND INFRASTRUCTURE

This outcome area supports research which will improve the quality of urban and infrastructure development, will help increase our national resilience to hazards and will help communities to grow, change, mitigate risks and maximise infrastructure efficiency.

ENVIRONMENT

The Environment outcome area will provide knowledge that helps New Zealand's economy develop within environmental limits. Investments will support both the sustainable development of New Zealand industries and the work of the statutory management agencies and government departments, for example, setting development limits. The science and innovation supported by this outcome area will encompass work on land and freshwater resources, terrestrial ecosystems, climate and atmosphere, marine ecosystems and Antarctica.

HEALTH AND SOCIETY

Science and innovation funded through this area will lead to improved health and social wellbeing outcomes for all New Zealanders. Its principal focus is on supporting New Zealand's research strengths and knowledge, including successful and distinctive approaches and solutions to Māori health and social needs, to build a healthier, happier society. This includes the promotion of innovation in the delivery of public policy and services, particularly in the health, disability and social sectors. This outcome area also includes research to understand, anticipate and help manage major societal trends and implications. It also supports research on New Zealand's economic and technological development in the wider context of social, cultural and economic wellbeing.

Other investment areas

The Government has identified that a science system that works well has underlying generic investment requirements.

These are:

- highly talented people (through fellowships for excellence)
- advances in knowledge in its own right, which might lead to opportunities for more strategic, outcome-directed research, and can produce serendipitous and important outcomes in itself (such as research supported by the Marsden Fund)
- stronger and more effective international relationships
- support for national research facilities (including the maintenance and retention of databases and collections), many of which will be relevant across several sectoral outcome areas
- Vision Mātauranga capability, which provides specific funding to support a theme that runs through all sectoral outcome classes. Vision Mātauranga encompasses Māori innovation and focuses on four thematic areas:
  - contributing to economic growth through distinctive science and innovation
  - Taiao: achieving environmental sustainability through iwi and hapū relationships with land and sea
  - Hauora/Oranga: improving health and social wellbeing
  - Mātauranga: exploring indigenous knowledge and science and innovation.

Funding delivery tools

In any of the outcome areas it is possible to support science and innovation across a broad spectrum from advancing knowledge to transferring knowledge to those who can use it. The relative balance of these activities will vary across different outcome areas, depending on what complementary capabilities already exist. For this reason it is important that government be able to identify not just what outcomes it is seeking to support, but also where it would like to target its support across the range of activities that will help achieve the intended outcome. In order to do this the Government has developed a set of generic tools to deliver funding to the identified priority outcome areas.

Each tool targets a particular part of the R&D and innovation spectrum and supports a different set of activities. Not all tools are relevant for all outcome areas and in some cases there is only one particular tool for an output area – for example, the Marsden Fund's only tool is investigator-led, excellent research. Other outcome areas use a variety of tools.

The table below describes the tools. Note that each tool may encompass a set of more specific delivery activities. These sub-activities respond to the particular needs and opportunities of the different outcome areas.

Related initiatives

Initiatives in other areas of government will also help users, funders and researchers develop more co-ordinated approaches to identifying their research needs. For example, MAF Biosecurity New Zealand has established a new biosecurity science system as outlined in the Biosecurity Science Strategy (2007). This receives support from expert advisory groups tasked with reviewing biosecurity research needs identified across the biosecurity system, and helping to support the uptake of research. This enables the biosecurity science system to provide clear signals on research priorities for New Zealand's biosecurity system as a whole, and helps ensure that research investments in this area deliver maximum benefit.

Funding Delivery Tool	Characteristics Of Tool
Support for excellent individuals	Includes fellowships, scholarships and prizes directed towards individual researchers.
Support for investigator-initiated excellent research	Operates independently of government priorities and supports curiosity-led research across all disciplines, including the social sciences and humanities. Selection is according to the excellence of the research proposal.
Science-led contestable funding	Supports smaller projects and larger programmes, in areas identified as government priority. Provides an opportunity to test new ideas and for new research teams to identify potential opportunities created by science.
Long-term non-contestable funding	Provides an opportunity to direct funding to broad outcomes while allowing research providers to develop a strategic and flexible approach to achieving that outcome. Funding supports large-scale, long-term programmes of research and can support and maintain essential research infrastructure.
Partnerships between researcher providers and research users involving co-funding	Supports co-funded partnerships between end-users and research providers to allow early and ongoing user engagement and develop user capability in engaging productively with researchers.
Support for commercialisation and technology transfer	Supports activities that help a) research providers to transfer research outputs to end-users, either through existing businesses or where necessary through the creation of new commercial entities; and b) research users to access technology and capabilities within research-providing organisations.
Support for business-led research	Provides support directly to businesses to help fund research activities that they either perform themselves or contract out to other research providers.

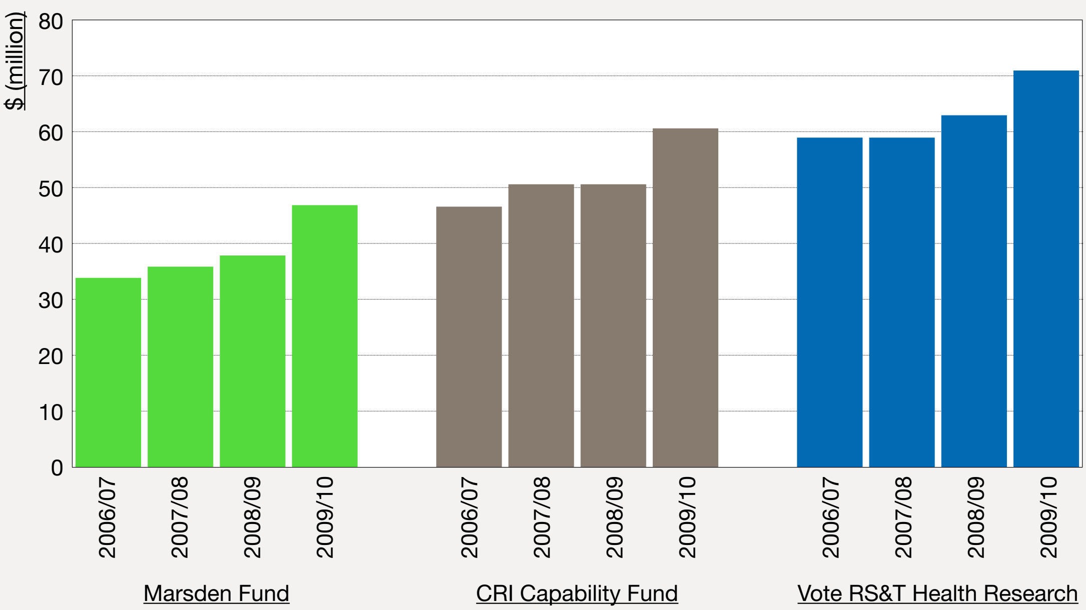
Supporting Fundamental Science

Fundamental science, such as the research largely carried out at universities, has many benefits. It adds to the store of human knowledge, which is good in and of itself. Though it is not aimed at commercialisation, the discoveries made from fundamental research can also have many serendipitous economic, social and environmental benefits. An example is the case study on Professor Colin Green's work included below.

The Government acknowledges the value of fundamental research and the benefits that can flow from it. In its first budget in 2009 the Government took some immediate steps to support fundamental science. These steps are on top of the continued support for the Performance-Based Research Fund, which supports university researchers. They were:

- providing the CRIs with a greater level of secure funding to support their strategic role in the system ($40 million over four years)
- boosting the Marsden Fund by $36 million over four years to increase the level of investigator-led research that expands knowledge across all disciplines
- increasing its investment in health research by $32 million over four years.

Growth in Marsden Fund, CRI Capability Fund and Vote RS&T Health Research



Vote RS&T is the Government's research, science and technology investment.

CASE STUDY

Marsden research delivers new treatment

A research project that initially focused on the development of embryos ended up discovering a new method of wound healing that is now being commercialised»

Professor Colin Green has spent 28 years investigating gap junctions, which is the cell-to-cell communication system that allows cells in the body to "talk" to one another. Seven of those years were at University College, London.

In 1997 he received a grant from the Marsden Fund to research the role of gap junctions in the development of chicken embryos but later, at the request of a student, devised an experiment to investigate the same issue in injuries to the central nervous system.

The results showed that when tissue is damaged, gap junction channels increase in number and the escalating "chatter" spreads from dying cells to neighbouring healthy cells, increasing the damage.

From that discovery, Professor Green and one of his former University College post-doctoral research students, Dr David Becker, developed a gel which is designed to block the formation of gap junction proteins and helps the body dampen down inflammatory responses and decrease the spread of a wound.

Another Marsden Fund grant was used to study how the gel could assist spinal cord injuries. The discovery was patented in 1999 and Professor Green and Dr Becker went on to co-found CoDaTherapeutics (NZ) and, later, CoDa Therapeutics Inc. in the United States.

