Report of the

National Science Challenges Panel

27 March 2013

The Hon Steven Joyce
Minister of Science and Innovation

27 March 2013

Dear Minister

I have pleasure in forwarding the first report of the National Science Challenges Panel.

The panel met between February 18 and March 1 and has interacted extensively since that time in preparing this report. The panel makes a set of unanimous recommendations and unanimously endorses the attached report.

The Panel acknowledges the exciting potential of the National Science Challenges and sees them as an important step in progressing the better use of science to advance New Zealand. The Panel obtained considerable insights from the submissions of both the public and the scientific community.

The Panel has identified twelve Challenges that meet with the criteria that you provided to the Panel. However it identifies a more fundamental Challenge that extends beyond those criteria and which the Panel has termed the "Science and Society" Challenge. The Panel believes that this Challenge also needs to be adopted and coordinated as an urgent priority. This is necessary for New Zealand to take full benefit of its scientific capacities and capabilities and for the twelve recommended Challenges to be maximally effective and impactful.

Our recommendations should be seen as an integrated suite of Challenges that extend from protecting our current and future environments to improving the health of our peoples to advancing the economic growth of New Zealand.

Of necessity our descriptions of the Challenges must, at this stage, be at a high level and additional work will be required by the Panel together with Officials to give these Challenges, if approved by Cabinet, greater granularity and specificity.

In our report we also identify a number of other important factors that reflect both on the state of science in New Zealand and on the potential to use it much better. In particular we note the importance of greater and more consistent application of known knowledge in policy formation and in both private and public sector decision-making. We also note the need to encourage multidisciplinary research with a far greater incorporation of the social sciences alongside the physical and biological sciences.

The Panel acknowledges the assistance of the Ministry of Business, Innovation and Employment and of Mr David Miller as facilitator and looks forward to further engagement in the development of these Challenges.

Yours sincerely

Sir Peter Gluckman KNZM FRSNZ FMedSci, FRS

Chair
National Sciences Challenge Panel
Chief Science Advisor to the Prime Minister

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Summary of recommendations

The Panel's recommendations are made unanimously.

The Panel congratulates the Government on the National Science Challenge initiative, and notes that organising and supporting research in this way will significantly enhance New Zealand's science capability and have multiple benefits for New Zealand through assisting economic growth, and promoting social, human and environmental interests.

The Panel considered a range of possible Challenges reflecting the extensive institutional and public submissions before settling on 12 Challenges that were assessed to be of highest priority and which we judge to meet those criteria we were asked to consider.

The Panel recommends these for approval and funding as National Science Challenges. These are:

- ***Challenge 1 Aging well:*** *Harnessing science to sustain health and wellbeing into the later years of life, so that older people can continue to contribute to New Zealand*
- ***Challenge 2 A better start:*** *Research to improve the potential of young New Zealanders (up to 25 years) to have a healthy and successful life*
- ***Challenge 3 Healthier lives****: Research to reduce the burden of major New Zealand health problems*
- ***Challenge 4 High value nutrition:*** *Research to develop high value foods with validated health benefits*
- ***Challenge 5 New Zealand's biological heritage:*** *Research to protect and manage our biodiversity*
- ***Challenge 6 Towards more sustainable primary production****: Research to enhance primary productivity to meet future demands while protecting water quality and recognising environmental constraints*
- ***Challenge 7 Enhanced biosecurity:*** *Research to enhance our resilience to potential harm caused by the invasion of organisms that affect the health of animals and plants*
- ***Challenge 8 Life in a changing ocean:*** *Research to understand, exploit and sustain our marine richness*
- ***Challenge 9 The Deep South****: Research to understand the role of the Antarctic and Southern Ocean in determining our future environment*
- ***Challenge 10 Science for technological innovation:*** *Research to enhance the capacity of New Zealand to use physical and engineering sciences for economic growth*
- ***Challenge 11 Building better homes, towns and cities:*** *Research to develop affordable and better housing and urban environments*
- ***Challenge 12 Nature's challenges:*** *Research to enhance our resilience to physical challenges that nature throws at us*

The Panel noted that each of these twelve Challenges had very different characteristics and would all significantly be to New Zealand's benefit, and it was therefore not reasonable to differentiate between these diverse and important Challenges further in terms of the criteria we were asked to consider. Some of the twelve can be initiated in a shorter timeframe than others because of the level of detail available on them and the degree of focused scientific resource already available to tackle them. Others need further evaluation and effort to build working partnerships and communities of interest prior to their implementation.

There may be considerable variation in the degree of additional resource required to meet each Challenge because of varying levels of support and arrangements within the current funding of the sciences. However, New Zealand will benefit greatly if all the Challenges identified are provided with significant additional resources and effective co-ordination.

In addition, the Panel strongly recommends a special Challenge ***'Science and Society'*** *that, although it does not meet the Challenge criteria, is of sufficient importance to bring to the Government's attention and requires Government leadership. Indeed the panel sees this special challenge as of the highest priority and central to giving optimal effect to the twelve scientific Challenges proposed.*

The Panel acknowledges the quality and utility of both the science community's and public submissions and notes the significant impact that they have had on their deliberations and the Challenges consequentially recommended.

The Panel further notes that within the submissions there are many other helpful and supportive comments regarding the science and innovation system in New Zealand, and draws these to the attention of the Government.

The Panel also notes that some common themes emerged from the submissions: in particular the need for New Zealand to use current science more effectively in policy-making and in responding to a number of social and environmental challenges. It was also apparent from the submissions that there has been insufficient focus on science as a tool of social, environmental and health advancement and protection. There was a very strong conviction evident in many submissions that social, economic and environmental matters needed to be much more integrated in scientific investigations.

The Panel itself noted the need in many areas to break down the jurisdictional and disciplinary silos that have affected New Zealand science over recent decades. It further notes that there is a need to incorporate social science much more extensively and closely with physical and biological sciences if we are to use the knowledge obtained from scientific research most effectively. It concludes that, in each recommended Challenge, significant synergies are added through an integrated joint physical, biological and social science approach.

While it is premature to consider appropriate governance structures for each Challenge, the Panel notes that relevant research is currently found within a diverse and variously coordinated range of programmes. Customised but reasonably consistent governance structures will be crucial to achieving integration of, and synergies from, contributing national science capabilities and ultimately to the success of the Challenges' outcomes.

The Panel notes that not all areas of science of importance to New Zealand are able to be covered by the Challenge approach, but this does not make them any less important for New Zealand to address, and the recommended list should not be seen as a complete set of national science priorities.

The Panel also notes a number of significant scientific infrastructural issues that must be addressed if these Challenges are going to be successfully completed over the coming years. These are expanded on in our report. In particular, while the Government has shown scientific leadership in establishing the KAREN high bandwidth data network, and facilities that build on this, further development will be needed to underpin the National Science Challenges.

It will be important that the Panel continues to assist the Ministry of Business, Innovation and Employment in detailing the Challenges approved by Cabinet.

The Panel notes the importance of promoting effective feedback to the science community and the public regarding their contributions to this process, and in nurturing ongoing public interest and involvement in the critical role science must play in advancing New Zealand socially, economically and environmentally.

1. Background

The National Science Challenges are a new initiative aimed at injecting momentum into the goal of applying science for the benefit of New Zealand. The Challenge concept was approved by Cabinet in August 2012. Following that, the Minister of Science and Innovation established Terms of Reference for the Panel and criteria for the selection of Challenges (see appendices 1 and 2). The identification of potential Challenges involved both public submissions after a television and social network advertising campaign and an extensive period of consultation with researchers and research providers.

The National Science Challenge Panel was appointed by the Minister and was chaired by Sir Peter Gluckman, the Prime Minister's Chief Science Advisor. The Panel's membership is detailed in appendix 3. Essentially its brief was to recommend about ten Challenges to the Minister and thence to Cabinet in accord with the criteria and features established by the Minister. In doing so it was to take account of, and consider, the submissions from both the public and the academic/science sector.

2. Consultation

The Ministry of Business, Innovation and Employment (MBIE) undertook an engagement process with the science sector and the public between September 2012 and January 2013 to elicit ideas about the most important issues for New Zealand that can be addressed by science. The engagement included developing illustrative Challenges; workshops with the science sector to support the development of submissions; and *The Great New Zealand Science Project* (GNZSP) campaign to obtain ideas from the public via websites.

The science and research provider sector made 223 eligible and generally detailed submissions on potential Challenges.

The public campaign resulted in 138 eligible submissions posted to the websites and 616 further ideas and comments discussing the submitted Challenges. A Facebook page elicited thousands of comments and, as of 30 January, over 14,500 'Likes', indicating a high level of public interest in the Challenges.

The Great New Zealand Science Project and a mirror site on the Ministry webpages enabled visitors to indicate their 'support' for the illustrative Challenges; for example, there was significant support for biodiversity and fighting disease. As of 28 January (when submissions closed), the illustrative Challenges had received the following pattern of response:

Illustrative Challenge titles	**Supporters** (via GNZSP site and a mirror site on Ministry webpage)
Advanced materials	459
Biodiversity	760
Changing climate	579
Fighting disease	792
Food for health	471
Land and water	584
Resilience to natural hazards	363
Rich seas	572
Total	**4580**

While such a process can only be seen as illustrative of the views of those who chose to engage with the process, and notwithstanding the inevitable bias in such a process, it does suggest that there is a broad understanding that science can contribute much more effectively across many domains to the betterment of New Zealand.

The Ministry of Business, Innovation and Employment (MBIE) collated all the submissions and made them available to the Peak Panel, together with the original illustrative Challenges and the output from the science sector workshops. The science sector submissions were provided in a database as well as collated in hard copy in full for the Panel's deliberations.

3. Characteristics and features of a Challenge

The key material underpinning the Panel's consideration was an understanding of the criteria and features that would comprise an effective Challenge. These were defined in a Ministerial paper provided to the Chair. The criteria for a Challenge were:

1. Each National Science Challenge will target a high level goal which, if achieved, would have a major and enduring public benefit for New Zealand.
2. Scientific research is essential to the Challenge.
3. There is a wide public consensus that the Challenge will address an issue or opportunity of wide public importance to New Zealand.
4. New Zealand has broad scientific capability and capacity to undertake the Challenge successfully.
5. There is sufficient external motivation and linkages for the research results to be implemented to achieve the Challenge goal.

