NATIONAL STATEMENT OF SCIENCE INVESTMENT DRAFT
Response from Rutherford Discovery Fellowship recipients (2010-2013)

We thank MBIE and the Minister for the opportunity to comment on plans for future investment in Science.

This is a joint response written and co-signed by 97.5% of New Zealand's Rutherford Discovery Fellows. We are a group of internationally recognised early- to mid-career researchers who have been selected for our innovative approaches to research across the sciences and the humanities. We work in diverse fields, spanning physical, engineering, information and communications technology, medical, molecular and environmental research through to social sciences, law and the humanities. We are based across a wide cross-section of New Zealand's Universities and Crown Research Institutes (CRIs), and are engaged in basic, applied and near-to-market research. All of us have directly benefitted from the investments and changes that the Government has been making to the Science sector. As a result of the Rutherford Discovery Fellowship, we have chosen to return to, or to stay in, New Zealand.

We agree strongly with the Government's message in the draft National Statement of Science Investment (the "Draft Statement"), that greater investment in science is critical for the future prosperity of New Zealand. This document signals a step in the right direction for the future prosperity of our nation.

There are, however, three key issues that we unanimously agree are not adequately addressed in the Draft Statement and require urgent attention:

1. *Funding for science* and research in New Zealand must, as a matter of urgency, be increased until it is comparable to science investment in other small advanced economies (as a fraction of gross domestic product (GDP).

2. Greater expenditure on *investigator-led funding*[a] is required if New Zealand is to develop into a strong and prosperous advanced economy. This must happen in the short term.

3. New Zealand urgently requires *postdoctoral funding* on par with other small advanced economies.

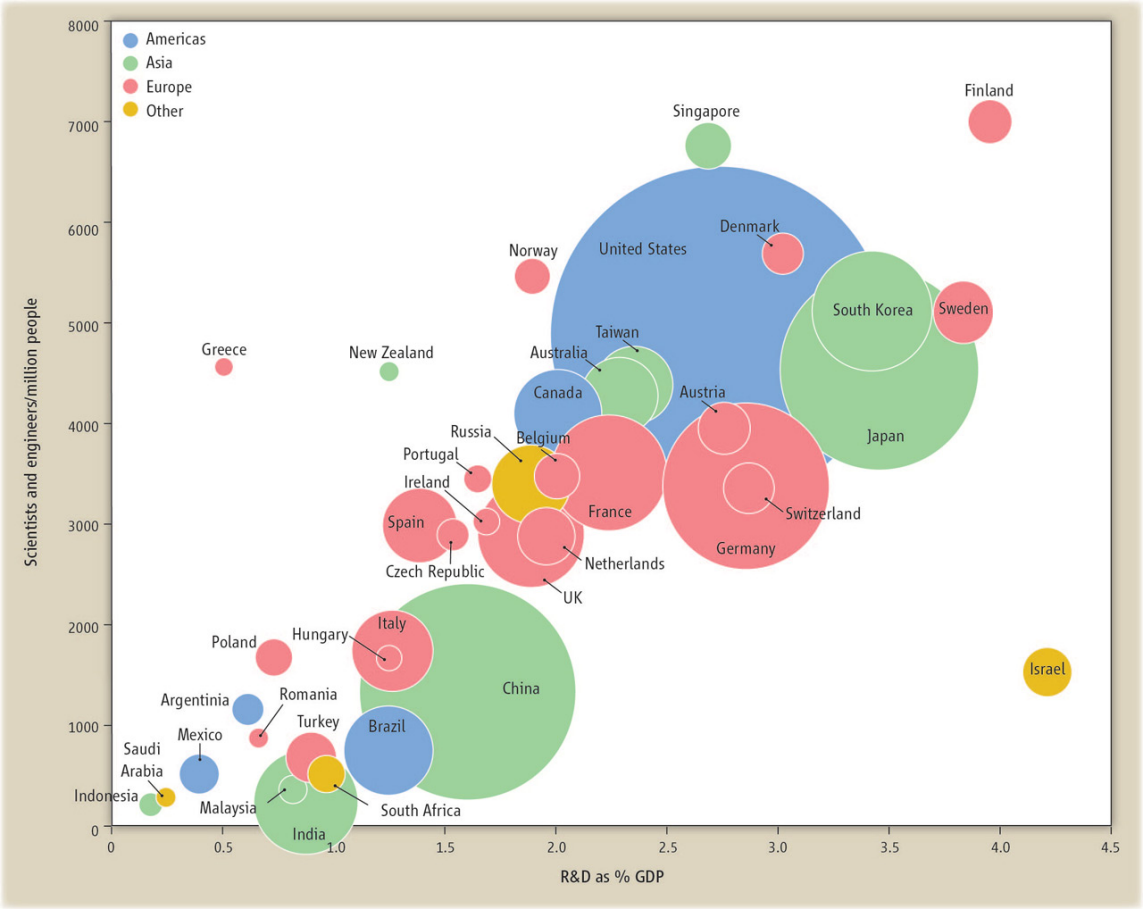
We are pleased that the Draft Statement raises all of these matters, and heartened that some steps have already been taken to address them. However, the benefits of investing in these key areas are not fully articulated in the document. Nor are clear commitments to increasing investment in them made. This is of significant concern – without substantial investment in these key areas, the full economic benefit of a thriving research and innovation sector in New Zealand may never be realised.