The first human application of the gel was recorded in Auckland in 2006 with compassionate use in a patient with a severe chemical burn to the eye. Today, the patient has full 20/20 vision.

CoDa Therapeutics has already attracted US$23 million of investment and is registered in both New Zealand and the United States. Phase one clinical trials on skin and the eye have been completed and phase two trials will conclude this year.

"If the phase two trials are successful and are verified in phase three, we will have turned a piece of experimental research into a revolutionary new wound healing treatment," says Professor Green.

www.codatherapeutics.com

Professor Colin Green

Supporting the Primary Sectors

The 2009 Budget also featured the Primary Growth Partnership (PGP), a partnership between government and industry aimed at boosting the economic growth and sustainability of New Zealand's primary and food sectors. The PGP has funding of $190 million over four years and will invest in significant programmes of research and innovation across New Zealand's primary and food sectors.

These industries include: pastoral and arable production; horticulture; seafood; forestry and wood products; food processing; and climate change initiatives.

PGP responds to the critical need for innovation in these industries, which is vital for New Zealand's long-term economic growth and improved environmental performance. PGP investments will cover the whole of the value chain – including education and skills development, R&D, product development, commercialisation and technology transfer.

Industry interest in the PGP initiative has been high. Two application rounds have been held, with 25 proposals submitted from across the primary industries.

Raising the Profile of Science

Along with supporting fundamental science and introducing the PGP, the 2009 Budget included measures to raise the profile of New Zealand science. These included:

- the appointment of a Prime Minister's Chief Science Advisor, Professor Sir Peter Gluckman, one of New Zealand's most distinguished scientists. Sir Peter has provided valuable advice on the science and innovation system and is helping the Government to use science to improve its decision making and recognise the roles of well-funded science
- the creation of the Prime Minister's Science Prizes, with $4 million over four years. For more information about the prizes, see section five of this document.

Key actions

STEPS TAKEN:

- Science and innovation have been made central to the Government's economic growth agenda.
- The Government has increased funding for science and innovation, with a focus in the 2009 Budget on supporting basic research, the PGP and raising the profile of science.
- Professor Sir Peter Gluckman has been appointed as the Prime Minister's Chief Science Advisor.
- Government science and innovation investment has been restructured so that it can set priorities in a more direct, explicit and transparent way with a direct line between priority setting and funding decisions.
- The outcomes of science and innovation have been made the focus of funding.

NEXT STEPS:

- Implement the priorities.

4. 2010: Supporting Business, Reforming CRIs and Simplifying Government Structures

During 2010 the Government has increased the scale of the changes it is making to the science and innovation system. The largest of these changes focus on increasing business R&D, improving the CRIs and making the Government's science and innovation structure more efficient.

The Importance of Business R&D

The Government believes that increasing business investment in R&D is essential for the future of New Zealand. Without such investments our economic development and wellbeing are at risk. For this reason, the support of business R&D is a central element of Budget 2010.

Funding for business R&D will increase by more than $250 million over four years.

Future economic growth will depend heavily on increasing the role business plays in the science and innovation system, through R&D. Research by economists has shown that, at a national level, increasing business expenditure on R&D has a strong correlation with high economic growth.

Businesses draw on their market intelligence and commercial links to convert research findings into improved productivity, increased competitiveness and new markets. These produce direct financial returns for the firm. When other businesses and consumers use the improved products and services that result from business innovation, the nation receives far-reaching social and economic benefits. These are reasons why governments support business R&D.

Along with outputs that firms use directly, business research has other, less tangible but equally important, benefits for firms that do their own R&D:

- they develop capabilities that put them in a better position to make use of opportunities presented by public R&D
- they are in a better position to use new technologies
- they have more opportunity to generate the inter-firm links that are becoming more important with the move to open innovation. Such links extend to shared investment in creating distribution networks and supply chains
- they are a more attractive partner for other firms across a broad range of activities.

One measure of the importance of research to business is the way in which business investment in research has been increasing rapidly around the world. Across the OECD as a whole, business funds more than 70 percent of research undertaken and the absolute levels of expenditure are swiftly increasing.[1] In most countries that we compare ourselves with, private sector spending on R&D is two to three times that in New Zealand. Many countries have also set targets for national expenditure on R&D (with many at around three percent of GDP and some even higher, as compared with New Zealand's current 1.2 percent) – with the expectation that increased business expenditure will make a significant contribution to meeting this target.

1. In New Zealand in 2008, the business sector was responsible for 43 percent of all expenditure on R&D, with the government sector contributing 27 percent and the higher education sector 30 percent.

Business R&D in New Zealand

Over recent years the level of business expenditure on research in New Zealand has increased, although it still remains well below OECD norms. We need to perform better. Some of this difference reflects the structure of our economy. For example, agricultural innovation traditionally depends on research performed and funded by the public sector. New Zealand also lacks multinationals, which is reflected in the level of R&D spending, as the larger a firm the more likely it is to perform research. Nor do we have some large R&D-intensive industries, such as pharmaceuticals, aerospace and defence.

A new approach to government support for business R&D

The Government will establish a one-stop shop for firms seeking public support for research. Eligible firms will be directed to the kind of support most suitable for their needs. This will enable business to readily access the most appropriate support.

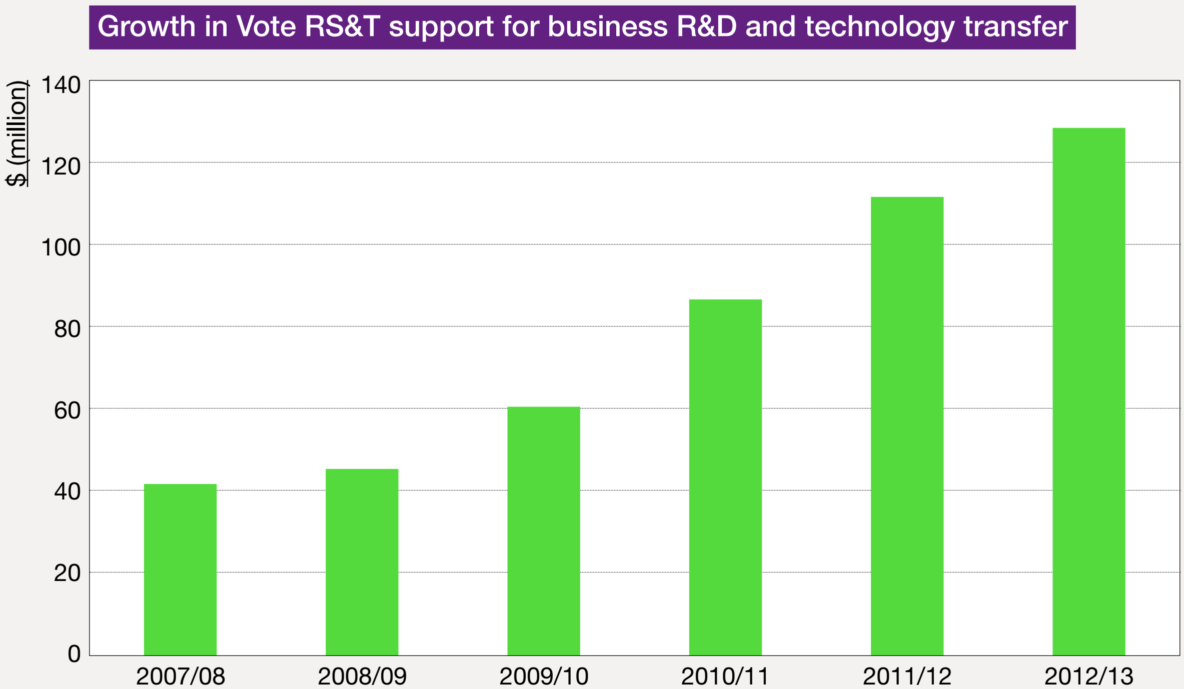
Increased support for business research and development will help diversify the New Zealand economy, creating opportunities for the further development of high-technology, research-intensive business. These firms build on the skills, creativity and imagination of our people and complement our ability to trade on our rich endowment of natural resources. Firms in the research-intensive sector offer interesting, highly paid jobs and their investment also helps create jobs for scientists and other talented people in research organisations.

Building and strengthening research-intensive firms will help transform New Zealand, as their impact goes well beyond their revenues and direct use of their products. Their products and services create innovation opportunities for their customers. They attract the best and most creative people in search of new employment options; and they encourage firms to relocate because they wish to draw on industrial capabilities that complement their own.

Having a critical mass of research-intensive firms can create an industrial commons and a set of skilled people and capabilities interacting synergistically. This environment encourages the development of new firms and new ideas. It provides a foundation from which to build highly competitive, internationally recognised industrial clusters – such as Silicon Valley.

The Government's changes will make it easier for business to engage with the science and innovation system. Many of the changes aim at making the system more responsive to user needs and will encourage research providers to work with potential users of their research, including business. Other changes will improve the flow of information, knowledge and technology from publicly funded research organisations to business.

