**OFFICE OF THE PRIME MINISTER'S SCIENCE ADVISORY COMMITTEE**

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

**Speech by Sir Peter Gluckman to the Centre for Educational Leadership at the University of Auckland**

***'First class schools: how the benefits of science can increase the effectiveness of schools'***

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Good afternoon.

What I want to do this afternoon is to make some remarks about the interconnections between schools, science and society. Clearly, New Zealand's progress to becoming a smart nation requires a scientifically literate population who have benefited from a good science education system. But insights from science – and here I use science in its broadest sense as the acquisition of organised knowledge in any discipline – can also help us to improve other aspects of our society, and in one particular example I want to discuss today the application of the scientific approach has the potential to improve the lives of our young people as they transition through the education system. But first let me talk about the nature of science itself.

Science and technology are at the heart of every major challenge we now face – both by contributing to causation but more importantly as part of dealing with those challenges by mitigation and adaptation. Those challenges include food security, water management, biosecurity, dealing with terrorism, dealing with urban conurbations, coping with mental health issues in an increasingly complex world, addressing issues of the internet and brain development, the potential for regenerative medicine, obesity and of course climate change. But the very nature of science has changed. Yes, traditional linear science still exists – we know that birds evolved from dinosaurs, that there are five not four species of kiwi, that stomach ulcers are caused by bacteria, not stress, and that AIDS is caused by a virus. These are all examples of traditional linear science which follows the Baconian approach of idea, experiment or observation, hypothesis testing and reformation until knowledge is developed.

One of the most important things that we 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 world, and in ourselves. But science is more than simply mathematical modelling or



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

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.

And scientific process is key to understanding the new form of science, which has been called by some post-modern science. I think it is a somewhat unfortunate term in its implications and I would prefer to simply call it the science of complex systems. Here the scientific method is being increasingly applied to complex non-linear interacting systems. This type of science almost never produces absolute answers; rather it serves to elucidate interactions and reduce uncertainties. Precision is not the outcome, rather an assessment of probabilities. And all those grand challenges I mentioned earlier are about complex systems, whether it is climate change or food security or obesity.

And there is another feature about these complex systems – they interact strongly 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 that question of when does life commence in a way that will bridge the inevitable divide between people with different value systems.

Look at recent scientific debates – where does the science end and where do values emerge as the key determinant? In a narrow sense GM foods are safe and food from cloned animals is clearly safe, although a different set of scientific issues surrounds the issues of ecological impacts of GM crops. But even if the ecological issues were robustly addressed, the values argument remains at least for New Zealanders dominant; science will not address that issue and scientists should not be arrogant enough to think that their view outweighs that of the community – it doesn't. The use of nuclear power in a world worried about carbon has similarities, so does matters relating to assisted reproduction, or tolerating tobacco at some level in our society, or dealing with adolescent behaviour, or dealing with climate change.

**Evidence in policy**

Let me now talk about the application of evidence derived from the scientific method to the policy decisions that must be made in our society. Recently I released a report on adolescence commissioned by Prime Minister John Key on the following premises: he sensed that there is major public concern about adolescents and young people in New Zealand, that it is clearly a complex problem, and that it is not clear what pathways should be followed to address it. Rather than follow the more traditional New Zealand route of setting up a committee with multiple vested interests on it which inevitably produces a report reflecting political, ideological or self-interests, he asked me to consider how my office would address it. I suggested that the appropriate route was to establish a panel of academic experts, not to come up with recommendations but to consider the published literature, interrogate the



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evidence, and by summation provide the basis for policy formation. This was the path that was followed.

The report is an attempt to have an unbiased and relatively values-free summary of the issues from a scientific perspective. It deliberately does not attempt to make specific recommendations – that is not the purpose of scientific advice, except with respect to relatively uncomplicated issues concerning what I called 'linear science'. In general my view of scientific advice is that it provides base knowledge on which other perspectives need to be overlaid as policy is formed.