[a] Investigator-led science is defined on p12 of the Draft National Statement of Science Investment 2014-2024 as being "undertaken to acquire new knowledge but its direction is suggested by the scientists themselves"

1. **Funding levels need to be comparable to the investments made by other small advanced economies**

The Draft Statement very explicitly acknowledges that, at 0.56% of GDP, our current Government investment in science research and development (R&D) lags behind that of the small advanced economies of Denmark, Singapore, Ireland, Finland and Israel.

We applaud the open manner in which this point is made. However, by comparing ourselves only with these countries, our status as an extreme outlier is obscured. The figure below, published in *Science*, plots the number of scientists and engineers against % GDP for 2011. This shows that we are among the few global anomalies when it comes to R&D investment, and that we would be hard-pressed to convince others of our status as a small advanced economy. We have a comparable number of scientists and engineers to other developed nations, yet we spend far less as a proportion of GDP. With three exceptions, all countries adhere to the strong relationship between number of scientists/engineers and R&D expenditure. Of the other two outliers, Greece and Israel, the Draft Statement clearly signals we do not wish to emulate Greece.



Source: *Press, WH (2013) What's so special about science (and how much should we spend on it?) Science 342:817-822. New Zealand R&D figure includes both Government and Industry sources. Circle size indicates total R&D spending by individual nations.*

The graph makes it clear that we do not have too many scientists and engineers. We simply do not fund them in line with the rest of the world. This may partly explain the statistics in

the draft report, which indicate that New Zealand scientists publish at comparable levels to other nations, but our publications tend to have less impact—our scientists have to make do with far fewer resources. Without investment, the greatest risk is that the number and quality of scientists and engineers will decline with time, moving our nation further from its aspirational goals. The risk is that New Zealand will rapidly lose, not attract, top talent.

Recommendation 1

We therefore make an unapologetic call for a substantial and concrete commitment that:

- Government R&D investment will grow to 1.5% of GDP per capita by 2024; and
- Year-to-year funding levels will reflect New Zealand's annual GDP growth.

Increasing R&D expenditure will make New Zealand a far more desirable destination for the internationally mobile science and engineering workforce. We applaud the Government's intention to increase R&D investment to 0.8% but it falls significantly short of what is needed. A commitment of at least 2.5% (combined Government and industry sources) is required if we are to build New Zealand into a small advanced economy. As the Draft Statement recognises, increased future R&D funding will also need to come from the private sector, but that requires initial Government investment to create a healthy science sector. At the moment, there is not even a commitment to increase Government funding to a modest 1% R&D investment rate. Furthermore, the document fails to articulate the primary benefits of increasing investigator-led basic research funding and investing in He Tangata—creating the talented young scientists of the future and retaining internationally competitive mid-career researchers in New Zealand.

