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

Guest lecture by Professor Sir Peter Gluckman at the Wolfson Research Institute, Durham University, UK

Communicating complex and post-normal science to the policy maker and the public – lessons from New Zealand

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Thank you for the introduction.

To put my comments in perspective I should describe my role as Chief Science Advisor to the Prime Minister of New Zealand, which occupies about sixty percent of my time – the Prime Minister was adamant the role had to be filled by an active scientist. This is a new position and differs to the role in England in that it does not have operational responsibility for the science system. There is a Minister of Science and Innovation and a corresponding ministry which develops policy for, and operates, the publicly funded science and innovation system, but although I report directly to the Prime Minister there is a close liaison between my Office and those of both the Minister and the Chief Executive of the Ministry.

My office has five primary functions:

- To promote an understanding among politicians, officials and the public about the role of science in matters affecting them.
- To advise the Prime Minister on policy for science and assist in whole-of-government science issues.
- To advise the Prime Minister on science for policy – that is, how to improve the use of evidence in policy formation and implementation.
- To advise the Prime Minister about specific matters of science at his request – I will highlight adolescence in this talk.
- To assist the Government's needs in the interaction between science and diplomacy.

Much of the role then is about communication, and in the past year I have found myself dealing with officials, ministers and the public on matters ranging from earthquakes to climate change to the problems of adolescence. At the same time this interfaces with the other major task: that of improving the use of evidence in policy formation. It is these two intertwined objectives I will discuss.

In the middle of 2011 I released a report entitled *Improving the transition: reducing social and psychological morbidity during adolescence*. That report represented the culmination of 18 months of work by an academic and professional taskforce working from my Office. But it is not the content of the report I want to highlight, but rather, the pathway to it. The work was commissioned because there is broad concern about adolescents in New Zealand, that it is clearly a complex problem, and that it is not clear what pathways should be followed to address 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

As a result it has been a political football with approaches to addressing the issues driven by political process and ideology: lock them up, they need discipline, there are cycles of poverty that must be addressed, it is about ethnic minorities, about drugs and alcohol, and so forth. In the meantime New Zealand celebrates the highest rate of teenage suicide, high rates of teenage morbidity and pregnancy and so forth, and perhaps twenty percent of young New Zealanders transit adolescence in a way that has long term effects on their lives.

The traditional route would have been for the political process to set up a committee or commission with multiple vested interests on it which would inevitably have produced a compromise report reflecting political, ideological or self-interest. But the Prime Minister asked me to consider how my Office would address it. I suggested the appropriate route was to establish a panel of academic experts and professionals, who would consider the published literature, interrogate the evidence and by summation provide the knowledge base on which subsequent policy formation might follow. I engaged academics from across the range of disciplines and invited them to join a task force with the following well enforced rules: it used only the peer reviewed scientific literature, and the discussion was refereed to be kept objective.

This was an attempt to have an unbiased and relatively value-free (and I will expand on this later) summary of the issues from a scientific perspective. On purpose it did not attempt to make specific recommendations. That is arguably not the purpose of scientific advice, except with respect to relatively uncomplicated issues concerning what I will call 'linear science'. Scientific advice provides base knowledge on which many other perspectives need to be overlaid – that should be the basis of policy formation. That report has been the subject of wide and positive comment and has changed the nature of the public and political debate, which is now moving to a different level of conversation.

This example represents an approach that my Office has promoted, arguing that in complex areas of policy formation an attempt at an unbiased analysis of the knowledge base is a better starting point. The challenge is then for the policy maker and the politician to use that knowledge in policy formation – a process I shall return to later in this talk.

This process arises from a discussion paper I prepared for the government entitled *Towards better use of evidence in policy formation*. I think the key role of a science advisor must be to enhance proper use of evidence by governments in making and then implementing policy. With the establishment of my Office I saw it as my key role to start the dialogue that might lead to an improvement in how knowledge is used in policy formation.

