OFFICE OF THE PRIME MINISTER'S SCIENCE ADVISORY COMMITTEE

Professor Sir Peter Gluckman, KNZM FRSNZ FMedSci FRS
Chief Science Advisor

Speech at NIWA's "Science in the City" event

The Cloud, Auckland, 12 April 2012

We are here to celebrate some of the science performed by the Crown Research Institutes and some of it is important, marvellous and world beating. It is perhaps symbolic that we are only a few hundred metres from Wynyard Quarter, which will soon emerge as a critical piece of physical infrastructure for a much-needed enhancement of the science and innovation ecosystem in Auckland. In the last few years we have seen an accelerating effort to address weaknesses in this critical ecosystem. 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.

I do not need to justify why an investment in innovation is important but I think some comments about the importance of why we are continuing to invest more in science even when times are tough may be useful. Simply put, a vibrant science system is essential to an effective science-based innovation strategy. However in saying this, I want to emphasise that science and innovation are not the same things; science is neither directly nor linearly connected to science-based innovation. Science is critical to innovation, but science is also important in its own right and provides critical benefits to New Zealand well beyond simply fuelling the innovation system.

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 the segment of innovation that comes directly or indirectly from science, while acknowledging the numerous other forms of innovation, be they a new dance routine, organisational restructuring or in marketing.

It is easy 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, which in turn has impacted on our trade opportunities. Today's celebration is important. The Universities and CRIs together do us proud.

Science can be broadly defined as the process by which we seek to obtain reliable information about the universe—the natural, social and built world that surrounds us—and about our own biology and behaviour. Key to this definition is that science is a *process*, not a collection of facts.

Mail: PO Box 108-117, Symonds Street, Auckland 1150, New Zealand Physical: 2-6 Park Avenue, Grafton, Auckland 1023
Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
Website: www.pmcsa.org.nz Email: csa@pmcsa.org.nz

Sometimes that process is tritely reduced to the supposed iterative sequence of hypothesis, observation, analysis, redefinition of hypothesis and so on. Of course, science is by no means as neat as that, but however we describe the process, central to it is the idea of unbiased collection and analysis of observations and data. This is easy to say but often difficult to conduct, particularly when we deal with complex systems like the environment or a biological or social system where we are often left with inferential gaps between what we know of a system and the conclusions we are asked to draw. I have talked at length about this issue elsewhere.

We have developed a habit of talking about science using terms like 'basic' or 'blue skies' and 'applied'. This distinction can be misused, and in many ways these are just different perspectives on very intertwined activities. 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'.

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 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 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. And it is pleasing to see the Ministry has announced its new programme, 'Smart Ideas', to encourage such research.

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 'knight's move' away from where it started in its earliest phase. This has major implications and complications for how to manage science funding.

For example Townes and Schawlow, who invented the maser, the forerunner of the laser, were working on radio wave 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). When I set out to study hormonal changes at birth in 1980 I had no idea that 20 years later the work would emerge as the Cool-Cap, designed to treat brain damage occurring at birth. Indeed I was not interested in the subject when I started that work; the implications only emerged from a casual discussion with some scientists in a different field in a bar in Hannover late one night.

Getting the balance right is complicated, much more so in a small economy than a large one as we cannot do everything. Some research must be bottom-up, while 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.

But science is not certain, and so 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

Mail: PO Box 108-117, Symonds Street, Auckland 1150, New Zealand Physical: 2-6 Park Avenue, Grafton, Auckland 1023
Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
Website: www.pmcsa.org.nz Email: csa@pmcsa.org.nz

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.

What science needs is enquiring minds, coupled with the capacity for acute observation, for without these the unexpected is not recognised. There is a growing shift in public policy settings around the world to show 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 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 like the late Sir Paul Callaghan 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 may be changing. There must be less condemnation of failure when, for the entrepreneur, failure is an almost inevitable part of the pathway to success.

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 country 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.

The State has many decisions it must make: what is the balance of investment in scientists versus science? What areas do we want to emphasise, 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 incentivised or assisted to make an effective ecosystem? And so forth.

We have to think through the various arguments using a broader compass than just direct economic growth. We need to consider the various outcomes needed; 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 strong hand. Yet despite that, we continue to see the our Universities and particularly the University of Auckland ranked highly and indeed, New Zealand scientists publish disproportionately well for the size of the investment.

Without a vibrant University sector we will not retain the best and brightest in New Zealand. I am currently doing a survey of our brightest high school students, driven by my concern that far too many are doing their undergraduate degrees offshore and will not return. We need an intellectual base to our society because that is part of the necessary infrastructure needed 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.