2. **Investigator-led funding is critical for developing a strong and prosperous advanced economy.**

We share the Minister's view, that, "High-quality science and innovation can have a transformational effect on a nation" (p. 4 of the Draft Statement). In light of that, we strongly believe that the benefits of contestable, investigator-led funding must be fully recognised. According to the Draft Statement, the primary way in which investigator-led research benefits economies is by creating ill-defined 'knowledge spillovers' (p. 12). But this fails to appreciate the essential role that strong university environments play as *drivers* of successful Innovation Districts.[b]

To be more specific, here are three essential benefits of investigator-led funding that must be recognised as part of future science investment:

A. The capacity to produce the best educational environments

Whether they work in industry, CRIs or universities, New Zealand-trained researchers get their education from the tertiary sector. Advanced postgraduate training teaches people to undertake questions-driven research. In order to be an effective researcher, one must be able to propose new questions, to find innovative new routes to address these questions, and to develop the expertise needed to undertake the research. In short, innovation is the product of

[b] Katz & Wagner, "The Rise of Innovation Districts". Brookings, May 2014, p11 (http://www.brookings.edu/about/programs/metro/innovation-districts).

intellectual freedom. The gap between New Zealand and other small advanced nations in terms of quality of research outputs will widen if basic and basic-applied research environments cannot routinely undertake funded, high-impact international research. These educational environments train the minds that will address the National Science Challenges and find the new scientific applications that will drive the economy, and advance positive social reforms.

B. The reputational and economic benefits from doing international research

To attract and retain the best scientists and postgraduate students, we must respond to the education market. This market is affected by global league tables and New Zealand universities—in contrast to those of other small advanced nations—are slipping down these tables. It is not surprising, then, that New Zealand institutions are attracting fewer and fewer international students.[c] Good investigator-led research in the nation's universities impacts directly on the $2.6 billion education sector by making our institutions more attractive.[d] Conversely, if poor funding leads to declining institutional reputations, the university sector will shrink. This is bad for the education sector and for industry—weaker training of postgraduate researchers would have negative ramifications for industry, applied science, and society. High-impact research (basic or applied) is essential for building New Zealand's credibility as a knowledge and innovation-based economy. Yet, as a nation, we currently fail to adequately support our top researchers.

C. The capacity for new research to lead to new, unimagined applications

In innovative economies, companies are spun out of the best basic research environments.[e] Disruptive innovations emerge from beyond the horizon of what is conceivable in applied or industry-led environments. They require a critical mass of the best and brightest scientists working on the hardest problems. The Draft Statement's aim of improving the ability of applied or industry-led environments to contribute to the economy is good for New Zealand, but this is only part of the picture. Successful research environments overseas strongly rely on basic research to generate new and innovative businesses—that is precisely why innovation hubs are so often linked to universities.[f]

Finally, it is critical for New Zealand to maintain and develop expertise beyond current Government portfolios.[g] This is essential if we are to provide the necessary expert advice and scientific insight to respond rapidly to unexpected challenges, and to translate and apply the results of emerging research conducted elsewhere. This is an important but often under-recognised contribution of fundamental research to Government obligations, and is necessary

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[c] Fewer international students are choosing NZ: http://www.educationcounts.govt.nz/publications/tertiary education/145981 Fig. 18, 27.

[d] "The Economic Impact of International Education 2012/13"; the university sector provides the greatest value, at 34.7% of total sector value. http://www.enz.govt.nz/markets-research/general-research/the-economic-impact-of-international-education-2012-13.

[e] "Intellectual eminence" is a key driver of the generation of spin-out companies; Di Gregorio & Shane (2013) "Why do some universities generate more start-ups than others?" Research Policy 32:209-227.

[f] Katz & Wagner, 2014; Henry Etzkowitz, *The Triple Helix: University-Industry-Government Innovation in Action*, Routledge 2008.

[g] Current funding mechanisms are already heavily skewed towards mission- and industry-led science. In contrast, the Marsden Fund represents less than 10% of 'contestable' funds, NSSI Draft p.14.

both for gauging impacts on New Zealand, and to ensure that New Zealand can take advantage of new, unexpected opportunities.