While all of these changes are important, the most significant change the Government is making in Budget 2010 is the decision to increase funding for business R&D by more than $250 million over four years.



The 2010 Budget will introduce a package of reforms to support business R&D and technology transfer. By 2012 this package, together with existing schemes, will be worth almost $130 million a year.

The Government will enhance existing support for business research already provided through TechNZ's targeted and capability grants. These grants will remain. However, two new funding tools are being set up:

- technology development grants
- technology transfer vouchers.

These aim to address important gaps in the current support system and direct funding to areas where it will have the biggest impact – as determined by the firms themselves. The Government is also working to improve the commercialisation activities of public sector research organisations and increase the flow of useful knowledge and technology from public research providers to business.

Technology development grants

Technology development grants will support the R&D activities of firms that already have a good track record in R&D and spend a significant proportion of their revenue on research – firms with high research intensity. Such firms have demonstrated capabilities, not only in the performance of R&D but also in extracting commercial value from it. They have management, production, distribution and marketing systems that normally have the capability to expand readily as new products become available, or as production increases because of improved processes.

Technology development grants will provide support to eligible, R&D-intensive firms over three years, funding a wide range of both research and development activities.

The Government is investing $190 million over four years in these grants.

Technology transfer vouchers

The aim of technology transfer vouchers is to facilitate links between firms and publicly funded research organisations such as universities and CRIs by providing firms with funding to support commissioning of research. The vouchers will be easy to access and will encourage early, ongoing engagement between firms and research organisations.

The Government is investing $20 million over four years to trial these vouchers.

Technology transfer and commercialisation

The Government has commissioned work to improve the effectiveness and efficiency of existing commercialisation and technology transfer offices. Considerable consultation has been done, including a workshop run by the Prime Minister's Chief Science Advisor to consider the commercialisation of research, and continuing work by the Capitalising on Research and Development Action Group (CRAG). Work is underway to identify the best ways to increase networking and co-ordination across the commercialisation offices. The Government will initially support capability development in local commercialisation offices and may eventually support shared practices.

As an initial step, the Government has set aside $11 million over four years to lift technology transfer and commercialisation.

Food innovation

The Government is establishing a nationwide network of open-access food development facilities. The Food Innovation Network New Zealand (FINNZ) is a collaboration between central and local government, industry, and research and education organisations. It will help firms develop new food and beverage products and ingredients.

The Government is investing up to $21 million over five years. This started in 2009/10 on four regional hubs in Manukau, Waikato, Palmerston North and Canterbury, and an overarching network organisation.

Key actions

STEPS TAKEN

- The Prime Minister's Chief Science Advisor and CRAG have been engaged to work with business leaders to determine how to increase rates of commercialisation and technology transfer, and improve linkages between researchers and firms.
- High-value manufacturing and services have been made a priority outcome area for increased investment, and alongside our biological industries are key sectors for economic growth.

NEXT STEPS:

- Provide more than $250 million in new funding over four years to stimulate business R&D in New Zealand, and to make it easier for firms to identify what support is available and which programmes best meet their needs.
- Launch and implement two new business R&D initiatives in 2010:
  - a low compliance technology development grant aimed at companies that are already undertaking R&D, to incentivise them to undertake additional R&D
  - a pilot scheme using technology transfer vouchers for firms with less R&D experience.
- Increase funding for commercialisation and technology transfer, through support for commercialisation offices and development of other technology transfer activities important to firms.
- Development of a one-stop shop for businesses to get assistance with R&D and technology development.
- Strengthen food innovation.

CASE STUDY

Weta weaves digital magic

Twenty years ago in the quiet Wellington suburb of Miramar, one would never have suspected there would emerge the thriving film industry that exists today»

Now a cluster of world-class companies is firmly established in a corner of Wellington, providing everything from hand-crafted props through to world-class post-production facilities. They have created hundreds of jobs, generated hundreds of millions of dollars and raised New Zealand's reputation for innovation.

At the heart of this success is Weta Digital, whose stunning computer-generated visual effects have won five Oscars and many other awards. It's been the result of tireless hard work and imagination, dedication to excellence and R&D-driven innovation.

Weta Digital is now one of the world leaders in their field, having worked on some of the biggest and most visually impressive movies of recent times. These include *The Lord of the Rings* trilogy, *King Kong*, *District 9* and *The Lovely Bones*.

This work has culminated in the creation of the incredible digital world of Pandora in *Avatar*, the most successful movie ever made.

Avatar demanded a new level of realism and detail in computer imagery. Investment in R&D enabled the advances in technology – from motion capture of performers to rendering of images – that enabled Pandora to be believable in 3D.

To stay at the peak of the industry requires Weta Digital to continue pushing the boundaries. They are looking to make digital faces more realistic and to find ways to improve productivity so the company can work on more projects simultaneously. To help do this they were awarded a $5.8 million grant from the Foundation for Research, Science and Technology's TechNZ business investment programme. This is part of a $15 million R&D fund managed by Weta Digital, with the aim of connecting with other researchers and organisations here and around the world.

www.wetadigital.com

The Importance of CRIs

The eight Crown research institutes (CRIs) play important, distinctive and central roles in New Zealand's science and innovation system. They employ over 4,400 people, including many highly skilled scientists, receive around $480 million of government funding a year and earn total revenue of about $675 million.

CRIs perform strategic research that can create opportunities for business and provide information and technology that contribute to the wellbeing of New Zealanders. An example of this is the case study on sea swells that follows this section. This role is especially important because it helps compensate for New Zealand's relatively low levels of business R&D. CRIs also help meet the Government's need for research to promote innovation in government services, inform policy development, and provide capacity to respond to unexpected areas of need.

CRIs were established in 1992 to focus national scientific capability around the country's key economic, environmental and social needs. Since then, there have been major changes in the problems they need to address and significant changes to the structure of the science and innovation system.

To enable CRIs to meet these challenges and ensure the organisations add as much value as possible to the New Zealand economy and the wellbeing of its people, the Government commissioned a Taskforce in late 2009. The Crown Research Institute Taskforce, led by entrepreneur Neville Jordan and including a number of highly experienced business and government leaders, reported on how CRIs can best deliver on national priorities and respond to the needs of users, particularly industry and business.

The Taskforce's findings were released on 4 March 2010. The Taskforce found that the main factors impeding CRI performance related to their funding, ownership and governance arrangements. Taken together, these factors created a lack of clarity and purpose for CRIs, presented multiple lines of accountability, inhibited collaboration, and made it difficult for the organisations to operate strategically.

Summary of Government's response to CRI Taskforce report

The Government has endorsed the recommendations made by the Taskforce and agrees that Government should:

- provide greater clarity on the role and purpose of each CRI
- give CRIs more certainty of funding through greater use of long-term negotiated funding
- strengthen CRI board accountability with a focus on the outcomes each CRI is responsible for achieving
- establish balanced performance indicators that help measure the success and national benefit of the CRIs. In discussion with each CRI, shareholding Ministers will determine an appropriate rate of return on equity, taking into account the cost of capital to the Crown.

These changes require a behavioural shift within CRIs. Performance will be less driven by competition, and CRI boards will assume greater responsibility to lead and be held accountable for their results. The Government expects CRIs to form closer relationships with research users, improve their focus on science quality through the use of science review panels, and increase collaboration and partnerships with other research institutions.

The Taskforce recommendations create an opportunity to position CRIs as a critical part of the Government's economic growth agenda over the next five to 10 years.

These changes, along with recent decisions on government science investment priorities, the creation of a new department to align CRIs' funding, ownership and policy functions, and the upcoming Budget, represent the most significant change to CRIs and the wider science and innovation system in almost 20 years.

Implementation of the Taskforce changes is expected to be completed by 1 July 2011.

Key actions

STEPS TAKEN:

- Budget 2009 included $40 million over four years for the CRIs to support their strategic role.
- The Government convened a taskforce of high-calibre people to determine how to improve the performance of CRIs, and enhance the value of New Zealand's investment in them.
- The Government considered the CRI Taskforce's report and agreed to implement its recommendations.

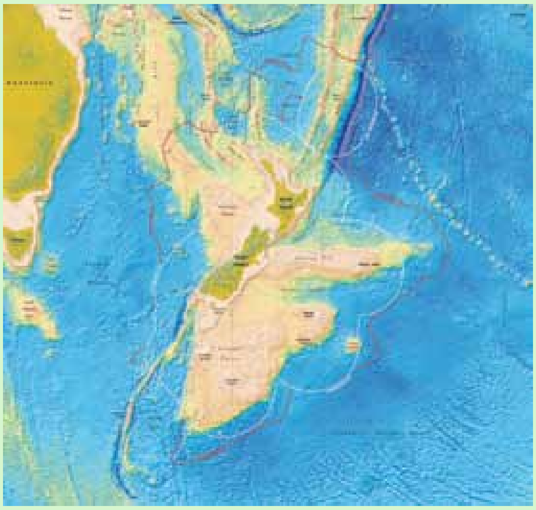
NEXT STEPS:

- Work with CRI stakeholders to produce statements of core purpose for CRIs and statements of corporate intent.
- Align current funding streams with the proposed new funding arrangements and establish contracting arrangements for CRIs.
- Review Government procurement practices with respect to CRIs and other research providers.
- Develop a set of key performance indicators and methods for conducting rigorous independent evaluations.
- Develop requirements for CRIs to establish independent scientific advisory committees and end-user panels.
- Use the CRI board appointment process to examine board composition to ensure boards have the relevant experience to manage the change process.
- Identify opportunities for legislative change to ensure the recommendations are embedded for the long term.