Mail: PO Box 108-117, Symonds Street, Auckland 1150, New Zealand Physical: 2-6 Park Avenue, Grafton, Auckland 1023
Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
Website: www.pmcsa.org.nz Email: csa@pmcsa.org.nz

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, 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; the difference is only a matter of what incentives are in play and the volume of research undertaken.

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.

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. Last week saw the Prime Minister announce a package of new initiatives in youth mental health that had their origin in a scientifically-managed process and in which the uncertainty of effect is acknowledged and 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 trans-national activity and there are many reasons why we need to be a disproportionately active player. There are cultural reasons, such as that which can allow New Zealand to promote its national identity by analysis of native fauna and flora and particularly provide understanding of our own peoples.

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, socialisation 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 tradeoffs. There will be a requirement to extract more resources, be it energy or food, to meet the demand of a

Mail: PO Box 108-117, Symonds Street, Auckland 1150, New Zealand Physical: 2-6 Park Avenue, Grafton, Auckland 1023
Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
Website: www.pmcsa.org.nz Email: csa@pmcsa.org.nz

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 tradeoffs that we may need to make. 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 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 better capitalise on this? 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. 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 ensuing 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-

Mail: PO Box 108-117, Symonds Street, Auckland 1150, New Zealand Physical: 2-6 Park Avenue, Grafton, Auckland 1023
Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
Website: www.pmcsa.org.nz Email: csa@pmcsa.org.nz

giving qualities. This builds off our existing competitive advantage in food regulation, in health research and in food production, and while it would need some infrastructural investment, it certainly could lead to major new product streams.

But we also have to think about how science leaves the CRIs and Universities—it is a complex and non-linear process. Most scientists are not entrepreneurs, and we need them to stay scientists. But equally, many business people 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. There is a difficult cultural boundary and multiple tools are needed to assist translation in either direction. We also have to think about the issues facing the smallest innovation firms as they are very different to those few 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. Have we got the right granting models, does the PBRF put the incentives in the right place and do the current approaches around IP ownership and management in Universities and CRIs encourage ease of transfer? Is 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 recognise that our situation has its own peculiarities. A coherent set of views on how to handle these challenges is emerging from the Ministry, but it will take multiple initiatives in parallel to develop an optimum configuration.

But there are other dimensions as well. Government has some role to play, but so has local government and the private sector. Innovation requires ecosystems—both physical and human. Only local government can ensure the former and the private sector has a lot to do with the latter. We have identified some innovation precincts in Auckland: Wynyard Quarter, Tamaki and the food hub are the three most obvious, but the University precincts in Massey and Grafton are also important. Auckland City is working to create a rational plan. Most attention is focusing on Wynyard Quarter and I see enormous possibilities there.

The private sector is starting to respond; the most rapidly growing part of our economy is the high technology sector. Some very exciting new companies are emerging and some of our larger companies such as Douglas Pharmaceuticals and Fisher & Paykel Healthcare continue to thrive with their knowledge based exports.

In my talk to Auckland City before Christmas, I emphasised the importance of cultural commitment to innovation. I think this may be the most critical factor. We still have a low-risk view of investment that is incompatible with knowledge-based innovation, and we still have a relatively individualistic approach in our corporate world. I was recently in Canada in Waterloo, now second only to Silicon Valley in the number of start-ups. The regional success factors, in this low-risk community of only 500,000 people, are fourfold: the University of Waterloo encourages all its students into private sector internships, it opened its IP to the private sector, there was investment in technology parks, and, perhaps most importantly, there was established a system of peer-to-peer support and mentorship led by the private sector that means that successful companies can mentor emerging companies. At the centre of this is a space similar to Wynyard Quarter, but the thing that makes it hum is the coordinated sense of community that now supports fulltime experienced retired CEOs as

Mail: PO Box 108-117, Symonds Street, Auckland 1150, New Zealand Physical: 2-6 Park Avenue, Grafton, Auckland 1023
Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
Website: www.pmcsa.org.nz Email: csa@pmcsa.org.nz

mentors for the several hundred start-up companies in the network. As an evolutionary biologist I know that cooperation sometimes beats competition. This is a good example.

I have suggested what is possible. We must exploit the scientific and innovative capacity we have. Auckland is in a position to take advantage of changed thinking where the relevant players are committed to such change. And it will require ongoing attitudinal change—not just amongst those here tonight, but by the whole population that must be convinced of what we are trying to do. It will take a decade and there will be failures along the way. However we really need to get beyond the typical kiwi-knocking machine and get on with it.

Thank you.

ENDS

Mail: PO Box 108-117, Symonds Street, Auckland 1150, New Zealand Physical: 2-6 Park Avenue, Grafton, Auckland 1023
Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
Website: www.pmcsa.org.nz Email: csa@pmcsa.org.nz