Sir Peter Gluckman public lecture at the University of Otago, Dunedin

"Setting Priorities for Science"

24 April 2012

It is nearly three years since I took on this role, and it is worth reflecting on how its core functions have evolved into about five distinct areas.

1. The first is to promote an understanding of science, knowledge, research and innovation and the role of science among politicians, officials, businesses and the public. I will expand on this further during the talk.
2. I advise the government on how science should interact with public policy and inform its development. Internationally, this is becoming a core role of Chief Scientists' offices. Increasingly, there is a need to evaluate evidence to inform complex policy decisions and similarly, evidence needs to be used better in assessing whether programmes should continue or halt. There is increasing concern globally about the need to ensure that political decision- making on complex areas involving science uses scientific advice appropriately and does not inappropriately conflate it with values-driven and political considerations, which properly should follow on after science has made its contribution.
3. As appropriate I have provided advice on policy for science, particularly across the whole of government as science pervades every aspect of government but this is primarily the role of the Ministry of Science and Innovation.
4. The size of my role in diplomacy was somewhat unanticipated and has grown very rapidly. In effect I have been acting as New Zealand's "science ambassador". The link between science and diplomacy is complex and important. Many international agreements now involve a science dimension. Another example of where science and diplomacy have interacted and continue to do is in informing international conventions around such things as biosecurity. For a small country like New Zealand, our scientific contributions help to keep us relevant.
5. And lastly, from time to time I advise about specific matters of science, as agreed with the Prime Minister. Most obviously this has led to specific public communication on issues such as earthquakes, climate change and the work I have done on adolescence.

Over the past four years we have faced the challenge of hard times because of the global financial crisis and the earthquakes, but despite the difficulties we have sustained some momentum in developing the science and innovation ecosystems. Because so much of the discussion in the media has been about the innovation ecosystem I want to focus more on the science system today, but we need to discuss them hand in hand.

In the last few years we have seen an accelerating effort to address weaknesses in these two ecosystems. It is not simple, particularly given the global and domestic financial situation. But we, like many other small advanced nations, have protected and reinforced our science and innovation investment during this period – unfortunately for a variety of reasons we start from a lower base than many comparator countries.

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Regrettably, much of the advocacy about this matter has been focused on the tools associated with the investment rather than the rationale for the investment. Much has come from the narrow perspective of advocating for one scheme or another. Before one asks the question of "how" we should invest, it is important to focus on the question of "why". I am not sure the scientific community has been clear enough on this. It needs to put its arguments into the same framework as other aspects of policy development – namely focus on the rationale of why the taxpayer should invest more in the science system. The arguments are more holistic than just advocating for university bottom lines or for keeping academics usefully employed.

I want to suggest to you that in advocating for a greater investment in science we have forgotten to make a robust case – rather, we have descended to some rather trite and thus less than convincing arguments. Also we tend to argue around fixed positions on the roles of universities, academics, Crown Research Institutes etc, rather than to accept that science systems can change and do change. Institutional stasis is one of the biggest causes of inertia in science systems and may be a real challenge in refocusing them. I recall a decade ago how Centres of Research Excellence were not universally acclaimed in the university sector because they removed the focus from institutions, and yet now they are seen as central parts of the science ecosystem.

The major part of this talk is going to be devoted to presenting a more holistic set of arguments regarding the reasons why we invest in science. I am not going to talk about how or the tools we use – the issue in setting science priorities has to be built around why, not how.

We have developed a habit of talking about science using terms like 'basic' or 'blue skies' and 'applied'. This distinction can be and is misused, and in many ways these are just different perspectives on very intertwined activities. What is basic to one scientist may have applicability to another. Most research has a potential application –the uncertainty is how and when. As Sir George Porter, a former president of the Royal Society of London, once put it – there are only two kinds of research, applied and not yet applied.

For the purpose of this talk, let me define innovation as the process of generating and developing new processes or products that have value, and let's focus solely on that that segment of innovation that comes directly or indirectly from science, while acknowledging the numerous other forms of innovation, be they a new dance routine, organizational restructuring or in marketing. I do not need to justify why an investment in innovation is important.

The core message I want state today is that while science is vital to innovation, science is also important in its own right and provides critical benefits to New Zealand well beyond simply fuelling the innovation system. Simply put, a vibrant science system is essential to an effective science-based innovation strategy, but in saying this I want to emphasize that science and innovation are not the same things; science is neither directly nor linearly connected to science-based innovation. The science community itself has advocated for a linearity which does not exist, thinking this is the way to get more funding, rather than promoting a true understanding of the complex relationship between science and innovation. This has harmed our case.