CASE STUDY

Sea study swells New Zealand

Not many people know it, but thanks to CRI scientists New Zealand has officially become a lot bigger»



Scientists at GNS Science and the National Institute of Water & Atmospheric Research played a major role in adding 1.7 million square kilometres of seabed to New Zealand's territory. This area might contain billions of dollars' worth of resources such as minerals and petroleum.

After 12 years of work by scientists and officials, in August 2008 the United Nations Commission on the Limits of the Continental Shelf confirmed New Zealand's rights over the seabed in this huge area.

The islands of New Zealand are the tips of a largely underwater continent. The UN decision gives the country sovereign rights over more than 5.7 million square kilometres of ocean floor, an area 22 times that of our land area, three-quarters the size of Australia, and one percent of the Earth's surface.

The team of scientists undertook surveys of the sea floor, analysed the data and helped with maritime boundary negotiations with Australia. They collected all existing information about the depth of the water, and the geology and tectonics of the area off New Zealand's coasts. Where there was not enough information, the team completed 13 surveys with specialised vessels, totalling 365 days at sea. The result was a completely new understanding of the geology and tectonics of New Zealand's marine territory. The work will support research in this area for decades.

The result of the massive project was a 2,600-page submission, plus a stack of supporting documents, which impressed the UN. New Zealand secured 98 percent of the ocean floor described in the submission.

The expertise of the scientists who led this project was recognised internationally, with many other countries asking for advice and other help with their claims.

Better Government Structures

The Government is by far the biggest single player in New Zealand's science and innovation system, and it is critical that government science and innovation structures are organised correctly.

Direct government involvement in the science and innovation system includes the CRIs and the funding agencies: the Foundation for Research, Science and Technology (the Foundation), the Health Research Council of New Zealand, the Marsden Fund Council and the Tertiary Education Commission, which provides funding supporting university research through the Performance-Based Research Fund. Then there is the Ministry of Research, Science and Technology (MoRST), which manages the Government's investment through Vote Research, Science and Technology and provides advice on science matters.

Additional support for science comes through many other ministries and a wide range of research activities contracted by other government agencies.

The complexity of New Zealand's science and innovation system has created problems for those working in and involved with it. Dealing with multiple government organisations can increase stakeholder costs and create uncertainty about which agencies they need to contact. Having multiple organisations involved in the same area can lead to a lack of transparency and conflicting advice or agendas. This is why the Government is combining MoRST and the Foundation into a new department.

The advantages of a new department

Creating a new department will improve the science and innovation system in a number of ways. For example, it will allow better integration of policy, strategy and funding. Stakeholders will deal with a simpler system, which will provide more consistency and certainty.

Information flow is also usually freer within agencies than between them. Integrating funding and policy will help those who oversee and deliver programmes to feed issues into the policy advice the Government receives. This will improve the quality of policy advice, speed up policy implementation and make the path between ministerial decisions and 'front line' operations more direct.

Combining policy and funding responsibilities will bring policy advisers and research providers closer, leading to greater trust and more effective sharing of information and expertise. Having a new department will also remove any potential confusion from split accountabilities to independent boards and ministers.

The new department will preserve as a key principle the independence of decision making for funding contestable research programmes and providing business assistance. This is likely to result from statutory authority given to the Chief Executive, who will be required to take advice from expert advisory panels.

As well as promoting the sharing of complementary systems and expertise, the new department will offer staff more varied career paths and development opportunities. Although not its primary purpose, combining responsibilities will also provide efficiencies, such as reducing administration and freeing up more research funding.

The Government will continue to consider ways of further enhancing the effectiveness of the science and innovation system, and its components. The interaction with the tertiary education system is particularly important. The Governments seeks a simple, transparent system that delivers high-quality research and knowledge so that all sectors of New Zealand, including business, can thrive.

To help simplify the system, the Government has already required its funding agencies to simplify their processes, reduce the costs for scientists dealing with them, make it easier to apply for funding and ensure reporting processes become less onerous.

5. Next Steps: People, Infrastructure and International Connections

As well as improving the structure of the system, increasing business R&D and enhancing how CRIs deliver for New Zealand, the Government is making changes to other important parts of science and innovation. These include supporting the people and infrastructure that are at the heart of science and innovation, and improving the international connections that are increasingly important for researchers and firms.

The Importance of People

The success of a science and innovation system ultimately depends on the quality of the people working within it. Regardless of the amount of public and private investment in science and innovation, without talented and enthusiastic people that money will be wasted.

This means much more than having highly talented researchers, even though it is essential that our researchers are top quality. There is an equal need for the likes of engineers, technicians and teachers. Scientifically aware business leaders are essential if New Zealand is to make effective use of the opportunities created by science and innovation. New Zealand also needs a scientifically literate population to enable informed debate about the use of science and technology, and to create an environment in which innovation can flourish.

School science

There is a decline in the proportion of students choosing to study science, which ultimately leads to a smaller pool of talented scientists. Attitudes towards science are set early in life, so it is important that school students receive a positive impression of science, its relevance and the exciting opportunities it offers.

The Government has recognised the importance of school science education and through Vote Research, Science and Technology supports a number of small programmes that help teachers pass on the relevance and excitement of science. These include the Science Learning Hubs, which provide accessible and New Zealand-relevant science in a form that teachers and students can use; fellowships that give both primary and secondary teachers opportunities to work directly with scientists; and support for programmes aimed at promising school students, including those attending the International Science Olympiads.

International comparisons show New Zealand's science education produces excellent results. For example, the OECD report *Top of the Class*, released in April 2009, shows our 15-year-olds are among the best in the world in science achievement.

Despite this ranking, challenges remain, including a wide gap between our highest and lowest performing students. It also appears that younger students are becoming less interested in science and less committed to studying it. The Prime Minister's Chief Science Advisor is working with the Royal Society of New Zealand and MoRST to review current research into this topic, identify and assess support for school science education, and suggest improvements.

Improving the status of science and scientists

When choosing which area to study, students make decisions in part because of potential salaries, job security and satisfaction. The prestige of a profession and the respect its practitioners receive are also important. The Government recognises the need to create a society that values scientists and celebrates their achievements and, in Budget 2009, allocated funding for the Prime Minister's Science Prizes. The first of the annual prizes, with $1 million in prize money and a top prize of $500,000, were awarded in March 2010. The following case study provides more information.

CASE STUDY

Outstanding research honoured

Two scientists who have put New Zealand at the forefront of the global roll-out of revolutionary new power technology were named as recipients of the 2009, inaugural, Prime Minister's Science Prize»

Prime Minister John Key with Dr Jeff Tallon (left) and Dr Bob Buckley (right)

Dr Bob Buckley and Dr Jeff Tallon have led Industrial Research Limited's (IRL's) superconductor research and commercialisation activity for more than 20 years. They have made many discoveries in the field of high temperature superconductors (HTS) and used them as a platform to establish world-leading export businesses in HTS products.

The Prime Minister's Science Prizes were introduced to raise the profile and prestige of science among New Zealanders. They combine recognition and reward, with five awards attracting total prize money of $1 million. The prizes celebrate scientific achievement, highlight the impact science has on New Zealanders' lives and aim to attract more young people into science careers.

There is keen global interest in superconductors because they allow the flow of electricity with no loss of energy. This allows smaller, lighter, more efficient machines and more environmentally friendly technologies that offer big cost savings in areas ranging from power transmission and generation to manufacturing, electronics, health and transport.

As well as contributing knowledge to the fundamental understanding of HTS, Drs Buckley and Tallon have been at the cutting edge of developing real-world applications, with New Zealand being one of only a few countries commercialising HTS.

The IRL team plans to use its prize money to establish a national, dedicated facility for research into the performance of materials under extreme conditions, including high magnetic fields, high pressure and low temperature, which use powerful HTS magnets.

The facility is expected to attract young New Zealand and international scientists and help New Zealand maintain its world-leading position with the development of HTS technology.