To assist in interpreting these criteria, a Challenge would have the following features. Some of these would need to be assessed at a later stage of the process when the Challenges are operationalised.

1. Each Challenge will have a strong virtual governance structure (existing or new), with clear leadership and accountabilities across the researchers and institutions involved in the Challenge.
2. Each Challenge is likely to involve a broad portfolio of multi-disciplinary research activity that will involve collaboration across a number of research providers.
3. Each Challenge will involve within it a number (say 2-6) of interrelated research themes (and, within each, identifiable components) that are integrated and coordinated to provide a plausible pathway to achieving the Challenge.
4. Each Challenge will seek to combine all of the relevant expertise available across the science sector in New Zealand to achieve the Challenge.
5. Each Challenge will be clearly linked with international research activity that will support achievement of the Challenge.
6. Each Challenge will exhibit strong collaboration between researchers and intended end-users of the research activity, including, where appropriate, obtaining investment from end-users in the Challenge's research.
7. Each Challenge will map and include relevant existing research into the scope of the Challenge.

4. Panel process

Because of the high public interest and involvement in the process, some detail is provided. Before the first meeting, the Panel was given summaries of the public and technical submissions prepared by MBIE staff. In addition, the Chair provided an explanatory note regarding the criteria and features and had a telephone discussion with each member to review the proposed process.

The Panel met on four occasions between 18 February and 1 March. It was supported by MBIE staff and by David Miller of Vantage Consulting Group as facilitator/rapporteur. At the outset all potential conflicts of interest and areas of expertise were declared.

Following your welcome, at the first meeting the Panel discussed the criteria and features of a Challenge at some length to be sure of a common understanding. We then had a general discussion of the opportunities and Challenges facing New Zealand that science might address. This was seen as a scene-setting discussion to place later consideration of the potential Challenges in perspective. The discussion was collaborative and all members were fully engaged.

The Panel then, informed by the morning discussion and its initial reading of the submissions, listed 'topics' that might form possible Challenges without reference to meeting all the criteria. These topics were discussed primarily from the perspective of need, and the need for the Challenge to be science led. Some forty potential Challenge topics were identified but at that stage we recognised that many were overlapping or did not meet the test of being science led. In addition, some 15 overlapping ideas were tabled on behalf of one Panel member who was overseas for the first meeting.

Beyond the general domains of possible Challenges, much of the discussion of the Panel was focused on achieving the right level of specificity – a Challenge could not be too general or too narrow and there had to be a coherent logic to a series of projects and themes requiring integrated oversight and coordination.

The Panel was divided into three teams to consider the broader domains of social/health, agriculture/environment and technology/physical sciences. The 55 Challenge ideas were allocated appropriately to the teams. They were asked over the coming week to interact and to reformulate the overlapping Challenges, consider the major possible themes, review and align them with both public and scientific submissions of relevance and consider the potential Challenges in relationship to the criteria.

By the second meeting, this process had reduced the Challenge ideas to about 15. After reviewing the criteria in detail, seeking any new Challenge ideas that Panel members had thought of (some new proposals were tabled), the Panel worked at times in smaller groups and at times as a committee of the whole to refine the Challenge topics and define the component themes. The committee of the whole discussion focused on the Challenges' features, ensuring they met the designated criteria. By the end of day two there were 10-14 Challenges under discussion. This number varied as the Panel worked its way through the issues of a potential Challenge being too broad or too narrow and some possible Challenges were either fused or split. During the day a number of generic points were identified from both the submissions and the Panel discussion that feature later in this report.

The Panel also concluded that there was a generic and substantive set of issues around the use of science in all sectors in New Zealand. This led to the unanimous view that for the total set of Challenges to be successful there was an additional Challenge that did not meet the criteria specified but was a core Challenge for the effective leadership of science and education in New Zealand. This has been termed the 'Science and Society' Challenge and will be discussed separately in this report. The Panel also identified some core infrastructural issues that need addressing that were common to many Challenges. Notable examples were the integrity and analytical support of large database collections, and the need to build national capability to handle massive data collections from diverse and sometimes incomplete sources.

On day three the small groups worked through further details of the themes and components of the themes within each Challenge. A generic style for presenting the Challenges was accepted and 12 Challenges other than the 'Science and Society' Challenge were agreed upon. A straw ranking exercise was conducted to test for exclusion but this did not suggest that any further Challenge should be eliminated.

The Panel members again worked on the detail in small groups both during and after the formal meetings to reach a common level of description. It was noted that at least one Challenge, which related to natural hazards, was already largely addressed in current science funding and organisational arrangements, but it still was considered as a Challenge as it met the criteria. The relationship of another Challenge (The Science of Innovating Industry) to the development of Callaghan Innovation was also discussed. The Panel concluded that there was a distinct and important scientific underpinning of physical sciences and engineering that needs to be coordinated and focused, and that this domain clearly met the criteria of 'additionality' over and beyond the emerging operations of Callaghan Innovation.

A list of points additional to the Challenges *per se* that merited reporting was agreed.

On the last day of the Panel, the validity and state of each Challenge was reviewed and a number of improvements made, including the decision to split one Challenge into two to ensure a coherent and managerially practical scope. The Challenges were again checked against the public and academic submissions (the secretariat had mapped the submissions to the 12 topics) and each theme and component reviewed.

The Panel confirmed that these twelve very diverse Challenges were of equivalent merit but noted that some could be initiated quickly due to the state of extant science and organisation, whereas others would take some time to develop. The set of recommendations at the head of this report was agreed unanimously.

Subsequent to the final meeting, the draft report and final version of the Challenge details were reviewed by the committee and formal agreement reached electronically.

The Panel is unanimous in its recommendations and all discussions were collegial and all decisions were reached by absolute consensus. A formal vote was only taken to approve the final report. No objections or reservations were declared.

5. Submissions – public and scientific

The process was informed by 361 eligible submissions from the public, scientists and stakeholder organisations. The submissions were very informative and crucial to the work of the Panel. Several key points come from the submissions.

- The public submissions highlighted the lack of use of science in informing many decisions and demonstrated a strong desire to see greater public commitment to research in social, health and environmental domains.

- A number of the submissions were very cogent (while not meeting the Challenge criteria) in demanding better use of available science in public policy, in risk assessment and in areas such as environmental protection. This was a major theme of the submissions and suggests a systematic deficit in how public agencies in New Zealand use science. Some submissions focused on applying known science to specific domains. While the Panel was sympathetic, these submissions did not meet the additionality test of requiring a large component of new science. For example, much of the discussion on fresh water focused on the need to apply current knowledge better and there was not a compelling case for a science-led Challenge, although clearly some new science is desirable – rather it is a case of a societal Challenge

based on applying what we know. Nevertheless, water issues are integral in a number of the proposed Challenges such as 'New Zealand's Biological Heritage', 'Towards More Sustainable Primary Production', 'Enhanced Biosecurity' and 'Better Living'.

- Many of the submissions noted important deficits in areas such as science, technology, engineering and mathematics (STEM) education and in the public understanding of science. These are issues that we have taken up in the 'Science and Society' leadership Challenge.

6. Recommended Challenges

Twelve Challenges are recommended to Cabinet as well as a distinct 'Science and Society' leadership Challenge, which is discussed separately as it lies beyond the criteria set. In the view of the Panel all are important, meet the criteria and features agreed upon and are of major benefit to New Zealand. All represent the views of the Panel and are strongly supported and influenced by submissions, both public and scientific.

These Challenges are detailed below, including a description of the opportunity, expected outcomes and major themes. Examples of components under the themes are also provided but these will require further work by the Panel in cooperation with MBIE once Cabinet has decided on our recommendations.

In reaching these conclusions there were some key tests – there had to be significant additionality created by naming an area as a Challenge. In practice this meant that the Panel considered that there would be merits in greater coordination in the science components identified – thus there had to be a practical and realistic clustering of themes so it could be governed as an effective and structured entity. Further, the Challenge criteria required that New Zealand science has the capabilities and capacities already extant to encompass much of a Challenge and, in each of the 12 Challenges recommended, we believe that test can be met.

In developing the Challenge descriptions, the Panel identified the major themes that the science should embrace. It also identified probable research components for addressing these themes by way of examples. However, this should *not* be seen as definitive: clearly, further work is needed between the Panel and MBIE to refine the Challenge descriptions, themes and components once Cabinet has considered our recommendations. There will generally be a need to engage in some strategic dialogue with the research community to refine the Challenge details. This is likely to be an iterative process with sector research leaders and the proposed Challenge leadership before contracts are entered into. It is also critical that mechanisms are put in place to ensure that, while the Challenges are about mission-led science, scientific excellence is maintained. This must be part of the governance and accountability requirements.

The 12 Challenges are:

Challenge 1	
Title	**Aging well: Harnessing science to sustain health and wellbeing into the later years of life, so that older people can continue to contribute to New Zealand**
Opportunity	New Zealanders are living longer. As in other advanced societies, there are great challenges of a social and economic nature that are arising from this demographic change. We can use science to ensure that these extra years of life are lived without disability and as active, valued and contributing citizens. The key challenge is to maintain physical, psychological and brain health into the advanced years. There are biological, psychological and social components to this and these need greater integration. The role of technologies in sustaining health and preventing frailty is also important. Challenge 1 is focused on maintaining health. Challenge 3 is related but focuses on the major diseases of middle and old age affecting New Zealanders. The Panel concluded that this Challenge would create very significant additionality arising from creating a much-needed coordinated research agenda and thus enhanced multi-disciplinary and cross-institutional research to meet the Challenge.
Science Goal	To maintain good cognitive, physical and emotional health into late life
Societal Goal	Family/whānau, community and economic (work opportunities) are maximised

Themes	Examples of research activities
Maintaining brain health	Addressing the causes and prevention of neurodegeneration (e.g. Alzheimer's disease) and cognitive decline Providing neurosupport; leveraging bioengineering skills and knowledge Maintaining good emotional health in later years (reducing depression, anxiety and substance use disorders)
Preventing physical frailty	Identifying modifiable risk factors earlier in the lifecourse to mitigate late-life frailty [links to Challenge 2] Monitoring and safe intervention to maintain bone strength and physical function Prevention of falls Physical support through advanced bioengineering and robotics research (innovative mobility aids)
Understanding and enhancing the role of the elderly in society	Understanding and planning for the future demography of the older population Increasing understanding of the psychology and sociology of living longer (e.g. coping with loss and regret, social isolation, lack of economic resources) Providing smart and assistive devices in homes (e.g. home-based health monitoring), and facilitating digital literacy (e.g. web nous) to improve quality of life and promote social cohesion [links to Challenge 10] E-health initiatives (e.g. mental health promotion via web-based platforms)

Comments	
Readiness:	Although there are some examples of integration/collaboration among different groups, the current overall picture is one of groups largely working in isolation. Thus there is great potential for this Challenge to improve integration of science programmes and advance significantly the level of understanding of the needs of this rapidly-growing segment of New Zealand's population. However, more granularity in the proposal would need to be developed and that is likely to take some time.
Other notes:	Components of this Challenge link to Challenges 2, 3, 4, 10 and 11.