While the relationship between science and innovation is not linear, there is ample research to show that the volume of public and private sector funded science is an important predictor of the innovative potential and productivity of a society. New understandings emerge from a cauldron of scientific enquiry of various types and particularly from the

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merging of ideas and insights across different fields. Hence the need to produce more laterally-thinking investigators rather than excessively focused reductionist scientists.

It is easy for the public and policy maker to forget how important science has been to getting New Zealand to where we are now – our dairy industry is entirely dependent on sustained science ranging from work on dairy herd improvement, soil and biosecurity research to research on advanced processing and food safety. The advanced technology sector is a very rapidly growing part of our export economy, and our science has been critical to allowing us to punch above our reputational weight globally; that in turn has impacted on our trade opportunities.

It is from earlier stage research that many of the most innovative new ideas emerge. No advanced country can afford to under-invest in such science; it is the cerebral engine of invention. The Ministry of Science and Innovation has announced its new program, "Smart Ideas", to encourage such research. I hope it is oversubscribed and so justifies further development. It reflects the growing trend world-wide not to see basic science in isolation but to encourage it to understand and emphasize its potential application.

But it is well known that where emerging science offers economic value, it happens, more often or not, to be in domains well away from where the original idea first focused. One estimate is that 50% of science has its major applications in areas which are a 'knights move' away from where it started in its earliest phase. This has major implications and complications for how to manage science funding.

A classical example is that of Townes and Schawlow who invented the maser, the forerunner of the laser. They were working on radiowave amplification: they would have had no concept that its major use would be in entertainment and software – CDs and DVDs are dependent on the device.

Because science is not certain, we need to be careful to avoid the trap of expecting the work to be so well defined in advance that the science can be envisaged in a way that is no different to a train going down a track and passing stations at exact times. If we knew precisely where the science was going we would not need it. As science progresses, its utilitarian potential does become more certain, the science can become more focused and in turn become discoverable to the innovator. But without the capacity to enquire, we will impede the amount of innovation that can emerge – simply put, successful patents are based on non-obviousness and novelty; it is no accident that new families of patents arise disproportionately from early stage research.

What science needs is enquiring minds, coupled with the capacity for acute observation; for without these the unexpected is not recognized. There is a growing shift in public policy settings around the world to recognise that an important element in a public science investment portfolio is to invest in innovative and intellectual scientists. This creates some challenges, as it can be more difficult to invest in individual potential: it is administratively easier to try and define the science outcomes. Conversely, it would be a gross mistake to assume that all scientists have these lateral thinking skills – many do not. A science system needs find the way to identify those few scientists at a young age, nurture them and let them flourish.

Innovation also relies primarily on individuals, individuals who are willing to take the risk to develop a new idea and who can see a pathway to high impact development. Perhaps the biggest impediment to innovation in New Zealand is the risk-averse nature of our society, although this is maybe changing. There must be less condemnation of failure when, for the entrepreneur, failure is an almost inevitable part of the pathway to success.

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Science and early stage innovation are two areas where the market does not work and the government has a core role. Much science is not appropriable and thus is not the domain of the private sector. At the earliest stages of innovation there are levels of risk that may be too high for the private sector. Compounding this we are a countries of SMEs. In short, there needs to be clarity over the intervention logic.These ideas might all seem rather philosophical but we need to have a rational and agreed basis from which to understand the role of the State in supporting science and innovation.

Getting the balance right in setting science priorities is complicated, much more so in a small economy than a large one, as we cannot do everything. The State has many decisions it must make – what is the balance of investment in scientists versus science? What areas do we want to emphasize and why? What is the balance between research where the system defines the problem versus traditional investigator–led academic research? What components need to be incentivized or assisted to make an effective ecosystem?

Some research must be bottom-up, some must be more directed. Indeed there are big questions that we need to answer and this will be the focus of the "Grand Challenges" scheme that the Minister announced prior to the election. We already have a forerunner of this approach in the competition underway for research aimed at reducing greenhouse gas emissions from agriculture that has attracted considerable international interest. The Global Research Alliance on Agricultural Greenhouse Gases is a formal alliance of 33 countries, including all the large economies and food producers, with the secretariat based in New Zealand.

Its mission is to focus on research, development and extension of technologies and practices that will help deliver ways to grow more food (and more climate-resilient food systems) without growing greenhouse gas emissions. Let me remind you that New Zealand, because of its high dependence on agriculture on one hand and its non-transport energy supplies being already primarily renewable, has an unusual emissions profile for a developed country with about 50% of its emissions originating from agriculture. The New Zealand government provided funds to the Alliance for it to issue grand challenges in strategic areas to reduce emissions associated with our particular agricultural profile, pastoral farming in temperate conditions, and this has, in turn, encouraged some highly innovative transnational partnerships.