Other Prime Minister's Science Prizes are awarded to an emerging scientist at PhD level, a young secondary school scientist, a science teacher and a science communicator.

www.pmscienceprizes.org.nz

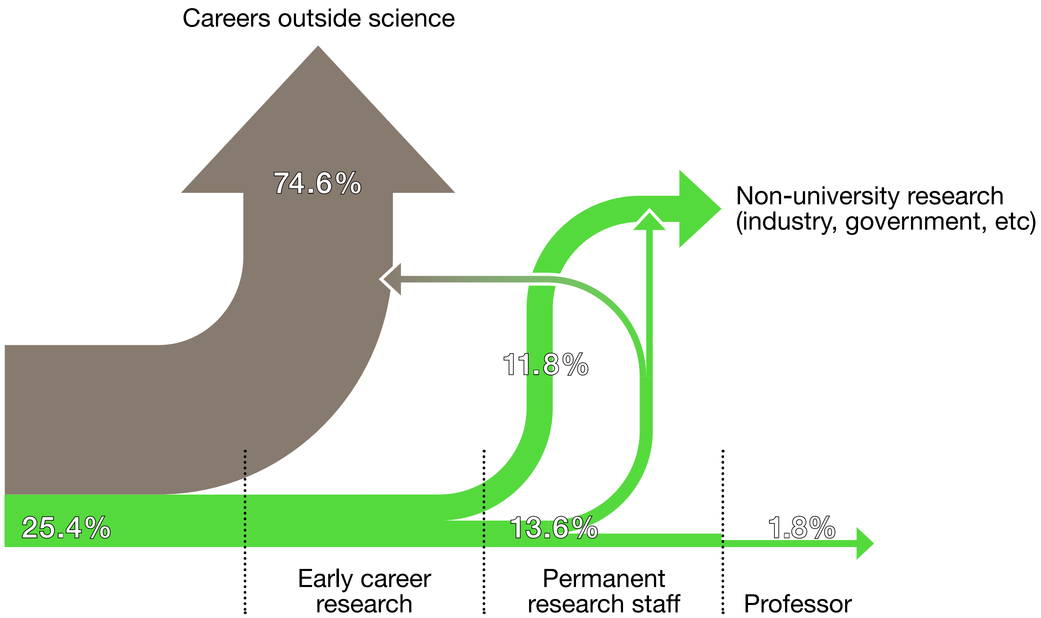
Science for non-scientists

One factor that discourages students from continuing study in science is that science often seems the only career option. However, an education in science equips people for many different careers. There is real demand for these people in professions that do not involve the direct application of scientific knowledge but do require an appreciation of what science can do.

For example, nearly 75 percent of science PhDs go into jobs outside science, as shown in the figures below. It is vital to promote the variety of opportunities that flow from a science education and for scientists and those with a background in science to take a higher profile in discussing the benefits of their work and education.

Career pathways for New Zealand science PhD students

Sources: Statistics New Zealand, *Research and Development in New Zealand 2006*, *Census 2006*, Ministry of Education, *Profile & Trends: New Zealand's Tertiary Education Sector* (2006).



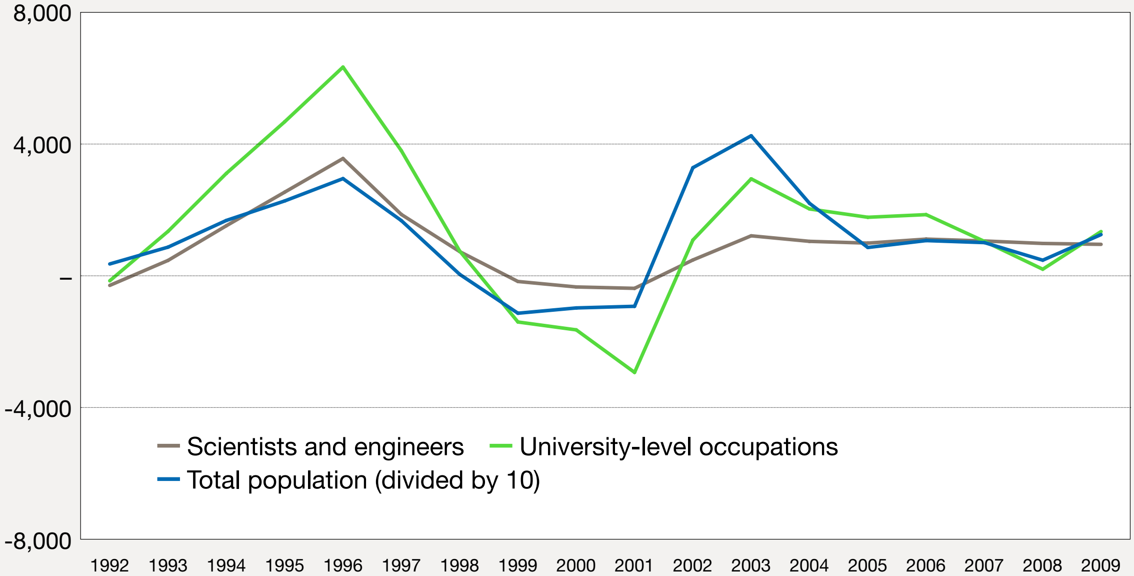
Researchers

Researchers are the single most important part of a science and innovation system, as they unearth the discoveries that drive the system. The availability and quality of researchers in New Zealand depend on both the education system's effectiveness and this country's appeal as a place to do research.

New Zealand is attractive to foreign-born and trained researchers. The number working here outweighs the number of New Zealand researchers working overseas.

Migration of skilled people, 1992-2009

Source: Statistics New Zealand Infoshare



In every year since 1993 (except for 1999 to 2001) New Zealand's science and innovation system has had more scientists and engineers immigrating than emigrating. Since 2003, the net number of migrants to New Zealand working as scientists and engineers has been steady at around 1,000 a year.

However, demand for high-quality scientists and engineers is increasing around the world and the market is highly competitive. As a result New Zealand will continue to rely heavily on the scientists it is training and employing. In some fields – such as environmental management, social science and health – local knowledge and experience can be an advantage.

Creating attractive careers

Attractive career opportunities bring people into science. The Government recognises the need for attractive, secure science jobs and, as a result, has reviewed the major science career stages from PhD level to established researchers.

The work has highlighted a critical gap in scientists at the post-doctoral, early to mid-career stage (i.e. three to 10 years after completing a PhD). This is the stage where scientists become established in their careers and develop research leadership and other skills that complement their technical expertise and knowledge. Unfortunately, this has been the stage at which scientists find it most difficult to win support and it is also the stage where we compete most with other countries. In 2010 the Government has introduced the Rutherford Discovery Fellowships to help fill this gap. These will:

- provide support for emerging scientists
- support recipients for a longer period of time
- provide more competitive funding, up to $200,000 a year
- focus on developing excellent researchers in New Zealand.

This new fellowship scheme also aims to attract top researchers, with overseas post-doctoral experience, back to New Zealand.

The Government is also exploring options to encourage increased entrepreneurship, including by attracting top entrepreneurial scientists to New Zealand, with a view to providing funding in Budget 2011.

Finally, the Government's increasing support for business research and development will increase the number and variety of research positions available in New Zealand.

Key actions

STEPS TAKEN

- The prestigious Prime Minister's Science Prizes were launched, to increase public recognition for those involved in science.
- A Postgraduate Internship Programme was piloted through TechNZ, with the aim of giving New Zealand's future innovators a head start in their careers through a placement with a company.

NEXT STEPS

- Establish the Rutherford Discovery Fellowships, a prestigious fellowship scheme to establish early to mid-career researchers in New Zealand.
- Review current research into engaging young New Zealanders in science and innovation, identify and assess support for school science education, and suggest improvements.
- Look at options to encourage increased entrepreneurship, including by attracting top entrepreneurial scientists to New Zealand.

The Importance of Infrastructure

Modern science relies on advanced equipment to explore increasingly complex problems effectively and productively. Up-to-date equipment, or research infrastructure, allows new approaches to research, helping scientists to work productively and keep abreast with peers overseas. Having this world-class infrastructure also makes New Zealand more attractive as a partner for international collaborations and as a place for scientists and engineers to work.

Large-scale research infrastructure consists of big, expensive assets in the form of experimental facilities, and associated services to deploy those assets.

Infrastructure commonly includes particular pieces of equipment, national collections (such as a herbarium) and communications facilities, such as high-speed broadband. However, it also covers metrology (accurate measurement systems), data collection and access standards, a robust intellectual property system and a regulatory system that supports research and facilitates its application.

New Zealand's approach

The Government recognises the value of investing in infrastructure and the need to plan for the future. Because research infrastructure is growing in scale, capacity, sophistication and often in cost, it is hard for one or even several institutions to justify the spending.

Large-scale infrastructure is a science sector-wide issue, so it is essential that government takes a leadership role where needed, shares the costs to encourage co-operation between research organisations, and ensures affordable, equitable access.

The Government is investing more actively. The 2009 Budget included a $16 million capital injection into the Kiwi Advanced Research and Education Network. This provides an ultrafast broadband network that links New Zealand's research organisations, tertiary education institutions, some government agencies and schools.