Challenge 2	
Title	**A better start: Research to improve the potential of young New Zealanders (up to 25 years) to have a healthy and successful life**
Opportunity	To use science better to understand and improve New Zealanders' start in life so their capacity to thrive throughout life is enhanced. It is now increasingly recognised that environmental exposures (both good and bad) from conception through the early years can exert profound effects on how people's lives turn out, over the long term, and across multiple life domains. These include at school, in work, in relationships, and economically, as well as in respect to pathways to good mental health and avoidance of an array of common aged-related diseases. The 'scene-setting' nature of the early years is now internationally recognised, and New Zealand researchers have made a very important contribution to this knowledge base. Given our historic strengths in this area, we are ideally positioned to expand our understanding of new aspects of human development, and how these might be translated into policy and practice to optimise development. Importantly, the uptake of new knowledge should be guided by established scientific principles sometimes known as 'prevention science'. This involves proceeding in a stepwise fashion, amassing evidence of intervention efficacy then effectiveness, before large-scale roll out/government investment occurs. The linking of key groups to address this important Challenge promises both basic science discoveries and their smart application to benefit the whole population – in both the short and longer term. The Panel concluded that this Challenge would create very significant additionality arising from the strengthened coordination and integration that would flow from the multi-disciplinary and cross-institutional research required to meet the Challenge.
Science Goal	To understand the process of early human development and how environmental factors can influence life trajectories
Societal Goal	To ensure an adaptive, resilient, healthy population

Themes	Examples of research activities
Developmental epigenetics, gestation, maternal health	Effects of changing patterns of human reproduction Maternal effects on child development in utero and during infancy Optimising conditions during gestation and infancy for healthy development The biology underpinning intergenerational effects Birth order effects on development Infant growth and development, weaning practices Biological embedding of early environmental influences (both good and bad) Long-term outcomes of early life events
Behaviour, social processes, mental health, adolescent transition	Antisocial behaviour and opportunities for intervention How early temperament shapes life outcomes Risk for, and protection against (i.e. resilience to), the development of mental health problems Understanding heterogeneity of response to childhood psychosocial stressors (e.g. maltreatment, socioeconomic disadvantage, social isolation) Science of neurodevelopment during key developmental transitions e.g. Early Childhood Education (ECE) to primary school, adolescence to young adulthood How parenting and other family factors impact development Smoothing the transition through adolescence: managing risk Intergenerational transmission of risk and protection (i.e. do we reap what we sow?)

Themes	Examples of research activities
Education, living in the digital world	The opportunities afforded by (ECE) for promoting optimal human development STEM: how to strengthen science skills and knowledge, and instil curiosity and excitement about science Teaching children in the new digital world: is more of the same good enough? Digital natives: does their development differ from that of prior generations?

Comments	
Readiness:	Historically the key players in this area have not worked closely together across biological, behavioural and other domains. However, this has recently begun to change, which augurs well for future integration and promises traction on important scientific questions. The Committee agreed the potential for additionality was high.
Other notes:	We acknowledge the potential conflicts of interest in this Challenge for two Panel members (Gluckman and Poulton), both of whom have been heavily invested in research in this area. There are linkages between this Challenge and Challenges 1 and 3 insomuch as evidence exists suggesting that the pathogenesis for age-related diseases (such as those described in Challenges 1 and 3) involves gradually accumulating damage to organ systems beginning in the first half of the lifecourse. There are also links to Challenge 11. There are also potential links between this Challenge and Challenge 4: healthy foods can facilitate healthy life trajectories. The Leadership Challenge 'Science and Society' applies strongly to knowledge generated by the science of human development.

Challenge 3	
Title	**Healthier lives: Research to reduce the burden of major New Zealand health problems**
Opportunity	To improve the primary and secondary prevention, and ensure more effective management, of the most important non-communicable diseases (obesity, diabetes, cancer and cardiovascular disease), taking into account the distinctive features affecting the New Zealand population with regard to these. Obesity is a major and growing issue in New Zealand (28% of New Zealand adults were classed as obese in a 2009 survey), as in most developed countries, but particularly in our Māori and Pasifika populations, which have significantly higher levels. It is also rising in prevalence in children and young people. It is a major risk factor for a number of diseases, notably cardiovascular disease and cancer, but most prominently for type II diabetes, for which Māori and Pasifika populations also have a greater propensity. Cancer continues to be the major cause of death in New Zealand (132 per 100,000 people annually) and a much-feared disease, with New Zealand having among the highest rates in the world for melanoma, colon cancer and lung cancer. While rates of cardiovascular disease are declining, it is still a major cause of death (63 per 100,000 people annually) and disability in New Zealand. The panel concluded that there is very significant additionality created by developing a more integrated scientific approach to research aimed at mitigation of these diseases, using our social science for improved preventative measures, our biochemical and medical science for improved treatment options, and our collaborative and well-integrated society to ensure equitable access to healthcare.
Science Goal	To understand the biological, environmental and social factors that contribute to effective disease prevention and management of our major non-communicable diseases at the individual and population level. Cancer and metabolic diseases (such as diabetes) are biochemically similar, being caused by abnormalities in cellular biological pathways. Their study involves similar science techniques, and while there remain major difficulties in achieving effective control of them, a raft of new techniques in disease identification (genomics) and treatment (diagnostics, targeted drugs) are beginning to be applied.
Societal Goal	To ensure a long and healthy life for all New Zealanders [link to Challenge 1] and improved health and economic benefits for New Zealand

Themes	Examples of research activities
Prevention	Primary (early life interventions) - diet, learning healthy behaviours, health education [Links to Challenge 2] Secondary – preventing smoking and substance use, controlling weight, mental health [Links to Challenges 1 and 4]
Management and innovation in health delivery, diagnostics and therapies – *'the right treatment for the right patient'*	Genomics for patient stratification Better-targeted diagnostics and drugs Improved drug delivery and monitoring (e.g. mobile wearable devices) [link to Challenge 10] Studies of the 'gut microbiome', which is increasingly seen as an important arbiter of health
Population/Cultural/ Social factors	Improved extraction, visualisation and interpretation of human health data from large and complex datasets. Improved population stratification and epidemiology Improved equity of healthcare

Comments	
Readiness:	Good expertise is available in developmental biological and longitudinal epidemiology studies. There is substantial clinical expertise in addressing these diseases. There is significant expertise in the science underpinning subject stratification. There is significant medicinal chemistry expertise relevant to these diseases. Although there are examples of integration and collaboration among different groups, the breadth of this research is large. Thus there is great potential for this Challenge to significantly understand the needs of this rapidly-growing segment of New Zealand's population. However, more granularity to the proposal would need to be developed, which will take some time.
Other notes:	Quite apart from the misery they cause, obesity, diabetes, cancer and cardiovascular disease are a major economic burden to New Zealand, both in treatment costs and for the premature deaths that cut short so many people's productive years. The risk factors for these diseases are well known, making more effective prevention and treatment strategies important. The application of genomics and targeted drugs, now being pioneered in cancer therapy, but also beginning application to the management of other diseases, together with new delivery technologies, offers a potential 'step change' in disease management by better tailoring of treatment to the individual patient. We acknowledge the potential conflict of interest in this Challenge for a Panel member (Professor Bill Denny), who has been heavily invested in research in this area. Professor Poulton noted his association with longitudinal studies. [Components link to Challenges 1, 2, 4 and 10]

Challenge 4	
Title	**High value nutrition: Research to develop high value foods with health benefits**
Opportunity	There is enormous capacity to leverage both our primary industry and medical research to discover, validate and develop nutritional products with proven health benefits of significant market potential. Globally the food industry is moving to develop high value foods based on claims that they improve human health. But at the same time, there is a recognition that such developments need to be associated with regulatory oversight and the formal validation of higher level food claims. The potential for validated food products with validated health claims for either health maintenance or in some cases prevention of deterioration in Asia is particularly high. New Zealand has recently developed a regulatory framework that is favourable for such development, but there is a large research agenda needed to exploit the possibilities that exist. Furthermore, New Zealand's expertise in clinical nutrition, medical research and food sciences, together with its milk-based economy, puts in a very competitive position. However, it is important that the science is driven from clinical need to food science, which is a different strategy to that most commonly applied. The Panel concluded that this Challenge would create very significant additionality arising from creating a coordinated research agenda and thus enhanced multi-disciplinary and cross-institutional research undertaken to meet the Challenge.
Science Goal	To identify the clinical benefit of food-based interventions for important diseases, health maintenance and disease prevention, and to develop nutritional products from such research and test them to the level where regulatory approval for higher level claims in international markets is possible. This will involve clinical and biochemical and nutritional research to inform and support the development of new foods.
Societal Goal	The development of higher value products with demonstrated health benefits and market acceptability, particularly in Asia, which would add considerable value to our primary and food industry sectors. Further, the development of such foods would have local benefits for the health of New Zealanders.