Unless these fundamental questions about science priorities are answered and an integrated approach taken, advocating for individual components is likely to fall on deaf ears.

But already we are falling into the trap of how rather than why, and in the remainder of this talk I want to parse the "why" question. We have to think through the various arguments using a broader compass than just direct economic growth. We need to consider about the various outcomes we need – what are the components of a complete science ecosystem?
First and foremost we need a scientifically literate population and young people who want to undertake careers in science. There is global competition for scientists and engineers and New Zealand does not have a very strong hand. Yet despite that, we continue to see the our universities ranked highly and indeed, New Zealand scientists publish disproportionately well for the size of the investment. But we need to emphasize why we need at least some of our universities to be higher ranked.

Ranking is important. Without a vibrant university sector with some universities in the top rank we will not retain the best and brightest in New Zealand. Ranking also will help us attract the best overseas students, those in 30 years who will become key leaders in their own countries or successful migrants here.

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We are still reaping the successes of the Colombo Plan whose graduates now are leaders in many parts of SE Asia. But now the best students from Asia chose to go where rankings are highest. This has domestic ramifications, as it is unrealistic to imagine us having eight universities in the top rank – but one, two or three is possible.

We need an intellectual base to our society, because that is part of the necessary infrastructure if we are to value knowledge generators and exploiters and support them. The definition of a first world country is increasingly one that generates knowledge and exports it.

Because we are small, we will always import much knowledge and technology and if we are not skilled from within our universities and CRIs we cannot be fast adopters; I expect that fast adoption will be necessary to be strong in the knowledge-dominated world ahead of us. And of course the universities and CRIs themselves remain important sources of ideas that will lead to science-based innovation.

There are dangers in extrapolating from large to small economies, but in small and more comparable economies such as Israel, Canada, and Denmark it has been found that a very large percentage of the exploitable ideas have the core of their origin in university or science institute research. Indeed, universities may be the most important institutions in innovation. The Israelis are blunt – they need 100 ideas to emerge from a university or institute technology office for one to be a commercial success. The universities in Israel generate a far higher rate of ideas than ours – I would guess about 2 to 3 times ours – the difference is only a matter of what incentives are in play and the volume of research undertaken. We need to understand this and why our incentives are not achieving what we want.

Research also acts indirectly to support our economy in other ways.

We must defend our environment, our primary sector and our animal and human populations. This defensive activity requires research ranging from atmospheric and water research, to geological research, to soil research, to bio-protection research, to animal health research, to human infectious disease and toxicology. It is no accident that large parts of several CRIs are deeply involved in such work. That is the proper role of state sector research.

Government science expenditure is essential for health, social welfare and education and with this there is enormous flow-on value to justice, police and other ministries. So understanding our society is also critical. Without well-performed and unbiased social science, both investigating the issues and evaluating interventions, decisions are more likely to be based on dogma and thus are more likely to be less effective. Two weeks ago saw the Prime Minister announce a package of new initiatives in youth mental health that had their origin in a scientifically-managed process in which your Vice Chancellor played a central role. Notably, the package acknowledges the uncertainty of effect of the proposed interventions, and they will be monitored prospectively. This is a trend to be encouraged.

We undertake science for other reasons as well. There are diplomatic reasons – for example our superb Antarctic research and some activities undertaken by our foreign aid division. Science is a transnational activity and there are many reasons why we need to be a disproportionately active player. Maintaining our relevance to the world is important. There are also domestic and cultural reasons – research can allow New Zealand to promote its national identity by analysis of native fauna and flora and particularly provide understanding of our own peoples.

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And there is another big challenge in which science will play a critical role. We live in a world which will expand its population by at least another 40% within a generation and that growth will be associated with increasing expectations of better standards of living by many, thus putting greater pressures on limited international resources. While we have changed the world through our unique capacity to use learning and technology over the past 100,000 years, change is now occurring at an exponential rate leading to challenges that must be scientifically interrogated. To take an immediate example – does the shift to the virtual world fundamentally change the way young people's brains develop and what will that mean for learning, socialization and social and organizational structures in the future world?
If we think of the core issues and challenges faced by any political leader in the future, there will inevitably be a need to pick between important but awkward trade-offs. We see this in both major decisions and many of the day to day political decisions that must be made. Indeed, it is arguing over these trade-offs that is the meat of partisan politics.

There will be a requirement to extract more resources, be it energy or food, to meet the demand of a growing world population and to sustain economic development versus an increasing awareness of the fragility of the planet. We face these issues now, be it handling the balance between dairy intensification and water quality or deciding whether to drill for oil offshore. What are the risks of a viral epidemic affecting our cattle or us in a more connected world? How will we to decide whether to use new genetic techniques to develop food plants and forages which could dramatically increase our food production? These issues all have scientific underpinnings needed to inform the required decisions and concepts of risk and risk management come to the fore. We need to get more skilled as a society in understanding risk and its management and using this as the basis of consensus on trade-offs that we may need to make. We need to understand that the proper use of precaution is not an argument for paralysis but rather for proper risk assessment and management. This is essential to our participatory democracy.