Recommendation 2

If we are to emulate the successes of other advanced small nations, we must make the connection between basic research and innovation. Increasing Marsden funding in 2013 was a step in the right direction but it needs to continue. The Marsden Fund is the main sponsor for investigator-led basic research in New Zealand. It is well conceived but woefully under-funded—current success rates are below 10%.[h] With few funding alternatives, many first rate research projects (i.e. in the top 20% of applicants) are left unfunded, time that could have been spent on research is lost to futile grant-writing,[i] or, worse still, the research is carried out overseas and our intellectual property is lost offshore. We propose that future strategic investment includes a commitment to turn the Marsden Fund into a powerful generator of innovation. We would like to see application success rates rise to 20%, in line with other, similar funds overseas.[j] At 2013 levels, this would entail an increase to $152.2 million.[k]

3. **New Zealand urgently requires postdoctoral funding on par with other small advanced economies**

We are pleased that there is some dedicated Government funding for postdoctoral fellows through the Rutherford Foundation Trust. However, this is extremely limited (it currently funds only five positions per year) which creates major problems surrounding the opportunities for postdoctoral research in New Zealand. There is widespread agreement that there are too few opportunities for postdoctoral scientists in New Zealand. We wish to highlight two major problems that result.

A. New Zealanders and New Zealand-trained foreign PhD students are pushed overseas at the most productive point in their careers

The effect of the severe bottleneck at the postdoctoral stage in the careers of young scientists is that we are inadvertently creating ***a place where talent has to leave.*** Given the outward-looking nature of many New Zealanders, a period spent overseas can be valuable. However this is not universally true. For many PhD graduates from cutting-edge research groups, it makes better sense to stay in New Zealand and consolidate their skills. If they do this, they contribute to the New Zealand research environment just as they become most useful.

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[h] Last year, 40 of 330 Fast Start applications were funded (12.1%), and 69 of 827 Standard applications (8.3%). Increasing success rates to 20% across the board would mean funding 66 Fast Starts and 165 Standards.

[i] The reduction of successfully funded NIH grants in the US from 30% to 16.8% (http://nexus.od.nih.gov/all/2014/01/10/fy2013-by-the-numbers/) has been linked to the damaging effects of hypercompetition by Alberts et al. (2014) Rescuing US biomedical research from its systemic flaws. PNAS 111:5773-6; a recent calculation of the time spent in 2012 in Australia on grant writing indicates that, with success rates of 20.5%, the equivalent of four centuries of effort was lost (Herbert et al. 2013 "Funding: Australia's grant system wastes time". Nature 495: 314).

[j] Success rates for Australian Research Council Discovery grants are on the order of 20% (http://arc.gov.au/ncgp/dp/dp_outcomes.htm).

[k] Average Marsden Fast-Start grant in 2013 was $345,000 (including GST). The average Standard grant in 2013 was $782,754 (incl. GST). Therefore, total funding required to lift success rates to 20%, based on 2013 numbers, is **$152.2M** (incl. GST).

For New Zealand-trained foreign scientists looking to stay, or for international PhDs looking to settle, the dearth of postdoctoral funding for domestic or incoming scientists is a major problem. Postdoctoral research often coincides with other major personal milestones like getting married and starting a family. This makes it more likely that talented New Zealand and New Zealand-trained postdocs will settle offshore, particularly if they remember a NZ science system that fails to support top researchers. Failure to address this issue is a major shortcoming of the current Draft Statement.

B. New Zealand research teams are overly reliant on postgraduate students

Lack of dedicated postdoctoral funding also means that most New Zealand research teams, which are small, investigator-led teams, suffer acutely from talent loss. Because few students are able to secure funding for postdoctoral research, New Zealand scientists have to run research groups with scientists-in-training. It is routine for labs in other parts of the world to have one or two experienced postdoctoral scientists playing a senior role in driving research and providing coalface expertise to postgraduate students. Strong postdoctoral support is therefore essential for building research depth, allowing New Zealand science environments to capitalise on that depth, and creating an ecosystem where established early-career scientists can begin to drive their own research and develop their career, be it academic, applied or translational.