Themes	Examples of research activities
Clinical application (what food to do what)	The first step before advanced foods are developed is to obtain evidence of where nutrition is likely to provide benefit. This requires clinical research. The most obvious markets in the view of the food industry are maternal and child nutrition, nutrition associated with prediabetes and diabetes, and nutrition associated with frailty of aging.
Biomarkers (measuring impact, clarifying risk)	As most health claims will be based not on disease endpoints but on markers of health status and disease risk, a key area of expertise needed to support advanced health claims is accepted and validated markers of status and risk. This requires clinical and biochemical research married together.
Regulatory environment (sufficiency of evidence – validation of the biomarkers)	A related area is that of what is a sufficiency of evidence for a regulator to approve a health claim. In part this will be related to clinical trials, but in turn it will depend on the validity and acceptability of biomarkers.
Nutritional hedonics (marketing into niches)	Depending on the market, different populations have different taste and related perceptions. This needs to be taken into account in food development. Food sensory science becomes important.

Themes	Examples of research activities
Basic food science	Food science is important but in the area of advanced health claims it should follow rather than lead the clinical, nutritional and biochemical research needed to advance a claim.
Food safety (external and internal to New Zealand)	Inherent to New Zealand's status as a major food exporter, and alongside the need to have strong a science base to an advanced foods, is the need to protect the supply and export chain with research on traceability and food safety.

Comments	
Readiness:	Because of the MPI and MBIE (MSI)-led work to date in this area, it is in a position that a coordinated approach could be rapidly developed.
Other notes:	Discussions have been held by MBIE with Singapore about their involvement in this development. Ireland has also raised the possibility of collaborative research – they have just funded a major centre of excellence in this space. Sir Peter Gluckman noted his activities in this area.

Challenge 5	
Title	**New Zealand's biological heritage: Protecting and managing our biodiversity**
Opportunity	We have a unique biodiversity with high levels of endemism (species known only in New Zealand) and an economy strongly based on the use of exotic species. We value both indigenous and introduced biodiversity, yet our current understanding of the implications of biodiversity change and loss – even at the broadest scale – is still very limited and fragmented, such that making choices about which biodiversity to support provides significant challenges. New approaches are required that view biodiversity management more holistically, where all elements of biodiversity (ecosystems, species and genes) contribute to sustaining our economy, environment and society. We have the opportunity to leverage our investments in biological collections and databases, and research on ecosystem functions, to make a major contribution to develop a scientifically-based understanding of one of the great unresolved questions in ecology – the specific nature of interdependencies between the structure and diversity of biotic communities and the functioning of ecosystems (e.g. biogeochemical processes). Resolving this question has immense implications for our society, especially through the delivery of ecosystem services (e.g. production of food and fibre, carbon storage, maintenance of water and soil quality, regulation of climate change). The values and services from biodiversity are also threatened by invasive species and habitat loss, so this Challenge will provide the framework to focus research on threat management. Strong public interest in biodiversity will also be harnessed in building resilience into community-based restoration initiatives and supporting the development of 'citizen science'. The Panel concluded that this Challenge would create very significant additionality arising from creating a coordinated research agenda and thus enhanced multi-disciplinary and cross-institutional research undertaken to meet the Challenge.
Science Goal	To resolve the interactions and interdependencies of biodiversity (ecosystems, species and genes) across a range of land uses and scales to support evidence-based decisions on biodiversity management that take into account economic, environmental, social and cultural values
Societal Goal	To ensure biodiversity is valued, protected and managed across a range of landscapes for wide societal benefit and supports the provision of ecosystem services such that we will be a global exemplar in effective integrated management of biodiversity

Themes	Examples of research activities
Discovery and evaluation	Building information on microbial biodiversity Improving the quality and quantity of biodiversity data Societal values and their implications
Linking ecosystem functions to ecosystem services	Species occurrence and environmental change Functional and evolutionary relationships Identifying complexities and interdependencies
Threats and resilience	Impacts of pests, climate change, land use etc on distributions New technologies for pest and disease detection and management Relative stability and resilience of different environments

Themes	Examples of research activities
Measurement and assessment	Innovative sampling designs and detection systems Scaling assessments with multiple values Optimisation of management interventions
Social partnerships	Frameworks for restoration and rehabilitation Business models for ongoing support Citizen science as a driver of change

Comments	
Readiness:	The biodiversity research community is well connected, with strong user and societal links. Improving coordination through this Challenge will give immediate benefits to effect a step change in understanding and managing our biodiversity.
Other notes:	This Challenge will be contingent on building a strong foundation in bioinformatics where databases can be openly accessed across a range of ecosystems and scales. This Challenge will focus on the land and freshwater environments and complement the Challenge of 'Life in a Changing Ocean' with its coastal and marine focus and link to 'The Deep South' initiative. The interests of Professor Penman in providing advisory services and governance processes in this area were noted.

Challenge 6	
Title	**Towards more sustainable primary production: Research to enhance primary productivity to meet future demands while protecting water quality and recognising environmental constraints**
Opportunity	Growth in productivity in the land-based primary sector, particularly in food production, is a critical economic issue for New Zealand. How do we promote growth while addressing the increasing needs for environmental protection and minimising environmental impacts such as fresh water quality? We need to increase production from the same production area while meeting the challenges of climate change and increasing pressure on resources. Our export food production is also under increasing global pressure from demands on food safety. We must ensure that we have environmentally and socially sustainable production systems, while addressing nutritional requirements of national and international consumers with increasing health and nutrition problems. Our opportunity is to sustain growth in productivity by harnessing and developing smart technologies in precision agriculture, plant and animal genetics, bio- and agri-technology, information and decision-making tools, and systems modelling throughout the food supply chain, and so revolutionise New Zealand primary production. In doing so, we can also provide a model for future world food production and food security within the bounds of environmental and social constraints. The Panel concluded that this Challenge met a very significant additionality test in that it would create the necessary integration and coordination needed in this area to use New Zealand's research capacities optimally to meet the Challenge.
Science Goal	Future productivity growth in high value food and other products from the primary sector comes from the use of new tools, technologies, plants and animals that allow economic growth while explicitly recognising and incorporating defined, measurable and expected environmental constraints
Societal Goal	Primary sector growth addresses social and cultural demands, while meeting trade and consumer demands on energy use, food safety and food security

Themes	Examples of research activities
Adaptable and responsive agriculture	New biotechnologies Precision agriculture, production systems, robotics, sensing and remote technologies Systems models and mitigation tools Smart genetics for adaptable plants and animals
Water and nutrient management	Robust means to measure impacts and footprints New-generation tools to manage water and fertiliser use The science of the land/water continuum Land use decision-support tools
Optimising the food supply chain	Smart technologies for logistics and energy use to meet trade and consumer needs Food safety technologies with traceability
Social acceptability	Methodologies for community-based decision-making and engagement Coordinated risk assessment and risk management procedures End-user uptake methodologies

Comments	
Readiness:	The primary production community is highly active in this area, with strong end-user and increasing societal links. There are good examples of cross-provider and end-user coordination and collaboration that can rapidly be built on.
Other notes:	Societal (and Government) acceptance of genetic modification and other biotechnology is still not at a level that allows rapid uptake of new technologies and further societal discussion is needed as the global experience of this technology and the nature of this technology evolves. International food safety issues are increasingly impacting on production practices and there is a need for more foresight and prediction in this area. Success is predicated on end-user acceptance of predicted changes in environment and food types. This Challenge would be greatly assisted by the 'Science and Society' Challenge. Dr Rowarth's and Dr Ferguson's interests in this area were noted.

Challenge 7	
Title	**Enhanced biosecurity: Research to enhance our resilience to potential harm caused by the invasion of organisms that affect the health of animals and plants**
Opportunity	New Zealand has a world-leading biosecurity system, especially the pre-border and border components. Despite this, we can expect continuing and growing threats to our economy, environment and public health from incursions. The opportunity is to build on the existing research base to expand our understanding of incursion and invasive processes to human and animal pathogens, zoonoses (animal-derived diseases affecting humans), marine invasive organisms, weeds and other potential risk organisms. We need a much more wide-ranging, intense and coordinated research platform to future-proof New Zealand's economic development. We can continually improve our detection and surveillance systems and build more integrated flows of information. Based on these and given that incursions will continue, we can address the Challenge of understanding why 'incursions are frequent and inevitable, establishment is rare' with a view to developing new approaches to prediction, eradication and management of risk organisms across marine, coastal and terrestrial (including urban) environments. This science Challenge expands existing programmes to integrate the 'post-border' component of our biosecurity system and will complement the more integrated approach to pre-border and border biosecurity within the 'Better Border Biosecurity' collaboration. An effective Challenge would provide the platform for developments and debates on other areas of pest (including insects, disease vectors, pathogens of plants and animals and weeds) management. We have the potential to demonstrate world-leading science-based biosecurity with effective pre-border risk assessment, the development of innovative detection systems at the border, and acceptable approaches to eradicating establishing populations, and to widen the toolbox for the management of established pest populations. The Panel concluded that supporting this Challenge would create very significant additionality, with strengthened coordination and integration flowing from the multi-disciplinary and cross-institutional research needed to meet the Challenge.
Science Goal	Surveillance and monitoring systems detect incursions across all environments and decisions on management options are based on best available evidence and socially acceptable technologies.
Societal Goal	To protect our unique assemblages of species and ecosystems across the full range of intensively managed primary production systems through to the conservation estate, using approaches to biosecurity that support our economic, environmental and social wellbeing

Themes	Examples of research activities
Characterising emerging and future risks	Analysis of biology and ecology of risk organisms across all dimensions of our society, economy and environment Estimating and modelling the risks from potential zoonoses to public health
Detection and monitoring	New-generation tools and technologies that extend our ability to rapidly and accurately detect and identify incursions across terrestrial and aquatic environments and those impacting on public health

Themes	Examples of research activities
Invasion to incursion	Identification of the factors that result in the establishment of invasive populations Development of new approaches to eradication and management
Integrated solutions	New science to enable scaling up from island sanctuaries to mainland and area-wide pest management, and integrating controls with widespread social acceptance
Social licence	New approaches to engage the public in accepting change and uptake of new technologies

Comments	
Readiness:	There exists a basis on which to build a wide network of researchers to expand the scope and intensity of biosecurity research. This will include more emphasis on post border pest management and on building links with the health sector.
Other notes:	This Challenge will have close links to parallel investigations into risk management and with the development of sensing technologies. The area will also need to address data access and management issues in more coordinated manner. Dr Ferguson's interests in this area were noted.