A research infrastructure investment strategy is being developed that will set out future national, large-scale research infrastructure investment priorities together with the rationale and basis for the investments. This will support the case for continued funding for infrastructure over the next four years.

Funding is limited, so each investment will need to be considered on its merits. This will involve discussions with the sector. The strategy will also reflect on issues relating to joint investments by multiple institutions – including governance, access and ownership models – and provide guidance on these aspects for those starting projects.

Data infrastructure and management

The Government is also encouraging greater reliance on, and sharing of, publicly funded data. Collaborative research based on sharing data as well as research capacity delivers economies of scale and allows scientists to undertake high-quality multidisciplinary research. This makes good data management essential and often involves a major shift from traditional approaches to data collection, storage, licensing, funding and ownership.

Data-driven science makes use of large-scale research infrastructure such as high-performance computing and high-speed broadband. Access to such infrastructure is vital.

An e-Science Roadmap is being prepared to determine the resources scientists need to best deploy infrastructure hardware and software in their work. There are also moves to roll out science data management policy and protocols to ensure publicly funded data is accessible and reusable.

International issues

Sometimes issues such as cost, technical support and a limited number of users make it impractical for New Zealand to invest in state-of-the-art infrastructure in New Zealand. It may be more practical to have secure access to international facilities through negotiating preferential treatment as of right for New Zealand users. A successful example of this is the Australian Synchrotron. For more information, see the following case study.

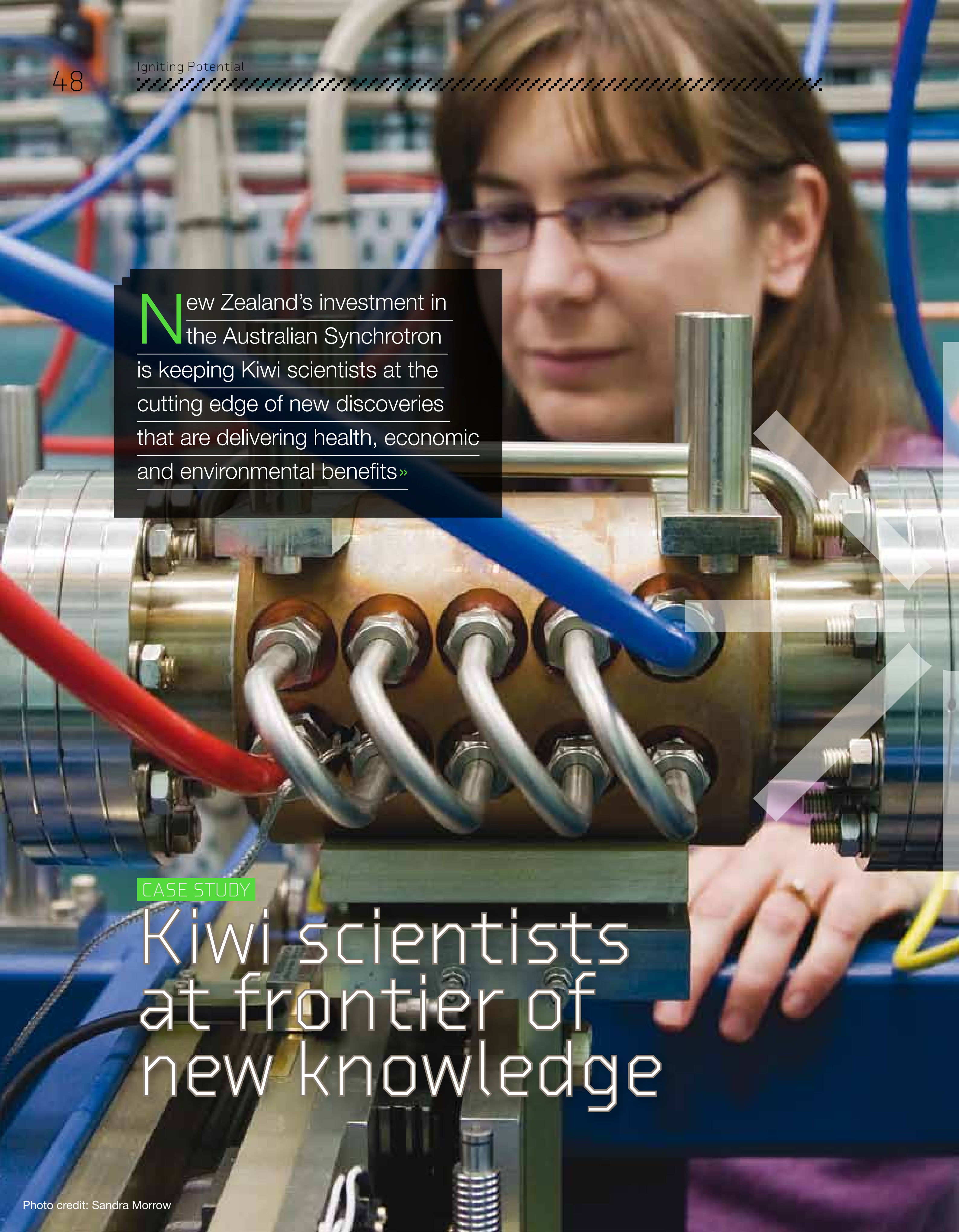
Key actions

STEPS TAKEN:

- A national advanced computational network, including e-Science services for researchers, has been proposed.

NEXT STEPS:

- Develop a research infrastructure investment strategy that identifies the most strategic priorities for investment in national infrastructure.
- Present an investment case for the national advanced computational network, including partnership funding support from the sector, with a goal to implement this facility in the 2010/11 financial year.



New Zealand's investment in the Australian Synchrotron is keeping Kiwi scientists at the cutting edge of new discoveries that are delivering health, economic and environmental benefits »

CASE STUDY

Kiwi scientists at frontier of new knowledge

Photo credit: Sandra Morrow

New Zealand is a foundation investor in the NZ$231 million synchrotron, the first to be built in the southern hemisphere. The investment was made through the New Zealand Synchrotron Group, a company formed by New Zealand universities and public science research institutes to guarantee access to the facility.

Until it opened in 2007, New Zealand scientists had to travel much further afield to use a synchrotron, adding prohibitive costs to many research projects.

A synchrotron is a machine the size of a sports stadium that produces light a million times brighter than sunlight by accelerating electrons almost to the speed of light. Once sped up, the electrons are deflected through magnetic fields to produce synchrotron light, which is then channelled into beam lines at the end of which various experiments can take place.

Researchers can use the synchrotron to investigate the composition of materials, including drying paint and corroding steel, through to developing new ways to treat and diagnose disease and conducting experiments that are difficult or impossible with conventional techniques.

New Zealand scientists involved in the Vital Vegetables® programme are using the synchrotron to identify how and where selenium is stored in vegetables. The findings of this study will play an important role in the development of new vegetable varieties with added health benefits.

Others, like IRL synchrotron science specialist Bridget Ingham, are using the facility to study the behaviour of nanoparticles, which are so tiny they can not be viewed with conventional laboratory equipment.

A programme of short courses for New Zealand postgraduate students is underway at the synchrotron and Dr Don Smith, from the New Zealand Synchrotron Group, says a wide range of new topics is being explored in applications for Marsden Fund grants as a result.

"The investment gives New Zealand scientists easy access to world class equipment that we cannot afford to build ourselves."

www.synchrotron.org.au

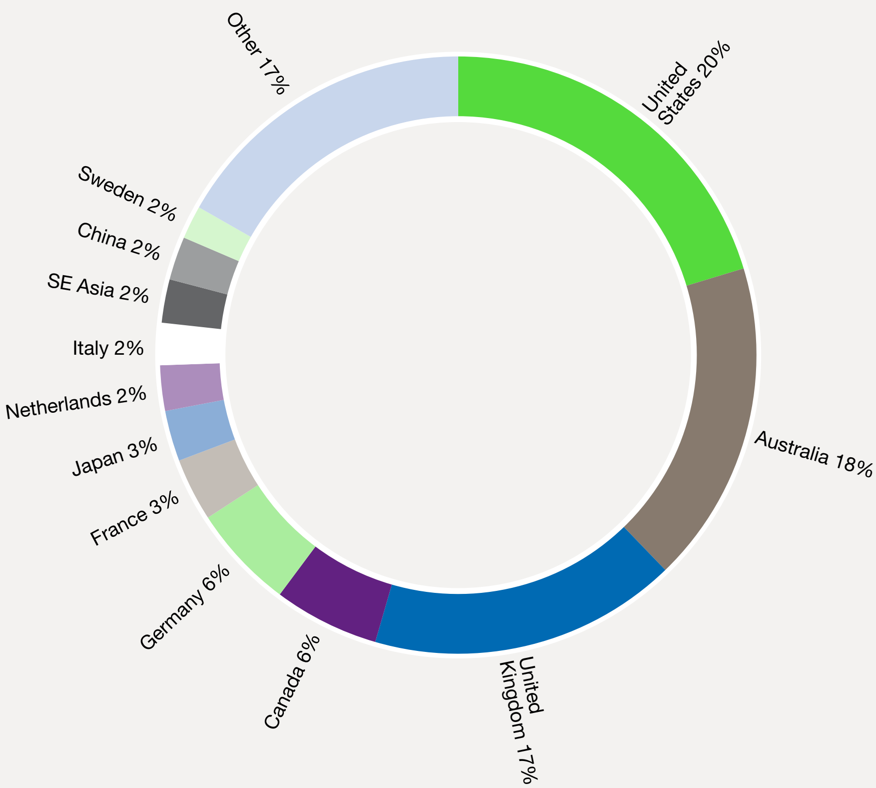
Photos courtesy of the Australian Synchrotron

The Importance of International Connections

It is critical for New Zealand to be an active international science player. With a population of only four million and less than 0.2 percent of the annual global investment in science, New Zealand is a very small player. Effective international research collaborations extend our science capabilities and create opportunities for successful technology transfer. International connections ensure members of our scientific community are able to share data, expertise and knowledge; gain access to equipment and other infrastructure; and contribute to scientific solutions to current global challenges, for example, pandemics, biosecurity and climate change.