It should also be noted that although the impact of the postdoctoral funding void is most keenly felt in academic and applied science, it also impacts on industry. Scientists with five to six years of advanced training are better placed than recent PhD graduates to recognise opportunities to develop and spin-out advanced technologies.

Finally, the postdoctoral period is the 'make-or-break' time in a researcher's career. As a result, postdoctoral students are usually highly productive and hardworking. Savvy institutions can capitalise on this to increase their productivity. The fact that many science environments overseas are reducing their investment creates a real opportunity for New Zealand to recruit top international and expatriate postdoctoral scientists to our shores.

Recommendation 3

Government funding for postdocs should be radically increased. We believe that an increase from the current five (funded by the Rutherford Trust) to 100+ new postdocs (0-5 years post-PhD) per annum would transform research quality, depth and diversity in the way the Minister desires. It would bring NZ into line with the nearly 400 postdoctoral fellowships available in Australia for researchers at this early career stage[l] and provide a competitive foil to the tendency for young, productive researchers to leave New Zealand and never return.

[l] Through the Discovery Early Career Researcher Awards, 200 postdoctoral positions are available annually (0-5 years post PhD) (http://arc.gov.au/ncgp/decra.htm), and similar numbers of fellowships are available through National Health and Medical Research Council (http://www.nhmrc.gov.au/grants/outcomes-funding-rounds)

Rutherford Fellowship scheme

Finally, we think it is appropriate and timely to provide feedback on the Rutherford Discovery Fellowship scheme, from which we are all benefitting. The initial scheme, as run in 2010 and 2011, was a fantastic initiative as it provided a strong incentive for talented New Zealand scientists to stay in or return to New Zealand. It also provided employment stability. While we appreciate that external pressures necessitated an early review, we are not convinced the majority of changes that have emerged from the prematurely initiated review process are helpful for early- to mid-career scientists, nor for the science sector of New Zealand. We agree that the original tier system was not necessary, and we welcome the decision to allow both citizens and permanent residents to apply. However, we question the decision to allow hosts not to employ Fellows at the end of their Fellowship. This creates instability and uncertainty, may deter future overseas applicants from relocating, and risks recipients being forced to leave New Zealand at the end of their contracts. We therefore favour the introduction of a clear tenure-track requirement as part of the revised scheme. Leading research providers in other advanced economies, including Sweden's Karolinska Institutet, Denmark's University of Copenhagen and the University of Helsinki in Finland[m], are now providing clear guidelines for tenure, modelled on the tenure-track system in the US. Given the potential for the RDF scheme to be of value to tertiary providers, CRIs and the development of science that could create spin-out companies, we favour evolution of the scheme towards a tenure-track model with a clear path for successful Fellows to transition to tenured academic or employed staff scientist positions. Currently there is no clear pathway, even for those scientists who have been identified as New Zealand's future research leaders.

Summary

It is our strong belief that a national research funding pipeline that provides for early to mid-career development of New Zealand-based scientists and researchers is critical to the goals laid out in the National Statement of Science Investment document. There is an urgent need for a coherent career funding programme that provides opportunities throughout the career development of young researchers which can fully support internationally competitive research groups based in New Zealand. To achieve this, there must be substantial support for both junior postdoctoral researchers and early-mid career researchers (senior postdoctoral fellows) to pave the way from PhD research into permanent positions as lecturers/professors/staff scientists working in CRIs and industry. Such a funding pipeline requires three key components:

1. A substantial postdoctoral fellowship scheme, with dedicated funding for 100+ new postdocs each year, covering 0-5 years post-PhD.

2. A tenure-track Rutherford Discovery Fellowship, funding 10-25 new 5-year fellows each year, covering 3-10 years post-PhD.