Challenge 8	
Title	**Life in a changing ocean: Research to understand, exploit and sustain our marine richness**
Opportunity	Oceanic and coastal resources have the potential to provide significant opportunities for economic development. However, our large EEZ is relatively poorly understood in terms of the scope and nature of biological (including fish stocks and other species) resources and their interrelationships. Our coastal marine environment is undergoing rapid change through aquaculture and other inshore fisheries, plus land-use impacts. This Challenge provides the platform for New Zealand to participate in a global initiative (www.lifeinachangingocean.org) to expand our knowledge of marine biodiversity to support healthy and sustainable oceanic and coastal ecosystems. It will integrate the development of new technologies for biological and environmental assessments and integrate knowledge across four interconnected Themes: Discovery in Time and Space, Ecosystem Services and Functions, Sustainable Resource Management, and Human Exploitation. We need more knowledge of life in diverse environments to more effectively adapt management to environmental change such as climate change, land-use change, and the incursion of invasive species, and to sustainably manage economic development such as our fisheries and potential sea bed resource extraction. Marine biodiversity also has great potential to contribute to a wide range of ecosystem services including developing new foods and other products. Humans have long used the oceans for a range of functions and through this Challenge we will build a greater understanding of human impacts, and societal values for our marine resources, elucidate key processes and indicators of change, identify future trajectories and provide information for more sustainable management. An even bigger challenge will be to understand the sea bed and the underlying mineral resource and its potential for exploitation, while protecting the environment and minimising impacts on biological resources and sustaining the ecosystem. Research in that domain is large in itself and current and future research in this area will need coordination with a study of the biota and physical marine environment. The Panel concluded that supporting this Challenge would create very significant additionality with strengthened coordination and integration flowing from the multi-disciplinary and cross-institutional research needed to meet the Challenge.
Science Goal	To expand the knowledge base of our coastal and oceanic biological resources to better define the ecosystems and understand the role of environmental and human-derived changes in the management of marine resources including oceanic geo-resources within environmental and biological constraints
Societal Goal	To ensure decisions on the regulation, management and exploitation of marine and coastal resources have a sound foundation in knowledge on the roles and distribution of biodiversity within the context of a rapidly-changing environment and competing human uses

Themes	Examples of research activities
Discovery in time and space	Widening the range of biodiversity baselines and observations Integration with physical and chemical parameters New technology to increase the rate of biological description Studies of the sea bed and its ecology and the underlying mineral estate
Ecosystem functions and interrelationships (services)	Patterns and variability in ecosystem functioning and relationships Role of biodiversity and their interactions and connectivity Socioeconomic implications

Themes	Examples of research activities
Sustainable resource management	Understanding the land-water continuum in the context of increased economic use of coastal waters. Research which assists managing economic exploitation within environmental, social and cultural constraints. New technologies developed for high value food products from marine resources (fish, shell fish and algae), and to counter threats to incursions and food safety.
Human exploitation	Historical basis for changing marine ecosystems Future trajectories, products and services Sustainability in the marine context

Comments	
Readiness:	New Zealand was a key participant in the global predecessor to this Challenge 'Census of Marine Life' and a community of collaborators exist. Some widening of skills will be needed especially in the human dimensions of change.
Other notes:	This Challenge will be contingent on building a strong foundation in bioinformatics where databases can be openly accessed across a range of ecosystems and scales and with physical and chemical oceanographic data. There will be close synergies with the terrestrial focus of the 'Biodiversity' Challenge and within the biological component of Challenge 9. A complete understanding of our marine resources will require consideration of the interactions of marine life with the coastal environment and the ocean floor but within the frame of potential oceanic geo-resources. This latter area was considered by the Panel as being very important to our potential economic development and could perhaps more usefully be considered a distinct, but related, activity with wider Government, science and industry involvement. The Panel noted the involvement of Professor Penman in advising on the development of the global initiative.

Challenge 9	
Title	**The Deep South: Research to understand the role of the Antarctic and Southern Ocean in determining our future environment**
Opportunity	For New Zealand the biggest impacts on our climate are likely to come from ocean and climate systems strongly influenced by Antarctica via the Southern Ocean. Relatively subtle changes in ocean currents could have dramatic impacts on our climate and ability to farm and live as we currently do. Yet we have little understanding of the interactions from changes to the Antarctic such as ice melt raising sea levels and the impacts on ocean currents. We can expect complexity in responses and, given the growing awareness of the impact that the Antarctic Circumpolar Current and other systems have on potential global climate change trajectories, we have the opportunity to make a major contribution to global science. The Southern Ocean includes some of the Earth's most productive and unique marine ecosystems, yet we have insufficient information on which to base effective management such as for fisheries and tourism. This Challenge will have links to the 'Life in a Changing Ocean' Challenge but will have a greater focus on the more remote Southern Ocean and build on a long heritage of Antarctic research. The Challenge will be based on three themes: Non-linear Behaviours and Tipping Points (understanding complex interactions); Predictions of Change (future options for management based on changes in the Southern Ocean); Consequences for Change and Resilience (how marine and terrestrial, e.g. Antarctica and Sub-Antarctic Islands, ecosystems respond to multiple environmental pressures). Changes in the Antarctic system which remain poorly understood could have fundamental effects on New Zealand's economic and environmental future – relatively subtle changes in ocean currents could have dramatic impacts on our climate and ability to farm and live as we currently do. This Challenge will contribute to our global leadership position in Antarctic and climate change issues and we have the opportunity to become a global centre for research in the Southern Ocean. The Panel concluded that supporting this Challenge has very significant additionality and will provide critical leadership in linking changes in the Southern Ocean and Antarctic to potential impacts on New Zealand's economy and environment. This is an area where strengthened coordination and integration flowing from the multi-disciplinary and cross-institutional research is in New Zealand's core long-term interests.
Science Goal	To determine how the Antarctic influences the oceanic/climate interfaces through the Southern Ocean to build predictive models of potential impacts on marine resources and understand interactions between the Antarctic Circumpolar Current and wider climate systems and their potential impacts on New Zealand
Societal Goal	To contribute to policy development in international fora responding and adapting to climate change and to the management of marine resources. To ensure our society understands the critical role of the Southern Ocean to our economic and environmental wellbeing. To have a better understanding of our environmental future

Themes	Examples of research activities
Non-linear behaviours and tipping points	Ice shelf stability and links to the ocean Global heat transport at the ice-ocean interface
Predictions of change	Temperature and circulation changes in the Southern Ocean Effects of changes in the Antarctic Circumpolar Current

Themes	Examples of research activities
	Impacts on New Zealand's climate
Consequences for change and resilience	Baseline knowledge of species, communities and ecosystems Climate change scenarios affecting biological processes Understanding multiple drivers of change Understand the consequences of these changes on New Zealand climate and land use

Comments	
Readiness:	New Zealand has capability to address and lead many of the research issues. Infrastructure investments will be needed to ensure access to information and research in other regions. We have strong international science and diplomatic leadership in this area.
Other notes:	There should be close synergies with the Challenge 'Life in a Changing Ocean' and the 'Biodiversity' Challenge, especially in developing a common bioinformatics platform. There will also be close links with other oceanographic data and modelling initiatives. Dr O'Kane's membership of the Board of the New Zealand Antarctic Research Institute was noted.

Challenge 10	
Title	**Science for technological innovation: Research to enhance the capacity of New Zealand to use physical and engineering sciences for economic growth**
Opportunity	Research-led technological advances in the physical and engineering sciences provide the foundation for an economy based on innovation, and also underpin most research discoveries in all other domains of science. Genome sequencing and mass spectrometry in the basic biological sciences, robotics and automation in our primary industries, satellite imaging and other sensing technologies in environmental sciences, and communications infrastructure such as the internet and mobile phones are a few well-known examples. The creation of innovation-led economic recovery, supported in part by the newly established Callaghan Innovation, will depend on our ability to support a well-connected New Zealand physical sciences research sector across the Universities, Crown Research Institutes (CRIs) and the business sector. Unlike many of the other Challenges, however, it is not possible to identify a single, standalone science Challenge topic – instead we have identified five major themes that we feel best capture the key areas of important New Zealand fundamental and applied research in the physical and engineering sciences. It is vital that we grow and harness New Zealand's creative talent and skills in these areas. The thrust of submissions and our own deliberations have led us to focus specifically on research that provides a base for the future design and manufacture of new products and services for New Zealand healthcare, the primary sector and the environment. The Panel concluded that supporting this Challenge would create very significant additionality with strengthened coordination and integration flowing from the multi-disciplinary and cross-institutional research needed to meet the Challenge.
Science Goal	New medical device technologies that improve health outcomes for New Zealanders, reduce healthcare costs and generate export earnings Improved yields in our primary industries (meat, dairy, forestry, fisheries, horticulture) using innovative technologies New materials from sustainable sources; and new monitoring technologies for maintaining sustainably productive agricultural environments
Societal Goal	To provide opportunities for talented Kiwis to live and work in New Zealand and to contribute to an innovation economy. To retain ownership of creative Kiwi ideas for the health, social and economic benefit of New Zealand. To maintain sustainable and biologically diverse ecosystems. To maximise benefit to New Zealand from international science developments with rapid application to the New Zealand context

Themes	Examples of research activities
Discovery and development of novel materials	The use of engineering quality timber, fibre composites, plastics, cellulose and lignite-based materials and other sustainable engineered materials for the manufacture of new and improved industrial components Novel use of natural products including animal products (and current discarded material), such as collagen extracts, manuka honey and BSE-free bovine pericardium, in wound healing, tissue engineering, regenerative medicine and prosthetic implants
Robotics and automation	Robotics and automation for efficient fruit harvesting, forestry and meat carcass processing. Precision agriculture Human-friendly interfaces in the use of robotics increasingly needed to meet the needs for New Zealand's aged care Autonomous marine drones for cost-effective offshore mineral exploration and extraction

Themes	Examples of research activities
Sensors and actuators	Telemetry-based sensing for precision in healthcare, agriculture and the environment. Machine vision and optical technologies to increase throughput and productivity Assistive devices for stroke rehabilitation, mentally handicapped and the aged
Design and manufacturing	Medical devices, reflecting New Zealand industry's particular strengths in this area Precision electromagnets in the manufacture of computer chips, flat screen televisions, white ware and medical systems Needle-free injection technologies for agriculture and safer and more cost-effective healthcare Use of new high tech manufacturing technologies such as metal and ceramic-based 3D printing to boost productivity
IT, data processing and modelling	Software and IT infrastructure, including data fusion and visualisation tools, for more cost-effective health service delivery Multi-scale and complex systems modelling in materials research, biotechnology and bioengineering Statistical data analysis and scalable learning algorithms essential to efficient, safe and high quality industry operations New business models based on emerging digital technologies

Comments	
Readiness:	A number of New Zealand Universities and CRIs have capabilities in the five research areas above that underpin innovation. We have a long tradition of developing technology to increase the productivity of our primary industries and in designing innovative products for high tech industries and healthcare.
Other notes:	In comparison with agricultural, biomedical health and environmental research, New Zealand has put minimal investment (with one or two specialised exceptions) into the science that underpins innovation. The potential conflict of interest of Professor Peter Hunter both as a researcher and as a member of the Board of Callaghan Innovation was noted. Elf Eldridge is undertaking a doctorate through the MacDiarmid Institute, which includes Callaghan Innovation, where he is based.