In the absence of a formal approach to evidence, the conflation of dogma, ideology and political pressure can lead to decisions on key matters in almost total isolation or even denial of knowledge. There is little doubt that this occurred in Britain around the first foot-and-mouth epidemic and in the BSE crisis, and it was the advocacy of Lord May, then Chief Scientist, and his successors that has led to considerable improvement and formulation of processes for ensuring scientific advice properly enters the decision process.

Obviously it is a long complex process, not without pitfalls, and it is neither easy nor sacrosanct. We only have to look across the Atlantic to see how science and policy formation can become separated, as reflected in the partisan approach to climate change which dominates in American politics even now.

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But we are getting ahead of ourselves. The way science is incorporated into policy is complex: there at least three questions that need to be asked:

- Should science and evidence-based knowledge have a privileged place in policy formation within a modern democracy?
- Does the changing nature of science affect the way in which science advice is provided?
- How then should science advice be incorporated into the policy and political framework?

The nature of policy formation in democratic societies is based on many inputs including fiscal considerations, societal values, prevailing public views, and the ideology and ambition of the government of the day. In social democracies, subject to staying within their ideological framework, governments generally want to make good decisions. But tension between short term electoral ambitions and desirable long term outcomes is inevitable and it is easy to get cynical about this, but that is the price of democracy. The maturity of the electorate, the impact of the media and the skill of political leaders all assist in setting the balance.

My view is clear – the use of high quality information and evidence should be at the core of good decision-making for good outcomes. Decisions made in the absence of scientific knowledge can only be made on the basis of either anecdotal experience or belief and dogma – they are the only other sources of knowledge.

Let me deal first with the problem of anecdote and experience. There is now a large body of commentary, much from economic philosophers and decision theorists like Daniel Kahnemann, that illustrates the problem of bias in decisions made on the basis of 'common sense' and points out the ways in which so-called common sense can be in conflict with evidence.

A well documented example is driver education for adolescents. It would appear intuitive that formal driving education within the school curriculum would reduce the high rate of road accidents that teenagers experience. In the 1980s there was much advocacy for such programmes from politicians, families of road victims and insurance companies. But when such programmes were introduced in Europe and the US at great cost, it became evident that these initiatives either had no beneficial effect on, or even actually increased, the accident rates of young people. This was confirmed when formal evaluation with controls was finally done.

The reason: it promotes earlier licensing (maturity being the key determinant of safety) and over-confidence. This negative view of such programmes was initially vehemently rejected by some advocacy groups, but the scientific view became compelling and has been integrated into policy. This is a classic example of why an evidence base is desirable even when what seems like 'obviously sensible' new programmes are introduced, and of why programmes should be introduced in a pilot fashion capable of evaluation. The assumption that formal driver education would be of value led to investment in programmes which did more harm than good.

Another emotive example – one that I suspect I will soon have to engage with – is that of health claims associated with alternative medicines and herbal-type products. Of course many evidence-based medicines are based on natural products (a good example is taxol used in cancer therapies) so anecdote can serve as the basis of initiating scientific enquiry.

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But as Tim Minchin states in his poem *Storm*:

> *"By definition", I begin*
> *"Alternative Medicine", I continue*
> *"Has either not been proved to work,*
> *Or been proved not to work.*
> *You know what they call alternative medicine*
> *That's been proved to work?*
> *Medicine".*

And as Michael Shermer recently put it in his column in *Scientific American*: "The problem with testimonials is that they do not constitute evidence in science". They do not meet that key element that makes something scientific – the process by which reliable knowledge is gained.

The key point is that decisions made in the absence of scientific underpinnings must be based on opinion, dogma and belief, and are likely to be less effective, less efficient, and can entrench policies which may be of little value or even harmful. Many would apply that description to the slow pace of the international political response to climate change. But in stating this unequivocal view I am making a very clear statement about the position of scientific knowledge and arguing that it has a privileged place in policy formation.