3. An increase in investigator-led basic research funding, enabling the top 20% of Marsden applications to be funded.

[m] Wald, "Structuring Academic Careers in Europe". Science Careers, May 2008 (doi: 10.1126/science.caredit.a0800063); http://www.helsinki.fi/recruitment/tenuretrack.html; http://employment.ku.dk/tenure-track/tenure-track-at-ucph/

We welcome the opportunity to discuss these and other aspects of the Science ecosystem with the Minister and representatives from the Ministry. We will hold our annual workshop on 27th November 2014, and we cordially invite both the Minister and MBIE to meet with us during our workshop. Alternatively, one or two of our number could meet with officials to discuss the suggestions in this document.

Once again, we applaud the Government's efforts to engage in the building of a small advanced economy, and we sincerely believe that we can help create the conditions Sir Paul Callaghan aspired to build, namely: 'a place where talent wants to live'.

Signed,

Rutherford Discovery Fellowship Awardees 2010-2013

Full list of signatories:

1. Associate Professor Donna Rose Addis, The University of Auckland, RDF 2010.
2. Dr. Martin Allen, University of Canterbury, RDF 2012.
3. Dr. Barbara Anderson, Landcare Research, Dunedin, RDF 2012.
4. Associate Professor Quentin D. Atkinson, The University of Auckland, RDF 2011.
5. Associate Professor Nancy Bertler, Victoria University of Wellington, and GNS Science, RDF 2011.
6. Dr. Ashton Bradley, University of Otago, RDF 2010.
7. Dr. Brendon Bradley, University of Canterbury, RDF 2013.
8. Associate Professor Murray P. Cox, Massey University, RDF 2010.
9. Professor Alexei Drummond, The University of Auckland, RDF 2010.
10. Dr. Peter Fineran, University of Otago, RDF 2011.
11. Dr. Paul Gardner, University of Canterbury, RDF 2010.
12. Dr. David Goldstone, The University of Auckland, RDF 2011.
13. Associate Professor Noam Greenberg, Victoria University of Wellington, RDF 2010.
14. Professor Jennifer Hay, University of Canterbury, RDF 2010.
15. Dr. Justin Hodgkiss, Victoria University of Wellington, RDF 2011.
16. Dr. Jessie Jacobsen, University of Auckland, RDF 2012.
17. Associate Professor Eric Le Ru, Victoria University of Wellington, RDF 2010.
18. Dr. Peter Mace, University of Otago, RDF 2012.
19. Dr. Dillon Mayhew, Victoria University of Wellington, RDF 2013.
20. Dr Rob McKay, Victoria University of Wellington, RDF 2013.
21. Dr. Clemency Montelle, University of Canterbury, RDF 2012.
22. Associate Professor Nicole Moreham, Victoria University of Wellington, RDF 2011.
23. Dr. Suresh Muthukumaraswamy, The University of Auckland, RDF 2013.
24. Associate Professor Shinichi Nakagawa, University of Otago, RDF 2012.
25. Dr. Suetonia Palmer, University of Otago Christchurch, RDF 2013.
26. Dr. Wayne M. Patrick, University of Otago, RDF 2011.
27. Associate Professor Anthony M. Poole, University of Canterbury, RDF 2011.
28. Dr. Craig Radford, The University of Auckland, RDF 2013.
29. Dr. Nicholas J. Rattenbury, The University of Auckland, RDF 2012.
30. Associate Professor John N.J. Reynolds, University of Otago, RDF 2010.
31. Dr. Nicholas Shears, The University of Auckland, RDF 2011.
32. Dr. Lara Shepherd, Te Papa Tongarewa, RDF 2012.
33. Dr. Jonathan Sperry, The University of Auckland, RDF 2013.
34. Dr. Elizabeth Stanley, Victoria University of Wellington, RDF 2013.
35. Dr. Daniel B. Stouffer, University of Canterbury, RDF 2013.
36. Professor Jason M. Tylianakis, University of Canterbury, and Imperial College London, RDF 2010.
37. Dr. Angela Wanhalla, University of Otago, RDF 2013.
38. Dr. Geoff Willmott, The University of Auckland, RDF 2012.
39. Dr. Tim Woodfield, University of Otago Christchurch, RDF 2012.