Challenge 11	
Title	**Building better homes, towns and cities: Research to develop affordable and better housing and urban environments**
Opportunity	New Zealand has a number of relatively distinct needs related to housing. Our population mix is changing, with changing expectations, we are becoming more urbanised, we still have a high use of timber in building, we need to consider energy efficiency and resilience to natural hazards, and we need to address issues of affordability. There is a need to deliver dwellings and built environments that meet the needs and desires of New Zealand's diverse and changing households, communities and businesses. There is also the potential for global leadership in creating affordable housing systems and technologies. We need to identify and develop faster and more cost-effective construction industry innovations. There is a need for a more coherent approach to research in housing, building and urban design than exists now and the returns from such an approach should be both social and economic. The Panel concluded that supporting this Challenge would create very significant additionality, with strengthened coordination and integration flowing from the multi-disciplinary and cross-institutional research needed to meet the Challenge.
Science Goal	To provide tailored and appropriate scale solutions, technologies and information for decision-makers (such as councils, property developers, regulators) that enable transformation of our built environment
Societal Goal	To create vibrant cities and towns, new and upgraded homes and buildings that are of real value – modern, well priced, well located, high quality, resilient, and meeting our diverse needs and aspirations

Themes	Examples of research activities
Innovative materials, smart and assistive devices	Innovative use of engineering grade radiata pine timber technologies (New Zealand is world leader in this industry sector) Roof tile solar panels and energy storage systems
Creating vibrant cities and neighbourhoods including smart city initiatives	Sensors, solar cells, smart grids, integrated transport, digital infrastructure including urban modelling, Christchurch as a demonstration site Low carbon footprint cities, forging 'the New Zealand way' Multi-disciplinary research to design urban environments that are economically competitive, enhance health and wellbeing, and are resilient to hazards
Innovation in housing provision	Assessing different demographic demands and aspirations (e.g. the elderly, ethnic groups, mentally disadvantaged) Investigations into demand and the best means to supply housing within designated affordability and density parameters
Upgrading existing building stock and creating healthy homes	Investigating innovative designs and structures for healthy, energy efficient homes
Land information systems	Application of GIS, geodesic research and modelling approaches to monitor changing needs and land use patterns, including for growing export markets Visualisation of complex datasets to underpin essential Land Information Systems research capability

Themes	Examples of research activities
Uptake of innovation and productivity improvements by the building sector and clients	Use of social science research to understand and overcome entrenched constraints on the rapid adoption of innovations and life-cycle efficient decisions in the construction sector

Comments	
Readiness:	The building and construction sector is currently consulting on a 3-5 year research strategy which has been developed with and by stakeholders. See: www.buildingabetternewzealand.co.nz The document provides robust information on research needs. The need for this work is immediate, with the opportunity to incorporate new ideas and solutions into the rebuilding of Christchurch, as well as addressing the challenges of housing and urban development for the population growth (estimated at 40% growth to 2.5 million by 2040) in Auckland. User champions for this topic are most likely to be councils (e.g. Auckland, Christchurch, CERA, Wellington), possibly industry and civil society groups and the Ministry for the Environment and MBIE. EQC and MCDEM are also very interested in risk reduction through good planning of settlements – more resilient cities. There are also benefits for health and social welfare agencies.
Other notes:	A 'Smart Cities' delegation was sent to the EU in November 2012.

Challenge 12	
Title	**Nature's challenges: Research to enhance our resilience to challenges that nature throws at us**
Opportunity	New Zealand lives with many challenges created by nature: earthquakes, volcanic eruptions, floods and droughts are the most obvious. Our research community has already made major contributions in areas ranging from geology to engineering to social science. These activities are largely encompassed within the Natural Hazards Platform funded by MBIE. The Panel concluded that these areas of science clearly fitted a Challenge description and this Challenge should be listed as of equal status to the others, even though it is largely already being addressed through the Natural Hazards Platform funded by MBIE. The Panel concluded that this area should be confirmed as a National Science Challenge, the evidence of the value of strengthened coordination and integration flowing from the multi-disciplinary and cross-institutional research having already been demonstrated. It believes further and significant additionality is possible by identifying this as a Challenge.
Science Goal	Understanding hazards, and how to mitigate, prepare, respond and recover from disaster
Societal Goal	To create a more resilient built environment and more resilient society and economy

Themes	Examples of research activities
Geological hazards	Style and magnitude of volcanic eruptions, health impacts of ash, source characteristics of earthquakes, stress change influence on future earthquake events, liquefaction
Weather hazards	Tsunami risk to beaches, better understanding and prediction of wind, rain, snow, hail, drought, storm surge and sea level rise
Resilient engineering and infrastructure	Aspects of engineering performance (reporting to Canterbury Earthquakes Royal Commission and others), post-earthquake functioning of cities, tolerable impact levels of building functionality and safety, seismic performance of bridges, soil-structure interactions, coastal infrastructure resilience
Resilient society	Tsunami warning and evacuation framework, sheltering, evacuation and welfare provisions, aftershocks and resilience, economic impacts and recovery, management aspects of resilient organisations, post-event resource shortages and population behaviour
Risk models	Toolbox for evaluating options for mitigation of earthquake-prone buildings, development of the Riskscape model to evaluate impact of disasters and enable consideration of alternative options for future development in areas of hazard exposure
Fire – wild and building	Wildfire, building fires, safe firefighting, fuel moisture modelling, effects of changing climate, forestry and other land cover types, fire behaviour modelling and tools, community recovery

Comments	
Readiness:	The Natural Hazards Research Platform supports an important ongoing area of research for New Zealand and provides an exemplar for governance, collaboration and leadership of many of the proposed Challenges. The Panel considered that expanding the scope of the Platform would be achievable.
Other notes:	Leadership and collaboration for much of the topic is already in place via the Natural Hazards Research Platform. Maintenance of capability is important as well as taking the opportunities after the Canterbury earthquakes to understand better the perils facing New Zealand, and to improve our resilience to future events. More widespread uptake of science via evidence-informed decision-making (e.g. in planning decisions by councils) would be desirable and would reduce risk. This Challenge also links to Challenges 10 and 11 and must be informed by the research associated with some of the other Challenges.

7. Readiness to proceed

While the Panel could not establish a more granular priority ranking for the Challenges based on scientific merit, the Panel identified a group of Challenges that would be quicker to establish (say < 6 months) because there was clarity as to likely participant research groups and thematic detail. Other Challenges such as the Challenge related to biodiversity would require considerable preliminary work to bring the scientists together and to agree the detail underpinning the themes, to create an integrated package, and these Challenges were considered to require a longer lead time. By this categorisation the Challenges are divided into two groups.

a. Challenges that require less preliminary work and thus could have an early initiation

Challenge 2 A better start: Research to improve the potential of young New Zealanders to have a healthy and successful life

Challenge 4 High value nutrition: Research to develop high value foods with validated health benefits

Challenge 6 Towards more sustainable primary production: Research to enhance primary productivity to meet future demands while recognising environmental constraints

Challenge 7 Enhanced biosecurity: Research to enhance our resilience to potential harm caused by the invasion of organisms that affect the health of animals and plants

Challenge 9 The Deep South: Research to understand the role of the Antarctic and Southern Ocean in determining our future environment

Challenge 10 Science for technological innovation: Research to enhance the capacity of New Zealand to use physical and engineering sciences for economic growth

Challenge 12 Nature's challenges: Research to enhance our resilience to challenges that nature throws at us.

b. Challenges that require more extensive preliminary work and thus are likely to have later initiation

Challenge 1 Aging well: Harnessing science to sustain health and wellbeing into the later years of life, so that older people can continue to contribute to New Zealand

Challenge 3 Healthier lives: Research to reduce the burden of major New Zealand health problems

Challenge 5 New Zealand's biological heritage: Research to better protect and manage our biodiversity

Challenge 8 Life in a changing ocean: Research to understand, exploit and sustain our marine richness

Challenge 11 Building better homes, towns and cities: Research to develop affordable and better housing and urban environments.

8. Other notes on the twelve Challenges

There were three Challenges that have specific considerations. These are:

- **Life in a changing ocean** (Challenge 8). This Challenge is focused on understanding the marine biotic ecosystem. The issue of researching our mineral resources including potential gas and oil reserves – particularly those offshore – was discussed at length. The scale of research needed seems very large and it might merit being a Challenge in its own right. If that were the case it would need to be effectively coordinated with the environmental and biological components of Challenge 8. The Panel concluded that while the Challenge was viable without reference to mineral resources, a research programme

on evaluating our offshore mineral resources was desirable and, if resources and capability allowed, it might be managed separately but coordinated with this Challenge.

- **Science for technological innovation** (Challenge 10). It was unclear as to the extent to which coordination of the underlying research was within the ambit of Callaghan Innovation but clearly there is much activity in the CRIs and Universities that needs coordination with Callaghan Innovation.
- **Nature's challenges** (Challenge 12). It was unclear to the Panel how much more activity and how many additional groups should be added to the MBIE-funded Natural Hazards Platform hosted by GNS but involving a range of Universities and CRIs.