Percentage of New Zealand international publication collaboarations with major countries and regions

Source: Ministry of Research, Science and Technology (2009), *National Bibliometric Report 2002-2007*



Governments contribute to effective international co-operation by using diplomatic and political channels to help bilateral exchange and by providing essential resources to seed and sustain scientific collaboration. This 'science diplomacy' has another advantage in that science and scientific reputation can frequently provide the credibility and heft a small country needs to be noticed.

As important as formal government-level links are, a major element of international scientific collaboration is less formal co-operation and exchanges between peers. Data on internationally authored scientific publications demonstrates the extent of such co-operation.

The relationships created by scientific exchanges also help establish new routes to international markets and speed the use of research-derived innovations. The reputation as a 'smart nation' gained through successful international collaboration can allow firms to take advantage of New Zealand's image as a producer of high-quality, technologically advanced goods and services.

New Zealand's strategic approach

New Zealand's international strategy has resulted in the growth of a range of strong collaborative relationships with carefully selected bilateral partners. The policy shaping this is underpinned by three key principles, namely the need to:

- establish strong relationships with partners able to contribute to building, expanding or enhancing New Zealand's science capabilities and create economic or other forms of value
- contribute to creating solutions to global challenges
- contribute to the nation's wider diplomatic objectives through a 'NZ Inc' approach.

A primary aim of New Zealand's international science strategy is to protect our excellent reputation as adroit science operators, readily addressing issues of interest in other countries, while keeping New Zealand's needs and priorities at the forefront.

This approach has enabled New Zealand to build on its longstanding relationships with Germany, other European nations and the United States by negotiating new, or renegotiating existing, treaty-level co-operation arrangements to formalise and plan joint activities. Recently there have been highly successful discussions with the European Commission and the United States government over work programmes in selected fields that are seeing increasing levels of collaboration. The longstanding co-operation with Germany has gone from strength to strength. New areas for scientific co-operation with Australia are regularly being identified and implemented, such as the Australian Synchrotron and marine research.

Over the past 12 months these more traditional partnerships have been supplemented by a push into North Asia, to grow connections with the emerging science superpowers of that region. This has seen an energising of the bilateral relationship with the People's Republic of China to the point where significant reciprocally funded research programmes are being planned. A treaty-level Science and Technology Co-operation Agreement has been signed with Japan, supported by a programme of exchanges and jointly funded seed research activities, and a variety of co-funded applied research projects with South Korea have been arranged.

For the future, compelling opportunities are on offer in South East Asia, including India, Singapore and Vietnam.

Priority setting and funding

International science collaboration needs to move beyond the science-focused goals of the past to play a greater role in supporting New Zealand's global strategic objectives. This calls for mechanisms that can pull together advice and informed commentary from both within the sector and potential stakeholders with interests that align, for example, the Ministry of Foreign Affairs and Trade, the Prime Minister's Chief Science Advisor, the Department of Prime Minister and Cabinet, and New Zealand Trade and Enterprise. As a first step, an International Science Advisory Committee is being planned.

Funding set aside to foster international linkages is also being reconfigured. A new fund, the International Relationships Fund, will come into effect from 1 July and will amalgamate and replace the International Linkages and International Investment Opportunity Funds over time (as contractual commitments expire). This consolidated fund will provide greater flexibility to support the range of international unilateral and reciprocal funding obligations that result from the increasing number of substantive bilateral relationships New Zealand is now party to.

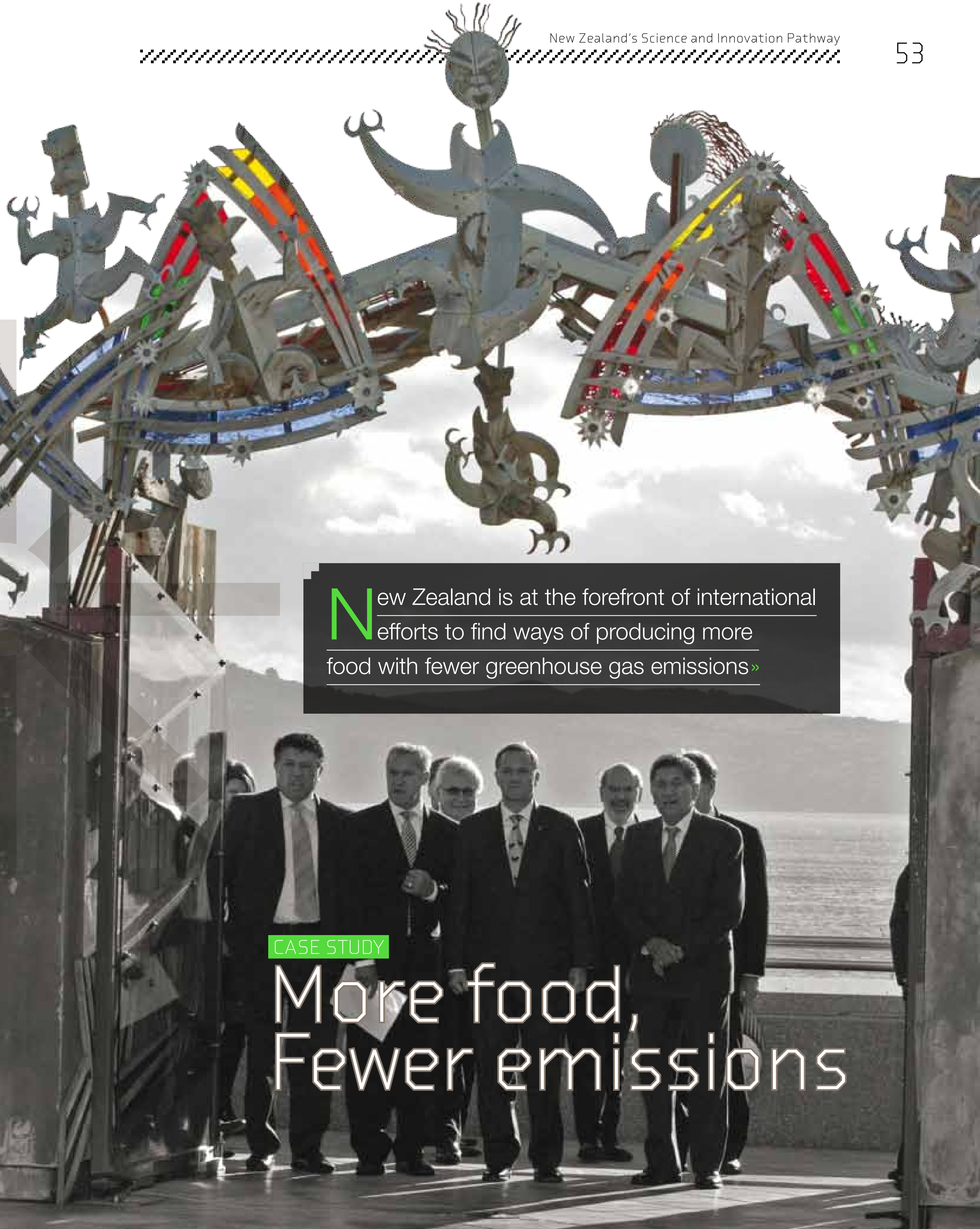
Key actions

STEPS TAKEN:

- The Vote RS&T international funding streams have been merged into one fund, which will focus primarily on New Zealand's key bilateral and multilateral science relationships.
- New Zealand has spearheaded an international co-operative research initiative, the Global Research Alliance on Agricultural Greenhouse Gases.
- The Government has hosted a major delegation of top US officials and scientists, which showcased New Zealand's ability to contribute to global science challenges.

