OFFICE OF THE PRIME MINISTER'S SCIENCE ADVISORY COMMITTEE

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

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Dr Stephen Goldson's opening plenary at the 7th Annual NZBIO Conference

'Science, Innovation & Business: the role of the Biological Economy in Building New Zealand'

Good morning, Auckland Council Chair Len Brown, fellow plenary speaker Professor Bob Elliot, Medical Director of Living Cell Technologies, distinguished colleagues, distinguished officials, ladies and gentlemen. I would like to thank Michelle Sullivan for providing me with the opportunity to speak at this, the seventh annual NZBIO conference.

I am actually an applied entomologist and have spent most of my career at Lincoln in AgResearch and its precursor organisations. Much of this has been working on the suppression of some of our worst exotic forage pest species using biological control agents. More latterly, I have developed a strong interest in ways to enhance New Zealand's border biosecurity and am currently the Executive Director of a multi-organisational Centre of Research Excellence called Better Border Biosecurity, or "B3". I have also had the odd excursion into science policy and strategy and spent time as AgResearch's Chief Scientist.

About 18 months ago, the Chief Science Advisor to the Prime Minister, Professor Sir Peter Gluckman, asked if I could assist part-time and I currently spend 30 percent of my time as his strategist. I advise mainly on agricultural and environmental issues and matters relating to CRIs.

I am pleased to be here this morning on Sir Peter's behalf, who apologises for not being here but the events of the last few weeks have disrupted his calendar somewhat and he has to be overseas today.

As an agricultural, horticultural and tourism exporter, New Zealand has always had a biologically-based economy. Today, there is an increasing need for food and biologically-based products from what are often stressed productive ecosystems. Worldwide we are worried about issues like food security and from a national perspective we have to be concerned about how to add value both before and after the farm gate. There is a set of inevitable tensions between the need for primary industries intensification, the need to reduce greenhouse gas emissions, protect water and energy sources, protect the environment and yet, maintain economic development. This situation is creating new challenges and opportunities for science. Indeed nothing has generated a realisation of the need for science in a crowded world more than the catastrophic events of the last month. About the only thing the world hasn't seen lately is a zoonotic epidemic such as influenza although I believe there have been some narrow squeaks.

If the work of 17th and 18th century scientists enabled the Industrial Revolution to take place, the 19th and 20th centuries arguably heralded the Medical Revolution. Given the current state of our planet, it looks like the 21st and 22nd centuries need to see an Environmental Revolution.

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

Climate change, population growth, ageing populations, habitat destruction and invasive species pose significant challenges. With them there are inexorable requirements for increased water, food and reduced or carbon-free energy in an increasingly fragile and densely populated world.

As a global community, the consequences of not making the transitions needed to provide environmentally and socially sustainable economies are sufficiently appalling to rule out any suggestion of choice. Indeed, even an immediate and energetic start will still mean that the next few generations are likely to have difficulties ahead of them.

But there are also exciting opportunities for those far-sighted enough to see them and bold enough to grasp them. Science-based business will be an obvious and important part of this drive for transition.

I should emphasise that biologically based high technology industries cannot be our only strategy in a knowledge-focused world; we need to also see where we have advantage in manufacturing and the service sectors. It is not a matter of either biotechnology or high technology manufacturing – we must do both where we can see competitive advantage. To this end I am delighted that government has recently announced a review of research supporting the high-technology sector. But equally we must not underplay the essential role that research and development has played and continues to play in supporting our agricultural and food sectors. It would be wrong to imagine that there are not enormous opportunities yet to be exploited.

This conference highlights some of the front-runners in the biological technologies space, from cancer diagnostics to bioactives to bioenergy. Such new and rapidly developing technologies combined with science-based business offers a great deal.

From a national economic perspective, it has to be asked what in 20 years will New Zealand be selling to the world that will earn thousands of millions of dollars – not tens of millions? It is clear that we cannot sustain growth only through ever-increasing production in the primary industries; the answer must be that we will be, increasingly, selling added-value and this added-value comes from clever minds. We will sell food not as a commodity, but as something that has real extra value because we will have demonstrated properties that provide undoubted health benefits. We will sell electronics and manufactured goods, not because they are cleverer than someone else's version, but because we will have added value through clever design. We will sell services because of the added value of our earthquake engineering skills or because of the skills of our environmental scientists. And we will sell our biotechnologies because they address human needs and wants in an environmentally and socially sustainable manner. This is what our future must be.