What I am saying here may sound out of place but it is actually pointing out that economic, environmental and social innovation requires a scientifically literate population and will need contributions from the basic, mathematical and particularly, the social sciences. We have seen examples where advances in technology have been poorly communicated or misunderstood, and the views become retrenched rather than reassessed as understandings emerge, and social science has a much greater role to play in understanding how our social selves and technology interplay.

So let us now turn to research with the potential to have direct economic impact and how should it be decided what to fund. I would argue that it is time to ask two questions. First, what science do we do now that drives economic growth and how should we capitalise this better? And second, what is it we are not doing or, at least, not doing enough of that provides competitive advantage?

Let me consider the first by way of one example. Clearly our economy has been built on feeding ruminants grass and clover and then having a string of applied sciences to support the production of the milk and meat that is sold to the world. We have done much to improve the genetic quality of the national herd and flock, as well as improving the supporting forage species and protecting them from pests and diseases. The basic biological principle is that value generated is the outcome of the interaction between the genes and the environment, and while we have focused on the first using selective breeding, our science community would argue that we have not given enough attention to the latter.

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Advancing this pastoral production might be a quick route to economic uplift, although this will require very different research efforts in soil, forage, pest management and related areas. The gains, through the multiplier effect, have the potential to be enormous, one estimate puts the combined increase possible at between $12 billion and $20 billion per annum without increasing the number of cows, just feeding them better. We know if we take New Zealand cows and ship them overseas some of them can more than double their milk production. However, such research is not seen as sexy; moreover it can be hard to appropriate the value of the results, and the outcomes are uncertain. Further lifting production and productivity would need to accommodate the inevitable environmental impacts. The corollary of all of this is what technologies would be needed and what would be the public acceptance of them?

But with respect to the second question, relating to what are we not doing much of that we could do so much better, the consideration is more complex. Every university, every CRI and many businesses would probably have a different answer but let me provide one example that builds off the one I have just given you. The nature of the food industry will change. Worldwide, there will always be demand for food commodities to feed 9 or 10 billion people, but for a small food producer like New Zealand, we will not compete against the largest commodity producers such as Brazil. Rather, what we will need to do is to produce advanced foods with added value based on demonstrated and regulator-approved health-giving qualities – this builds off our existing competitive advantage in food regulation, in health research, in food production and while it would need some infrastructural investment, it certainly could lead to major new product streams.

We also have to think about how science enters the innovation system. Most scientists are not entrepreneurs, and we need them to stay scientists. But equally, many businessmen are not technologically literate and competent to manage high-risk knowledge-based discoveries where the market is offshore. This is made more complex because we are a country of SMEs, which one of the reasons incentives used in large countries may not work here. There is a difficult cultural boundary between science and innovation, and multiple tools are needed to assist translation in either direction. We also have to think about the issues facing the smallest innovation firms – they are very different to those few companies of critical mass. How and when should we encourage aggregation?

Around the world, countries are trying new models to enhance knowledge flow to the private sector, encouraging both push and pull in an effort to create a private sector capable of exploiting knowledge. Incentives must lie in the right place.

Again there are questions that require honest interrogation for the good of New Zealand, not necessarily of individual institutions.

Have we got the right funding tools, does the PBRF put the incentives in the right place, do the current approaches around IP ownership and management in universities and CRIs encourage ease of transfer? We have one of the more confused systems where student and staff IP management are not always aligned yet graduate activity is key to most science. Some jurisdictions would argue that there a conflict of interest between CRIs or universities managing IP for their organisational financial position rather than to exit it to the private sector. Do we have the skill sets to incubate ideas, or the companies to buy into the knowledge generated? Do we have the skill sets to take knowledge profitably to the world – can we create networks to do that. Supporting extant knowledge exporters is different to creating new ones. Indeed, we have to build off where we are now and to learn from the other advanced small nations, but we also have to recognize that our situation has its own peculiarities.

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Using the appropriate perspectives to set our science priorities is essential for a vibrant and outward looking New Zealand. I have argued that, while science is critical for an effective innovation ecosystem, science has other dimensions that are important for protecting New Zealand's place in the world. A mature conversation about these priorities is needed to inform how we address the weaknesses of the current system. And in turn, a robust set of priorities may provide us with clarity about whether our institutions are fit for purpose in delivering the science that New Zealand needs for a prosperous future.

Thank you.

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