So what is science in the context of this talk? We are surely well beyond post-modernist argument and can accept that scientific knowledge is defined by the process about how knowledge is achieved; indeed it is the only process we have to build reliable knowledge about the natural and built world. The only other sources of knowledge are ultimately those of belief or dogma. This is an important if not essential point, for the particular authority of science is intimately associated with the particular nature of science.

I like a definition put forward by Jonathan Marks in his book *Why I Am Not a Scientist* (here I should point out that Jonathan is indeed a well published scientist and was a molecular and evolutionary biologist who later turned to social anthropology). His definition is "Science is the production of convincing knowledge in modern society".

It is worth parsing this definition:

Science is not passive – it is the product of a process. It requires an active process of observation by a primed observer and therefore the production of science is highly context specific.

Convincing – there is a social process beyond mere discovery or fact production. The fact has to become accepted in order for other scientists to incorporate and build upon it.

Modern society – while these words may seem controversial, I think it is now pretty well accepted that science as we know it now started with the ideas, values and social practices that arose in Europe and its colonies in the enlightenment, which 'separated' the natural world from the spiritual and moral worlds and moved from a Platonic to what we now might call a Baconian and Popperian approach: namely an iterative process of experiment or observation, hypothesis testing and reformation until knowledge considered to be reliable is developed. The key point is that science is not the facts themselves, 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.

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But even so, we must not posit that science-based knowledge is sufficient to make policy; a Platonic or technocratic society is not compatible with democratic ideals. Nor could I claim, despite the naïve claims of much of the scientific community, that science is value-free. But good information and evidence provides the essential base for a rational assessment of options, which must then be weighed up against those other criteria that politicians and their supporting policy advisors must consider. Indeed it is that balancing of inputs that is the basis of the political process.

There are perfectly valid other components to policy formation and these can lead to quite different outcomes. Those other components include societal values, public opinion, affordability and diplomatic considerations, and must also accommodate political processes. But these other considerations are primarily values-based and therefore I would strongly posit that scientifically derived knowledge sits within the policy framework in a different way to other claimed forms of knowledge. Indeed it means that it is inevitable that at times the decision-making process and science can be in conflict, but the reasons need to be transparent.

The week before I took up my role as Chief Science Advisor, a furore broke out in New Zealand over the issue of folate supplementation in bread. The science is pretty clear – folate supplementation reduces the incidence of neural tube defects. For various reasons this became controversial and an active programme was launched opposing it. It was a consequence of the new media conundrum we may have time to return to – the bias that can be created by the media desire for pseudo-balance so as to create controversy. I happen to be an expert in this area and I agree with including folate in bread. But I understand the delay the government agreed to – why? Unfortunately the debate had become so confused with misinformation that the public had lost confidence in the safety of folate-supplemented food.

The medical community had handled its communication very poorly, allowing this confusion. No government can easily or wisely allow its population to be uncertain as to the safety of the food supply. Here is an example where science advice has to take back-stage to overriding concerns; the proper response here is for the science community to do better in providing the evidence. A related challenge occurs when science clashes with popular belief and folk-wisdom – for an example, look at the public response in the UK to John Beddington's report on homeopathy.

Now to my second question which is central to our current world. Does the changing nature of science affect the way in which science advice is achieved?

We are in danger of underestimating how much the nature of science has changed; it used to be focused on linear questions, those aimed for reductionist precision. For example how much weight will this bridge take, are birds descended from dinosaurs, how old is the earth? As a result science was authoritative, definitive and largely accepted by a very different public. In general, science advice on such matters is issue-specific, linear, effectively value-free and can be provided by an expert to the relevant policy maker without an interlocutor. Such inputs happen every day in every political process and indeed reductionist science often falls into the trap of presenting all science in this way – this is clearly not the case.

Much science has undergone radical change, particularly as the biological, environmental and human sciences in their broadest definition have come to dominate. Science now increasingly deals with complex non-linear phenomena.