There was also extensive discussion of the issues of sustainable energy and of improving transport, but the Panel could not formulate these into a meaningful or effective Challenge given the criteria tests.

The Panel also recognised that not every domain of science and not every scientific activity required the additionality of a Challenge or met the criteria of a high component of current scientific capacity that was required. For example, while infectious disease in humans is important, it did not meet these tests and was not prioritised by the Panel.

The Panel also noted that a number of Challenges had interfaces with other Challenges and indeed in some cases the same activity was needed, or could be applied, in more than one Challenge. This is both desirable and inevitable.

9. Common themes underpinning the Challenges

Common themes of importance emerged from the discussions.

The Panel felt these Challenges were an important step forward in undoing the damage created by too much competition within the New Zealand science system over many years and the consequent effects of creating institutional, academic and disciplinary silos. Indeed it was felt that the greatest additionality created by the Challenge funding would be to break down these barriers and encourage multi-disciplinary and inter-institutional coordination and a more strategic approach.

It is noteworthy that every Challenge includes a social science component and it is striking that the New Zealand science system has been slow to recognise the importance of integrating social science with both physical and biological sciences – indeed the current funding arrangements discourage it and social science is insufficiently appreciated as a core part of all innovation science.

Many submissions were explicitly related to climate change. A common theme in many of the proposed Challenges is the potential response to climatically-based environmental changes to our production and natural estates. The absence of a specific climate change Challenge should not imply a lack of response to this major issue. Even apart from existing research structures and programmes (the New Zealand Agricultural Greenhouse Gas Research Centre and the Pastoral Greenhouse Gas Research Consortium), elements of climate change were reflected in components of Challenges (e.g. 'The Deep South' and 'Nature's challenges'). Indeed the major purpose of 'The Deep South' Challenge and a major reason it was prioritised is to examine the key role that climate change will play in affecting New Zealand through changes in the Antarctic and Southern Ocean.

A further common theme was the need for investment in science infrastructure. A priority area identified with nearly every Challenge is to develop national capacities to work with large databases. This should be an area where New Zealand should have a natural advantage in providing analyses to support a wide variety of public and private good science. However, the capacity is lacking even though we have the physical infrastructure of the high performance computing and KAREN networks.

There were a series of major issues identified that are addressed under the heading of the leadership Challenge.

10. Māori and Pasifika interests

All the Challenges have relevance to all New Zealanders. A number of the Challenge themes make specific reference to the cultural diversity and multicultural aspects of New Zealand society. The strong emphasis on social science in each Challenge attests to the Panel's commitment to ensuring that the science would benefit all of New Zealand. The focus of Challenges 2 and 3 address specifically issues that affect Māori and Pasifika peoples disproportionately, and research on housing provision in Challenge 11 also considers the diverse needs of different cultures.

11. A Challenge for New Zealand's leadership – the 'Science and Society' Challenge

It was most apparent both from the Panel's deliberations and from the submissions that, central to the success of all the Challenges and for New Zealand to benefit optimally from its investment in research, there were a series of underpinning issues about science education, science communication, science literacy and the application of knowledge in public sector decision-making at all levels. The need for a greater appreciation and understanding of science was necessary for knowledge to be well diffused and of utility to the policy, private and community sectors.

The Panel saw these deficits as so fundamental to the success of this initiative and indeed to New Zealand's development that they have formulated this as a special Challenge to the leadership of New Zealand. While this may be beyond our brief, we must advise that this is the most important Challenge to address if New Zealand is to advance through research and science and their application. The deficits we are addressing here are long-standing and distinguish us in a disadvantageous way from most other countries to which we would wish to compare ourselves. Successful implementation of this Challenge would have important and very positive implications for our future and would change the perception of science from being marginal to central to advancing New Zealand.

We see this Challenge as the most important and of the highest priority, and implementation of this Challenge should be regarded as critical. This will require actions across several central agencies, and the Panel therefore recommends that it be structured like the other Challenges with a Challenge Director and a coordinating group of responsible senior officials and Ministers.

A Challenge for New Zealand's leadership	
Title	**Science and New Zealand Society**
Opportunity	It is clear from the submissions that New Zealanders recognise the central part that science and technology can play in advancing the economy, the environment, their health and society. But it was also clear that the context for using science optimally is deficient. There are concerns about having a workforce and population competent to use the opportunities science can provide. Equally there are concerns about the capacity of government to use the knowledge that emerges – this was reflected in many submissions. Science identifies risks and technology can both address and create risks. The submissions repeatedly suggested the need for New Zealand to be better able to assess, and use, new technologies and to be able to use a more scientific approach to risk assessment and management. These many submissions make it clear that there is a challenge for the leadership of New Zealand to take concrete steps to address deficits in the public and policy understandings of science, to address issues in STEM workforce development and to foster a more innovative and aspirational use of science in the nation's development. Accordingly, and in the spirit of the consultation process, the Panel views this as a Challenge for government and its agencies to lead. Indeed the capacity to optimise the value of the other Challenges proposed will be greatly enhanced by adoption of this Challenge of better using science and technology, education and training to

	address the challenges faced by New Zealand in the 21st century. The Panel concluded that addressing this Challenge in a centrally coordinated and identifiable manner was essential to all 12 science Challenges.
Science Goal	To ensure the science capacities and literacy of New Zealand society so as to promote engagement between Science & Technology and New Zealand society, in turn enhancing the role played by science in advancing the national interest
Societal Goal	To allow New Zealand society to make best use of its human and technological capacities to address the risks and challenges ahead. This requires the better use of scientific knowledge in policy formation at all levels of national and local government, in the private sector and in society as a whole

Themes	Examples of research activities
Science education in schools (STEM)	Educational research on enhancing STEM education in primary and secondary school Evaluation of innovative STEM experiments done in New Zealand and elsewhere
Public understanding of science	Promotion of science literacy at schools as distinct from STEM education Promotion of research into science communication and its development as an academic discipline Incorporation of science communication into graduate training of scientists Promotion of 'citizen science', encouraging members of the public to participate in scientific endeavour through the internet (e.g. GeoNet 'felt' reports) and through practical observation and analysis (e.g. reporting pests and threatened species of flora and fauna) Greater coordination and evaluation of the disparate activities in public understanding of science and science communication
Technology assessment and risk forecasting	Promotion of the academic discipline of risk More transparent and formal processes of technology and risk assessment across government
Social licence for science and technology	Early and proactive discussion of new technologies with the community – linked to the above themes

Comments	
Actions	It should be possible to achieve greater coordination with clear leadership and accountabilities between key government agencies including MBIE, Tertiary Education Commission, Ministry of Education and associated parties including the Prime Minister's Chief Science Advisor, the Royal Society of New Zealand, New Zealand Universities, and Science New Zealand.

12. Other points the Panel wishes to bring to Government's attention

The Panel's deliberations also highlighted a number of points, many of which were also encompassed within the public submissions.

There were many examples amongst the submissions where the real deficit was not the absence of knowledge but the absence of its application. This was true for example in relationship to addressing issues of fresh water but it was also true in many other domains, particularly those where public policy settings were involved.

The Panel also discussed at length issues related to the standing of science within New Zealand society. Many of those issues are addressed within the leadership Challenge proposal. In building up each of the Challenges, it became apparent that concerns over STEM education, public understanding and the need for a more effective social contract for science within New Zealand were common threads.

The Panel noted that for the Challenges to be successful there would be the need to ensure scientific excellence and that would require organisational structures similar to MBIE-funded Platforms and TEC-funded Centres of Research Excellence. A relatively consistent approach to governance seems desirable. A critical feature will be the attributes of the Challenge leadership. Each Challenge will need to have a credible approach for planning, organisation and integration and ensure scientific excellence including international collaboration and end-user engagement as appropriate. The Panel also notes, however, that any increase in administrative load and associated costs and in complexity should be minimised. This is an area where the need for scientific perspectives on the development of the Challenges will be essential and the Panel should have an ongoing role in advising on whether these attributes are being met.

The Panel also noted that there were many and desirable overlaps between the Challenges. This was inevitable as no matter how the domains were divided, some activities in which there was good current scientific activity could be expected to contribute in multiple ways. For example, the healthy food Challenge has some overlaps with the other three health-related Challenges and with the primary productivity Challenge.

The Panel was concerned by the lack of significant proposals in educational research.

It did note that within the submissions there were other ideas that, while not meeting the requirements of a Challenge, could and should be the subject of consideration through other science funding mechanisms.

A feature of our recommendations is the strong emphasis on social science as an integral associate with biological and physical sciences. This is a domain which needs greater emphasis within the New Zealand framework if we are to advance on several fronts, not the least in using the biological and physical sciences to greatest effect and in addressing the effectiveness of the country's large social, health and educational spend.

In every Challenge there are some capability and capacity gaps that the additional funding may assist in addressing. However, given the obvious benefit to New Zealand and clear focus that we could identify in evaluating these 12 Challenges, the mere fact that so many gaps exist suggests that there is a lack of strategic oversight in mapping our science and research capacities to national need. The need to invest in identifying and developing future research leaders is a further gap.

13. Communication of outcomes

This Challenge project has been based on constructive engagement with the public and the science community. The engagement with the research community has needed regeneration and this is a positive step. It will be important to continue to build that relationship if there is to be cooperation in the shifting emphasis of the national science effort.

The involvement of the public in this process has been a welcome attempt to bridge the gap between science, policy and the community. It is clear that the public has identified that science can play a much greater role in New Zealand's development and they have also given greater emphasis to a coherent research effort with regards the environment, social and human health. While not detracting from the important role that science-based innovation will play in economic growth, and which is reflected in a number of the Challenges, these comments suggest that there is recognition that the public science research effort needs to be broadened.

It will be important to consider how to sustain their engagement moving forward. It is an important component of addressing the leadership Challenge.

14. Next steps in the development of the Challenges

This phase of the Challenge process has identified the general scope of twelve Challenges, including some that in the short term may require relatively little additional funding but merit the status of being a Challenge because of their inherent importance and the need to maintain consistency across the total set of priority Challenges. Having said that, it is important to emphasise that the Challenge process is not a national science prioritisation process – there are other components to a full prioritisation exercise and many other tools are required to develop and maintain a complete science system.