NEXT STEPS:

- Strengthen international science co-operation and science diplomacy across government, by establishing an International Science Advisory Committee.
- Contribute to large, international science opportunities such as the Square Kilometre Array, the proposed giant radio telescope.
- Launch a New Zealand-China Research Alliance that includes CRIs, universities and firms.



New Zealand is at the forefront of international efforts to find ways of producing more food with fewer greenhouse gas emissions»

CASE STUDY

More food, Fewer emissions

It is a founding member of the Global Research Alliance, and was the driving force behind the establishment of the Alliance at the climate change conference in Copenhagen in 2009. A total of 28 nations have so far joined the network.

New Zealand has committed NZ$45 million over four years to the collaborative initiative, which intends to develop and share the research and technologies needed to increase productivity while reducing agricultural greenhouse gas (GHG) emissions. The United States will give NZ$127 million and Canada NZ$63 million.

Agriculture accounts for 14 percent of global emissions and 48 percent of New Zealand's emissions.

The New Zealand Government has also committed NZ$50 million to supporting the Centre for Agricultural Greenhouse Gas Research in Palmerston North, which co-ordinates New Zealand's research efforts and develops tools and technologies to help farmers reduce on-farm emissions.

Goals of the Global Research Alliance include ensuring greater consistency in the way agricultural GHG research is carried out and giving developing countries better access to the latest science on mitigation technologies and practices.

There will also be emphasis on developing the science and technology needed to improve ways of measuring GHG emissions and carbon sequestration in different agricultural systems.

New Zealand will host the interim Secretariat for the Alliance and, together with the Netherlands, will also co-ordinate the livestock research group – one of three groups set up to drive the Alliance.

This role will confirm New Zealand as a leader in this area.

Japan will lead research into rice paddy management and the United States will oversee research into crop management.

Alliance partners come from all parts of the globe, with new members able to join at any time.

Previous page: Global Research Alliance delegates and dignitaries, including Prime Minister John Key (front row, second left), about to enter Te Papa Tongarewa's marae.

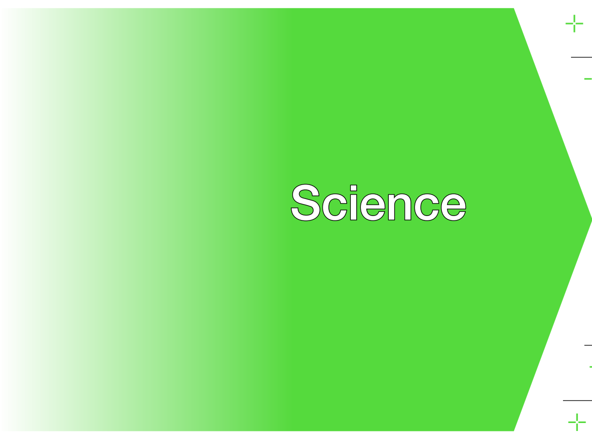
6. Potential Ignited: Capturing the Benefits

Creating impact

The Government's investment in science and innovation is about much more than the creation of knowledge. It is also about improving how knowledge is taken up and used, to benefit New Zealand.

Transfer of knowledge from research organisations to the public and businesses can happen in many ways. There is the transfer of technology developed in a research organisation to a company that can commercialise it. There is the employment of new graduates, with their knowledge and skills, by businesses and other organisations. There is also the transfer of knowledge to the public, such as when people learn new information and change their behaviour accordingly. Examples include information on healthy lifestyles, preparing for hazards such as earthquakes, and energy efficiency.

The diagram below (from Martin, B and Tang, P (2007), *The Benefits from Publicly Funded Research*, SPRU working paper 161) shows how science can have impact.



- Increase in the stock of useful knowledge
- Creation of new firms
- Supply of skilled graduates and researchers
- Creation of new scientific instrumentation and methodologies
- Development of networks and stimulation of social interaction
- Enhancement of problem-solving capacity
- Provision of social knowledge

It is notable that this diagram places importance on the general increase in the stock of useful knowledge, improved problem-solving capacity and the provision of social knowledge. These impacts provide a kind of insurance, creating a capacity to respond effectively to future issues.

Capturing the benefits of research will normally involve collaboration between different sectors. New Zealand's Centres of Research Excellence (CoREs) provide one example of a structure that builds on existing strengths by encouraging collaboration between many research organisations – creating a critical mass despite our relatively small and widely dispersed population. The principal role of the CoREs is to act as inter-institutional networks with researchers working collaboratively on a common, agreed research plan.

Actions taken

The Government recognises that impact comes in many different ways. It has linked science and innovation to its economic growth strategy. By appointing Professor Sir Peter Gluckman as the Prime Minister's Chief Science Advisor it has helped to establish clearer and more explicit pathways through which science can inform policy development. Sir Peter will continue work in this area, drawing on overseas experience, to see how the Government can further increase the effectiveness of these pathways.

The Government has focused on ways to make the science and innovation system more responsive to the needs and capabilities of users and has recognised the need to move existing knowledge and technology out from the laboratories into business, government and the general community.

In Budget 2010 the Government has established new tools to encourage links between research organisations and end-users of research, such as businesses. These include a technology transfer and commercialisation tool. This will allow government to allocate funding to technology transfer activities across all its priority outcome areas.

The Government already uses a range of mechanisms to promote the flow of research outputs to users. For example, it has funded Envirolink as a way of promoting links between regional councils and environmental scientists and helped research agencies develop research to an investment-ready stage.

Other organisations and departments also have technology transfer mechanisms. The Ministry of Agriculture and Forestry's Sustainable Land Management and Climate Change Plan of Action includes a technology transfer programme offered in partnership with the agricultural, horticultural and forestry sectors, Māori, and local government. Although there is a focus on climate change, most activity will have multiple environmental and economic benefits by extending new and current technology and practices to land managers and their advisers.

Changes being made to the funding and governance of the CRIs will help create conditions that facilitate technology transfer. In particular, greater certainty of funding and the requirement that CRIs appoint user panels to inform their strategy will help develop longer-term relationships that assist planning.

Increasing support for business research will boost commercialisation because there is a direct pathway from business research to impact, drawing on a firm's assets such as finance, management, distribution networks and market knowledge. Some of the additional support for business research specifically requires the development of links between business and public research.

The Government is also exploring opportunities and mechanisms to help existing technology transfer offices to work more effectively and is refining concepts for one or more centres of excellence in technology transfer.

CASE STUDY

Dunedin delivers new knowledge

A long-running and internationally renowned Dunedin-based study is poised to deliver to the world a new fund of knowledge about human development»

The Dunedin Multidisciplinary Health and Development Study has tracked more than 1,000 people born in Dunedin between April 1972 and March 1973, following them up at regular intervals since the age of three.

During an assessment phase, participants come back to Dunedin from wherever in the world they are living and undergo a wide range of tests of their physical and mental health. This includes teeth, blood samples, psychological testing, detailed interviews about relationships and behaviour, and family.

The assessment taking place in 2010/2011 as study members turn 38 will look, for the first time, at whether psychiatric disorder makes people age faster and be at greater risk of getting age-related conditions such as heart disease.

"Thirty-eight is an ideal age," says the study's director, Professor Richie Poulton. "Old enough to be past the peak age of the onset of the psychiatric disorders we wish to study and young enough for the information we collect to provide an important baseline for future research into the ageing process."

The world-leading study has produced over 1,000 publications since its inception and its findings have had a significant impact on family, child and public health policies both in New Zealand and overseas.

The study has influenced how a generation of children is raised and informed safety standards for children's nightwear, playgrounds, hot water temperatures and cycle helmets.

More recently, the study has researched criminal offending and anti-social behaviour, discovering that some people will offend throughout their lives but others only during the teenage years. This has major implications for how young offenders are dealt with.

Previous assessments have included the parents of study members and new studies are underway involving the children of study members, delivering unprecedented and ground-breaking information covering three generations of the same families.

http://dunedinstudy.otago.ac.nz

Professor Richie Poulton

7. Moving Forward

We live in a rapidly changing, globalising and unpredictable world. A nation's success in this world depends on ideas and creativity.

The New Zealand Government recognises this and is revitalising our national science and innovation system. New Zealand has some of the best thinkers and workers in the world, and has produced many amazing inventions and made many outstanding scientific discoveries.

But we can and must do better. As Prime Minister John Key has said, we need to have a high-performing public science system which supports economic growth, and a wider innovation system that encourages firms to increase their investment in, and take-up and application of, research.

More firms investing in science and innovation will lead to more valuable products and services, which in turn create new and better-paid jobs for New Zealanders.

The changes described in *Igniting Potential* are steps being taken at the beginning of an exciting pathway. Good progress has been made for science and innovation, but there are many challenges remaining.

Among the areas the Government will be examining is how to make the competitive funding system more effective. Work will also continue on how we can best attract and maintain top talent, including the entrepreneurs New Zealand needs to build on our research strengths to create new businesses.

This document captures the first stage of an ongoing process. The Government is determined to meet the challenges of the future and, in so doing, ignite New Zealand's potential.

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