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In such complex systems certainty is not possible, there remain many unknowns, and answers are defined in terms of probabilities and levels of uncertainty. This is a shift that many scientists caught in the reductionist detail of one particular element of a system have failed to recognise. More importantly, most of the public and many policy makers have also failed to recognise it. And the problem this creates is obvious: uncertainty is not what scientists want to be the outcome of their work, and it is assuredly not what policy makers want to hear.

A good example is that of earthquakes and earthquake prediction. We still have enormous gaps in our knowledge of plate boundary earthquakes even though they have been the subjecty of intense study. But the Christchurch earthquake was even more complex in that it is not on a plate boundary and represents a much less studied form of earthquake. Yet the scientist wants to be able to assist the public and policy maker in knowing how the future will unfold. The consequences were a number of issues in public communication, such as how to explain an earthquake where many uncertainties abounded, and there was a tendency for the press to magnify scientific debate and uncertainty in a way that caused considerable confusion for public and politician.

A major task I had to undertake was to work with the scientific community to encourage them to simply their message and avoid academic debates conducted in the public media. At the same time, we had to explain how to use the knowledge and its uncertainties to the public and the policy maker. All this was made worse by the willingness of the media to promote the ideas of an astrologer that grossly increased public unease. It was an enormous challenge.

Much of biology and medicine is complex science – what will be the impact of introducing an exotic to a new ecological niche, what will be the impact of a new pharmacological class? But while these complex areas represent interdisciplinary science, and we are developing the tools to deal with them, much complex science has another dimension. It involves a strong values dimension. Typical examples include food security, the use of genetic modification, dealing with adolescence or the aging population and of course climate change. These are issues of high public concern and political complexity and indeed the very matters on which governments turn to science advisors.

Such science has been termed 'post-normal science' by Funtowicz and Ravetz and can be defined as the application of science to public issues where facts are uncertain, values in dispute, stakes high and decisions urgent. So by the very nature of these characteristics such science is now intimately linked to and intertwined with the values and concerns of the public and body politic.

Coincident with this shift from linear to complex to post-normal science has been greater public access to information of varying quality and reliability that has resulted in greater expectation by the public to be engaged in decisions involving science and technology. Effectively this is a shift from an authoritative position of science and scientists to one in which many other voices are also heard.

While many scientists deny it, values have always played a role in what and how scientists choose to study, in research ethics, in funding decisions. Of course the process of obtaining the results and interpreting any set of observations must be value-free – that is core to scientific integrity.

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But an additional values-laden factor now arises, as the philosopher of science Heather Douglas makes clear in her outstanding book *Science Policy and the Value Free Ideal*, and this is how much uncertainty is acceptable when using knowledge as the basis of an action or policy. Such decisions are never value-free. Here values do not compete with or replace evidence, but determine the importance of inevitable inductive gaps left by the evidence.

Thus the key question becomes: when is a particular body of scientific work adequately 'sound' to serve as the basis of policy? One must ask how much evidence is sufficient, how reliable are the studies underpinning the evidence? How much uncertainty is acceptable? And I would give particular attention to the question: what are the risks associated with an erroneous conclusion in either direction? These are the challenges with which governments and their advisors must deal.

Douglas goes on to be clear. "Only in the weighing of uncertainty do social and ethical values have a legitimate role to play when deciding, based on the available evidence, which empirical claims to make".

But this does not mean that the role of science as the authoritative body is generally questioned. What is questioned is which science is adequate for the job, or which scientific experts are to be believed by policy makers and the public. And here we need to consider the distinction between advocate and broker – a distinction I will return to, for this is at the basis of the trust question.

Thus as science plays a more authoritative role in public decision-making, its responsibility for the implications of inductive error in either direction – premature action or persistent inaction – increases.