I am more-or-less an entomologist and it would be ridiculous for me to try to tell you about biotechnology. What I would like to do is talk about a couple of aspects of modern science that impact directly on New Zealand's biotech industry. The first is complex science or post-normal science and the consequential public understanding and communication issues that arise from this. The second is the importance of science such as yours in working with other domains such as diplomacy for New Zealand's benefit.

Science in much of the last two centuries has been dominated by the linear observation taught in schools; hypothesis development and the testing and re-evaluation of these hypotheses to produce scientific facts that are associated with increasing certainty. For example, what is the speed of light or are birds the descendants of dinosaurs?

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However, since the advent of quantum physics and the explosion of biological and ecological science coupled with massive ability to handle data, the science under consideration no longer fits into the reductionalist paradigm easily or neatly.

We are now increasingly grappling with complex systems with many feedback loops and interactions. Yes, reductionist science may cheerfully identify individual particular processes, but the scientific challenge now is to come to grips with the overall systems into which such processes fit. This is not just about simple measurement error; it is about incomplete knowledge with which to tackle the dimensions of complexity. The effects of confounding interactions cannot be precisely predicted; rather in such cases science has had to be developed to deal with probability, prediction and risk. Such endeavour is based on the use of models that incorporate what is known and what is uncertain, and are subject to ongoing revision and refinement.

This kind of science has been termed post-normal or complex science.

In other words post -normal science seeks an assessment of probabilities and generally a reduction in levels of uncertainty. This is the stuff of grand challenges such as obesity, water security and quality, biosecurity and climate change, to repeat but a few. This is very much in the domain of biotechnology.

Hugely topical, right now is consideration of the probability of a large-scale earthquake in a given area of a given magnitude, at a given depth, at a given time. All of this is calculated based on what is known about the tectonic context of that area; what faults are known to be present, the type of faults, how active they are and what has happened in similar environments elsewhere.

This rather messy multi-factorial, probabilistic science is extremely important and we cannot get away from it. Indeed one of the problems here is that it allows science detractors, deniers or prophets of doom to cherry pick components of the ideas that must feed into probabilistic science and use them to dismiss the entire framework and understanding built up. This has been very apparent with respect to climate change and earthquake prediction, with the unnecessary distress and delay in rehabilitation it has caused in Christchurch over the past week.

One of the most important things that we as scientists have failed to communicate well is that even this kind of science is not just about facts. Indeed science is not facts – science is a *process* by which we make our best efforts to understand what is going on in the universe, in the natural and social world, and in ourselves. Thus science is more than simply mathematical modelling or access to experimental data – there is much more to the process of science than that. To think scientifically one needs many tools – ideas about cause and effect, respect for evidence and logical coherence, curiosity and intellectual honesty, the willingness to create hypotheses which can be tested, the willingness to refine one's ideas in the face of evidence: these are the core skills of science and scientists.

The other feature of these systems is that there is an important interaction with people's values. There is an enormous difficulty in this intersection; it is easy for scientists to forget that the scientific process is designed to try and overcome individual bias and belief; it is easy for those focused on values to demand something of science it cannot address. The most obvious example is with abortion – no scientist can address the question of when does life commence in a way that can narrow the inevitable divide between people with different value systems.

Look at recent scientific debates that have affected your sector. Where does the science end and where do values emerge as the key determinant? In a narrow sense GM foods are safe as

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is food from cloned animals. A different set of scientific issues surrounds the ecological impacts of GM crops, but even if this were to be robustly addressed, the values argument remains. At least for some New Zealanders, science still does not address that issue around 'natural' processes and scientists should not be arrogant enough to think that their view outweighs that of the community – it doesn't. Issues around the use of nuclear power in a world worried about carbon have similarities, so do matters relating to assisted reproduction, or to tolerating tobacco at some level in our society, or to dealing with adolescent behaviour, or to dealing with climate change.

Indeed Governments have to make multiple decisions about these and many similar matters, and in a democracy governments do not and cannot move beyond the public consensus, unless under exceptional circumstances.

So how can we ensure that the public has the information necessary to reach a consensus on matters where science has something to contribute? The public clearly loves science – the syndicated stories acting as fillers around the advertisements packing the middle pages of the *New Zealand Herald* attest to that. Science and technology stories are some of the best read on newspaper websites and the scientific blogosphere is very active, albeit often compounded by the interplay with other agendas. However, the content of most local media stories about science is one of hype and breakthrough and unbalanced reporting.