We reiterate our view that the 'Science and Society' Challenge should be addressed as a matter of urgency.

Once Cabinet has opined on and agreed on the Challenges, there remains much work to do to establish a Challenge. It is important to note that the themes and components to each Challenge must be seen as indicative only of the major streams of work that the Panel expects to see encompassed by a Challenge, and that actual themes would be determined through the process of developing the Challenge. In doing so, participants and leadership need to be agreed; an organisational structure needs to be developed (or modified from a present structure); and a full science plan needs to be developed before funding commences. This will include mapping current activity as appropriate to the Challenge but at the same time identifying gaps and being sure that the rationale for inclusion of any group is based on additionality in meeting the Challenge. In addition, processes must be put in place to ensure that scientific excellence and scientists' motivation are maintained and not compromised. This will require careful attention to how funding is allocated, incentives and rewards, peer recognition and scientists' perceptions of the status associated with participation in Challenges and similar matters.

You have agreed that the Panel will continue to provide advice to MBIE as these steps are worked through.

Appendix 1: Terms of reference

Background

The National Science Challenges will address around ten big science-based issues that will make a difference for New Zealand. They will harness and focus existing and new scientific effort on the most important national-scale issues we face. They will drive greater collaboration between researchers and end-users of science, focus research on national goals, align funding and increase the impact of our science investment.

Role and Purpose

The role of the Peak Panel is to provide strategic and technical advice on the National Science Challenges.

The Peak Panel will recommend, by the end of February 2013, options for Cabinet to select up to ten National Science Challenges for New Zealand. The Peak Panel will consider possible Challenges submitted by research providers, research users and the public, develop them further where necessary and select a number of Challenge options. Further work may be requested of the Peak Panel or officials to meet the Government's requirements after they consider the recommendations.

The Peak Panel will provide ongoing technical and strategic advice to MBIE on the development of National Science Challenges. This will include, but is not limited to, advice on the leadership, structure, composition and science of each Challenge.

Membership of the Peak Panel

- The Peak Panel will consist of around ten members and will be chaired by the Prime Minister's Chief Science Advisor (Professor Sir Peter Gluckman).
- Membership will include a designated representative who can represent (as far as possible) Māori end user views on science/research requirements.
- Members will be chosen based on the following skill-sets/principles:
    - recognised as leading strategic thinkers across more than one sector
    - focused on outcomes for New Zealand; not captured by own institutions/positions
    - qualified to judge an area – i.e. recognised expertise, broad focus (rather than depth)
    - future thinkers
    - understand economic principles, trade-offs, and consequences of decisions.

Selection of National Science Challenges

- In order to select the National Science Challenges, the Peak Panel will:
    - familiarise themselves with any relevant background information provided
    - assess the long-list of potential Challenges collated from the initial submissions
    - use their own professional expertise, experience and judgement to develop Challenge options based on the possible Challenges submitted by research providers, research users and the public
    - assess whether the Challenges allow for Māori research requirements to be delivered to Māori end users
    - assess whether the selected Challenges are at an appropriate level
    - assess whether the selected Challenges represent an appropriate mix
    - assess whether the selected Challenges, once fully developed, could display the required features of National Science Challenges
    - consider whether additional factors should be taken into account in the selection criteria
    - apply the criteria to select a short-list of Challenge options
    - discuss any other significant issues identified by officials.
- The Peak Panel meeting will be facilitated using an independent facilitator.
- Peak Panel members will be provided with an agenda and background information prior to the meeting. This will broadly include:

  - the initial aggregation by officials of submitted Challenges
  - public and sector submissions on the Challenges
  - criteria for selection of the Challenges (as shown at Annex 4)
  - the features of Challenges (as shown at Annex 5)
  - any relevant advice.
- The Peak Group will seek to reach a consensus on the final Challenges within time limits. Where consensus is not achieved, a vote will be taken.
- A senior official from the Ministry of Business, Innovation and Employment will also attend the Peak Panel's deliberations as an observer and provide advice on government policy as required.
- Meeting minutes and notes will be kept by Ministry of Business, Innovation and Employment officials.
- The Peak Panel Chair will:
  - maintain a strategic, top-down overview
  - ensure the Peak Panel operates in a fair and transparent manner
  - moderate to ensure (as far as possible) a consensus is obtained on the final set of Challenge options
  - raise issues with officials as required.
- Working with the Chair, the Peak Panel Facilitator will:
  - support the Chair
  - organise and manage the group process, ensuring that:
    - progress is made and tasks are achieved within set timelines
    - minutes are taken and made available to members (support provided by MBIE).

Appendix 2: Criteria for selection of Challenges

The Challenges will be selected using the criteria below on the basis of the Peak Panel's judgement and experience. The criteria are intended to be used as a tool to help to select Challenges that will deliver value for New Zealand.

The high level of the Challenge could mean that it is more meaningful to assess lower level research themes within a Challenge and to aggregate these assessments when considering the broader Challenge.

Importance to New Zealand

1. **Each National Science Challenge will target a high level goal which, if achieved, would have a major and enduring public benefit for New Zealand.**

   This criterion is intended to ensure that scientific investment through the National Science Challenges primarily benefits the good of New Zealand as a whole rather than directly benefitting commercial businesses, specific sectors or private enterprise (although they may enjoy direct and indirect benefits) and will be sustained. In general, New Zealand is more likely to benefit from science investment that addresses a New Zealand-specific issue or where New Zealand has the capacity and comparative advantage to realistically exploit an economic opportunity. The longer benefits can be sustained, the more substantial the benefit for New Zealand. The size of the benefit depends on how soon the research results will be available for implementation; how long the benefits will be available; the duration of the need or demand for the benefits; the development of new solutions to risks, challenges, and opportunities; and the obsolescence of the research.

2. **There is wide public consensus that the Challenge will address an issue or opportunity of wide public importance for New Zealand.**

   This criterion is intended to ensure that the Challenge addresses a national-scale issue or opportunity that is widely recognised as important for New Zealand.

Science

3. **Scientific research is essential to solving the Challenge.**

   This criterion is intended to ensure that science is central to addressing or solving the Challenge. Other actions, such as changes to regulation, may also contribute to achieving the goal of the Challenge but are not included in it. Scientific research encompasses a wide range of research activity, including for example social sciences and engineering.

Science feasibility

4. **New Zealand has the broad scientific capability and capacity to undertake the Challenge successfully.**

   This criterion is intended to assess the likelihood that the science will be successful. This will depend on New Zealand's scientific capability (appropriately skilled scientists and infrastructure) and scientific capacity (critical mass of expertise and infrastructure) as well as access to overseas capability and capacity as well as the current state of scientific knowledge.

Likelihood of Impact

5. **There is sufficient external motivation and linkages for the research results to be successfully implemented to achieve the Challenge goal.**

   This criterion is intended to ensure that the benefits derived from investment in science through the National Science Challenges can be successfully implemented and successfully adopted. Successful implementation is more likely where there is external motivation, such as regulation or market need, as well as the ability to transfer and adopt new knowledge and technology.

Appendix 3: Membership of the National Science Challenges Panel

Name	Experience
Professor Sir Peter Gluckman (Chair)	Prime Minister's Chief Science Advisor, previously Director of the Liggins Institute and the National Research Centre for Growth and Development. Fellow of the Royal Society (London) and the Royal Society of New Zealand. Awarded KNZM.
Jacqueline Rowarth	Professor of Agribusiness at the University of Waikato. Fellow of the New Zealand Institute of Agricultural Science and Companion of the Royal Society of New Zealand. Awarded a CNZM for services to agricultural science.
Ian Ferguson	Departmental Science Adviser for the Ministry for Primary Industries and Chief Scientist of Plant and Food Research. Expertise in plant and fruit physiology, postharvest and horticultural science, biochemistry and biotechnology. Fellow of the Royal Society of New Zealand.
William Denny	Director and Leader of the Medicinal Chemistry Group at the Auckland Cancer Society Research Centre. Co-founding scientist of Proacta Inc and Pathway Therapeutics. Won the Rutherford Medal (Royal Society of New Zealand), and Adrian Albert Medal (UK Royal Society of Chemistry). ONZM for services to cancer research.
Elf Eldridge	Physics PhD student with the MacDiarmid Institute, developing nanopore technology. Involved in a number of emerging science education groups.
Peter Hunter	Professor of Engineering Science and Director of the Bioengineering Institute at the University of Auckland and Director of Computational Physiology at Oxford University. Member of the Callaghan Innovation Board (and recently a member of the Ministry of Business, Innovation and Employment's Science Board). Fellow of the Royal Society (London) and the Royal Society of New Zealand, member of the World Council for Biomechanics, and both the American Institute and International Academy for Medical and Biological Engineering.
Mary O'Kane	NSW Chief Scientist and engineer. Chair of the Australian Centre for Renewable Energy, Chair of the Development Gateway International, Chair of the CRC for Spatial Information, and a director of the Australian Business Foundation. Vice President of the Academy of Technological Sciences and Engineering, Australia.
David Penman	Consultant, previously Assistant Pro Vice Chancellor Research, Lincoln University, and until 2006 overall Research Manager at Landcare Research. Entomologist and agricultural scientist, with a focus on 'integrated pest management'. Previous Chair of Governing Body for the Global Biodiversity Information Facility (2005-09).
Te Ahu Karamu Charles Royal	Professor of Indigenous Development and Director, Ngā Pae o te Māramatanga (a Centre of Research Excellence), Faculty of Arts, University of Auckland. Member of the Science Board, Ministry of Business, Innovation and Employment. Former Director of Graduate Studies and Research at Te Wānanga o Raukawa, Ōtaki, where he was also Kaihautū (convenor) of a graduate programme in mātauranga Māori.
Richie Poulton	Founder and co-director of the National Centre for Lifecourse Research. Director of the Dunedin Multidisciplinary Health and Development Research Unit, based at the University of Otago. Formerly board member of Health Research Council. Fellow of the Royal Society of New Zealand.
Rachael Wiltshire	Samuel Marsden Collegiate, Wellington. Rachael graduated as the school's Dux in 2012 and has accepted a scholarship to Auckland University commencing a BA/BSc degree in 2013. Royal Society science award winner, CERN visit and London International Youth Science Forum, 2012.