Because of this intertwining of values with knowledge, a further complexity arises. Science can become the proxy for a values debate which is essentially independent of the science. Abortion is the classic example: in the 1980s, rather than having an open debate about what is solely a values issue about different perceptions of the status of the embryo and fetus, people like myself (I was originally a developmental physiologist) were being challenged to answer scientific questions about when 'life begins' – something that cannot be defined except in philosophical and moral terms.

The most current example of a proxy scientific debate is the pseudo debate about anthropogenic climate change. While there are real knowledge gaps, most of that debate is not really about the existence of climate change – rather it being used as a proxy for a values debate about economics and intergenerational equity. As scientists get drawn into such a debate, they can turn into advocates and risk loss of public trust. Complicating the matter, complex science is based on variable data and advocates for any one position may choose selectively from this to make a point. Then, because the media thrives off debate, giving equal time and pretending there is no agreed scientific consensus in the name of balance is in fact undermining the right of the public to have clarity as to what is known. The potential for values, beliefs and science to thus become conflated is almost inevitable and the public and policy debate becomes confused.

But to return to the key question in dealing with post-normal science. When is a particular body of scientific work adequately 'sound' to serve as the basis of policy even though a high level of uncertainty remains?

Douglas would argue that this must be linked to the question of what the risks associated with an erroneous conclusion in either direction are. But this question is more complex that it sounds because of the problem of the interpretation of the concept of risk.

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Let us look at anthropogenic climate change through this lens with the two counterfactual hypotheticals. If the scientific conclusion is that there is a significant risk to the human and planetary condition through global warming, and actions are taken and yet it turns out to be incorrect what has been the risk?

Clearly there has been a one-to-two percent effect on global GDP and many socioeconomic changes with a shift to a low carbon economy, changed employment etc, but there are collateral benefits in terms of moves to sustainable energy, new technologies, and less environmental degradation. If on the other hand the conclusion reached from the science was that no mitigation was needed because anthropogenic climate change was of minor significance, then the consequences of error if the conclusions turned out to be wrong would be so much higher – the human condition as we know it would be threatened. Clearly the outcome of which decision is taken is asymmetrical.

There remain values components to the matter which are not for the science advisor but for the politician and policy maker – how to balance intergenerational equity, although here the view might be influenced by advice as to the likelihood of successful mitigation by technology but again one suspects that argument is largely being used as an excuse to avoid decisions and for political confusion. The far more complex and real issue for the global community is how to avoid the tragedy of the commons.

But while this example seems straightforward, if one considers many other examples, for example genetically modified food, the problem is confounded by what risk means to different people and this is why understandings of the so-called precautionary principle are so confused. The interaction between science and technology on one hand, and society on the other, has its most acute interface in the issue of risk; and the lack of certainty in science and its capacity to generate unexpected results inevitably generates mistrust between scientist and society. The latter can easily generate suspicion.

This tension is codified in the precautionary principle. Despite popular misconception, this certainly does not mean doing nothing because the risk is uncertain or the knowledge is incomplete. Rather it is an approach to the management of risk in a situation of scientific uncertainty. It must not be confused with the prevention of risk; it does not require the demonstration of zero risk. Rather it promotes the concept of precautionary steps to evaluate the danger and search for the means to control it. Precaution designates an active, open, contingent and reversible approach which rests on a deepening of knowledge.

These concepts have critical implications for a person such as myself – they give rise to a decision-making dynamic that changes the relationship between science and politics. It moves away from the presumption that the time of knowledge precedes the time of decision and connects them in a to-and-fro movement that exists until uncertainty is removed, as we have seen in much of reproductive technologies.

So now let us turn to the third question: how should science advice interact with the body politic? I will focus primarily on the role of the science advisor which can be either an individual or a committee. Increasingly, governments are being persuaded on the value of truly independent science advice, but these agents only function well if they are just that – not conflated with end-user participation or getting caught up in the values game as has happened in some notable cases here. Advisors or advisory committees must not be advocates for anything other than the knowledge base, but must act as honest brokers.