Now, I hasten to add, I do not think this is the fault of the media alone. Clearly, many scientists overplay their hand and overstate the implications of their work – they have their own motives for doing so, whether it is to get attention or to impress a potential funder or donor. Likewise the media have their own motives – which is to sell stories or in many cases in the blogosphere to influence opinion.

So what should we do about this miscommunication of science? Whether the system studied is linear or complex, the public has a right to understand what are the bases for claims, predictions and risk assessments. The nation needs its public to understand why an investment in science and innovation is critical for its economic, social and environmental futures, and then the public has a right to know where their expenditure on science goes and what it is achieving.

Actually when it comes to complex science, the problem is even greater. The need to explain that science is now about reducing uncertainty, establishing the multiplicity of direct and indirect interactions and making predictions in terms of risk and probabilities is very different to communicating about a simple scientific finding. Further, understanding the limits of science becomes even more important. Science cannot provide certainty in many situations. Science cannot be used as a sole proxy for more complex discussions involving community values. For issues such as genetically modified organisms or climate change, if scientists wish to act as advocates for a value-driven or belief-driven position, they cannot act as true scientific communicators with any more validity than when a non-scientist advocates with certainty on a scientific matter. Coupled this with the vast expansion in electronic communication, associated changes in the media industry, and resulting changes in investigative journalism, combine as a clear recipe for potential mis-communication.

The importance of accurate and effective science communication is reflected in the growing number of resources on the subject, particularly from government departments, and, more recently, courses being offered by tertiary institutions. Of the number of exciting initiatives in this space, particular note must go to the relatively recent establishment of the Science Media Centre.

But the media have an enormous responsibility in this area. They discredit themselves when they misuse it, as they have in hyping up non-scientific earthquake predictions, with enormous

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immediate consequences for anxious people struggling already to come to terms with the earthquake. It is dishonest of them to pretend they are having an honest discussion on the topic when they give “equal time’ to hyperbolic pseudoscientist celebrities on one hand and scientists on the other, who try to be calm and informative. Given the size of the international seismological community and its scholarship, this is ridiculously unbalanced. Taken at its worse all the media are trying to do here is play the ratings game and make a controversy. Our TV channels shifted from being informative to being tabloid-like in this matter, lost respect and undermined the special privilege they have in being the primary transducers of information. I must say the earthquake predictors got far more attention on TV than in the Christchurch print media. Whatever branch of science we come from we should be truly alarmed by this episode.

But all of this does not negate the need for scientists to be actively involved in this area. It is a little disconcerting to move between the rigorous world of scientific communication with one’s peers, to the less structured and less predictable world of media communication with the general public. But this is as important.

Also notable is that science be it post normal or otherwise does not create policy in resolving matters but it is an essential element in the formation of appropriate policy options and in understanding the risk/investment relationship.

Clearly GE and other aspects of biotechnology are in no way exempt from such complication and I think that you have all be varying affected by it. Public confusion has abounded around probability and with that vanishingly small probabilities like those when dealing with horizontal gene transfer. Indeed any possibility, irrespectively of how remote, can lead to immediate societal fear of calamity. That said though, this does not preclude consideration of issues around low risk but appalling consequences; the nuclear reactors in quake-ravaged Fukushima are a case in point. Science cannot be arrogant and as I said, this post-normal science stuff is complicated.

This does not mean that a sensible level of agreement and compromises cannot be met. In New Zealand this has been illustrated by the nuclear debate. We allow nuclear technologies in situations where they can be managed closely and largely contained. These kinds of uses give New Zealander’s access to specialised medical treatments and assessment equipments, as well allowing scientists in registered research laboratories access to a widely increased range of research methodologies.

We do not, however, have nuclear power. From an economic perspective, some would argue that this is a sound decision, given our small population and relatively high access to a range of renewable power resources. In light of recent events in Japan, this decision may also have potential safety benefits in a seismically active country such as ours.

Further it may have also helped to enable New Zealand to develop an international reputation as an ‘honest broker’ that allows it to punch above its diplomatic weight on international issues.

Science and diplomacy

If I may, I will now divert to the second topic that is essential for NZ science and one that the CSA office is heavily engaged in. This is the relationship between science and the way we protect our place in the world; this is increasingly known as scientific diplomacy.