In these matters of post-normal science the role of the science advisor as a communicator with both the policy maker and the public becomes critical.

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Science advisors must be explicit about the assumptions, limitations and uncertainties underlying the evidence, and present technological options in ways that allow the full range of their possible benefits or adverse effects to be appreciated. Remember no science advisor is expert in everything they must advise on; indeed that is not their role. They must act as a broker between the science community and the policy framework. It is how that brokerage is conducted that is itself a key issue.

Roger Pielke in his book *The Honest Broker* distinguished between two kinds of advice about complex science: that of being the issues advocate and that of being the honest broker. The former is what it sounds like – the advice is proffered with the scientist having the *a priori* goal of getting a specific outcome. Such advice is already conflated with the other matters that policy makers must deal with.

Issues advocates abound in science on either side of many complex debates – genetic modification is safe, genetic modification is not safe. This is a big issue in New Zealand where public opinion has put very tight restrictions on GM – not allowed in the food supply and effectively not allowed outside the laboratory.

The honest broker on the other hand takes another approach. The evidence is summarised is a values-free way, in so far as that can be achieved. This is what genetic modification means, this what we know and do not know about GM food from the perspective of human health, this is what we know about the impact of genetic modification on ecological systems, and so forth. Values perspectives of what is natural or organic or clean or green and so forth are not directly for the science advisor, although how science is communicated to the public will influence the public and political consensus reached at any point in time.

The science advisor must be honest in admitting the limits of knowledge but also be informative about the implications of what is known and unknown. This must include definition of the limits of knowledge and where biases could exist in evaluating and defining the range of options that arise from the analysis. At all times the advisor must be conscious of where values can enter into consideration and when they do not. In the end the key is to provide the scientific basis for options and provide the basis for the policy process to proceed. Well presented knowledge can allow the appropriate values debates then to reach a decision that has a coherent logic to it.

The science advisor must also acknowledge that many decisions that governments have to make are developed in an environment of limited available information or where the use of science is unable to resolve competing policy options. There can be a seductive trap of being drawn into matters where science cannot provide answers. The classic example is the US debate over stem cells which became a debate about perspectives on when life begins – not a matter open to scientific answer, at least in the framework in which that debate occurs. We must remember that science cannot be authoritarian and does not make policy, it informs policy making.

Advice must be phrased in such a way to give confidence and authority to the policy advisor without usurping their role. The science advisor must be honest about the values dimension and act as an 'honest broker' providing options.

It is how that is done that determines whether the advisor has the trust of the public and the policy maker. It requires skill from the advisor and a good understanding and integrity of bureaucrat and politician as well. But it must be achieved, for at the end, policy formed in the absence of knowledge or without considering relevant knowledge is simply dogma and cannot serve the public well.

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As a science advisor, clarity of communication is essential even when dealing with concepts of risk and probability. But this is occurring against the background of scientists being poorly trained to communicate, a public with variable scientific literacy, and a new range of media which is increasingly unfiltered and no longer takes on its traditional role of discerning reliable from non-reliable information.

Thus the nature of scientific advice has evolved – first from a ‘decisionist’ model in which politicians decide the goals and scientists provide the tools to achieve them, then to an authoritarian ‘technocratic’ model originating from the absolutism of mid-20th century science which we have discussed. Then, in turn, to a more complex model, termed by Millstone as ‘co-productionist’, in which it is accepted that there is an intertwining of science and technology in the way people live their lives, that for that reason they have a legitimate interest in science-based decisions, and that for policy makers science defines the boundaries of uncertainty within complex systems.

Consequently, scientific advice and policy formation now increasingly act in a more iterative way in which policy makers, expert advisors and society negotiate to set policy goals and regulatory decisions that are agreed to be scientifically justifiable (in terms, say, of the information available and the levels of future risk that are tolerable) as well as socially and politically acceptable.

Thank you.

ENDS

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