There is an increasingly significant nexus between science, diplomacy and globalisation. Much of Sir Peter’s time is spent on that interaction as co-chair of the Prime Minister’s International Science and Innovation Coordination Committee. He recently had a round of meetings in

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Washington and at the UN on this very topic. I want to spend a few minutes expanding on this subject before returning to some concluding comments about the biotechnology industry.

There are in fact several dimensions:

Diplomacy has of course helped science for decades. Many big science projects such as the international space station and widespread disease eradication campaigns have only come about because of the efforts of diplomats in supporting scientific progress. Recent scares around SARs and bird flu come to mind. Much of this scientific collaboration is assisted by diplomatic processes. The EU framework grants arose from diplomatic processes in creating a new form of a grant. The New Zealand government supports our membership of many international scientific organisations such as the International Council for Science, set up in 1931 and its constituent parts.

But conversely, there is increasing recognition of the role of science for and in diplomacy. This has recently been highlighted by the Royal Society of London and the American Association for the Advancement of Science.

It is no accident that, science has now become part of nearly every bilateral agreement New Zealand enters into. All nations see science and innovation at the heart of future economic growth and as international relationships are developed science often plays a major role. In our case, in the past decades, the role of Antarctic science strengthened our relationship with the USA when there were other sources of tension. But science can also help build new relationships with countries such as China. Here the science has multiple values. It creates links at the personal level but also because science leads to innovation, such activity creates economic and trading opportunities.

For New Zealand this is ever more important, because as a small country we must work to protect our interests and maintain our presence on the world stage. Science has a big role in this. Our science is good and we now have scientific collaborations with nearly 100 countries, both developed and developing. Such connections build bonds as well as create opportunities for other sectors of the economy and in turn create employment and well-being. It is anticipated that the Square Kilometre Array telescope project may reflect such benefit

Science also serves diplomacy in other ways. For example, the science of nuclear verification is the key to modern arms treaties. The nature of international aid is also changing. We now see science-based programmes at the centre of much agency and foundation aid and focus is increasing on how we in New Zealand can pursue science in cooperation with our partners to advance the lot of those nations that we have a moral and political obligation to help. As the issues of food security, water security, adaptation to climate change, and dealing with the burden of non-communicable disease get greater in the Asia-Pacific region generally, we must increasingly use science to respond to these challenges.

Scientific diplomatic involvement is clearly multidimensional. It is a complex matrix and the drivers for scientists, businesspersons and diplomats are all different, yet science has a central role to play irrespective of the perspective. In general, scientist–to- scientist relationships need little encouragement at least with our traditional partners, but New Zealand's future is likely to be increasingly in Asia and we need to build more bridges with that part of the world. It is also important to ensure we are partners in various funding and internal infrastructure programmes – such as the synchrotron and hopefully, soon, the square kilometre array where New Zealand is taking a suitably-funded role.

Throughout such consideration, a key priority must be to use science to create truly innovation partnerships that will drive opportunities for us to export value-added goods. Take the UK for

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example. We have extraordinarily good relationships with this country at the scientist-to-scientist level, but we have not realised the full potential of these networks to move NZ more towards innovative and knowledge-based exports. As we develop closer links with the international science, innovation and business communities, such opportunities are essential.

Finally I should note that New Zealand science excellence in niche areas can buy us a seat at international fora. A good example of this is how our leadership in rumen microbiology and our increasing understanding of methanogenic micro-organism processes has provided us with a key role in developing the Global Alliance on Green House Gas Emissions

In conclusion, we live in biologically demanding times and we face a slew of issues ranging from population ageing due to advanced healthcare to a rapidly growing global population that threatens to outstrip technologically-assisted gains in efficient resource use. In top of this there is the spectre of changing, and increasingly extreme weather patterns, ocean acidification, accelerating biodiversity loss, increasing biosecurity threats and the plethora of other effects arising from anthropogenic climate change.

The biotechnologies sector has a vast potential to help to address these issues and there will be geopolitical consequences for New Zealand if issues associated with the biotech industry are not addressed to the best of our collective ability. More than that it is great to see the barriers come down between the biotechnological and environmental sciences; the old distinctions are wearing thin. Each can hugely assist the other.

New Zealand must protect its place in the world, politically, as a free trader, as a voice for reason, and work towards being a smart nation increasingly relying on its brains for innovation led economic growth.

The biotech industry must be a key part of that effort and I salute the scientists, entrepreneurs, policy makers and all of you here today who are working to help realise the imperative.

Thank you

ENDS.

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