This example represents a new approach by Government, recognising that in complex areas of policy formation an unbiased perspective in generating the knowledge base is desirable, if not essential. The way science is incorporated into policy is a more complex issue than meets the eye. It has three distinct elements:

- Do science and knowledge have a privileged place in policy formation?
- Does the changing nature of science affect the way in which science advice is provided?
- How should science advice be incorporated into the New Zealand policy and political framework?

Democratic societies make decisions and policy based on many inputs, including fiscal considerations, societal values, prevailing public views, and the ideals and vision of the government of the day. An underlying question is what kind of decisions do governments want to make. I think that all democratic governments, while staying within their ideological framework, want to make good decisions. My view is clear: the use of high-quality information and evidence should be at the base of such decision making.

Decisions made in the absence of informed background material are made on the basis of belief and dogma; they are less likely to be effective and efficient, and can entrench policies which may be of little value. Without evidence as to whether policies are working, governments can become constrained by earlier policy decisions that are not easily reversible because there may be a popular or political perception that they are effective when, in fact, they are not.

Again, to use an example from the adolescence report, the synthesis statement quotes from a recent OECD report about New Zealand saying, "New Zealand spends considerable amounts on single parent benefits which last until children are into their teens with the notion that this promotes child well-being. There is an international consensus that there is little to no evidence that these benefits positively influence child well-being." This is of course a reference to the DPB.



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Telephone: +64 9 923 1788 Facsimile: +64 9 373 7497
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This statement may well be correct. But it could also be wrong. Either way we just do not know within the New Zealand context whether this prolonged payment is of value to the child or not. The research has not been done. The programme was never set up to be evaluated and any decision to extend or contract it has to be belief-based. Given that, it becomes untouchable, because the default position of most people seems to be to assume that it does help, despite the OECD analysis suggesting otherwise.

Yet a policy that is expensive yet works would be better placed if the public saw unequivocal evidence that it worked and was value for money. Or, if the opposite was correct and there was unequivocal evidence that extending the payment for so long had negative effects, the public would be more supportive of a review of the policy. This is the problem – without knowledge we fall back on dogma, and rational decisions about scarce resources cannot be made.

But science and knowledge alone do not make for policy. There are other perfectly valid 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 they must also accommodate political processes.

Does the changing nature of science affect the way in which science advice is provided? The key question then 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? What are the risks associated with an erroneous conclusion in either direction? These are the challenges governments and their advisors must deal with.

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 goal of getting a specific outcome. Issues advocates abound in science on either side of many complex debates: genetic modification is safe, genetic modification is not safe.

The honest broker takes another approach. The evidence is summarised in a values-free way, insofar as that can be achieved. 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. It is how that is done that determines whether the advisor has the trust of the public and the policymaker. It requires skill from the advisor and a good understanding and integrity of bureaucrat and politician as well.

This is the focus of my discussion paper *Towards better use of evidence in policy formation*. My discussions in Wellington while developing this paper revealed that the use of evidence and its formal inclusion into the policy framework is very variable across ministries. Often,



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evidence is not considered in isolation as a base knowledge; it is considered from the outset in a values-conflated manner in that scientific advice is not sought independent of the end-user.

Further, few departments have a person with the brief to act as science advisor and whose role is to ensure the quality and independence of scientific advice. Yet overseas this is becoming an essential part of policy frameworks. Add to this the sad reality that unlike other public services we have very little or no rotation between the state sector, the private sector and universities, and even where there are scientifically qualified staff within departments they are remote from the actual progress within their disciplines. There is little quality control on departmental research. Frustration abounds at the dislocation between evidence and policy formation.

I make several suggestions in the report on how we might improve this situation. It is clear that there are deficits in how government obtains and uses knowledge and evidence and this must affect the quality of policy formation. My work has suggested a collection of relatively low-cost measures and an attitudinal shift that could, over time, advance the quality of policy advice, and thus assist the capacity of future governments to improve our national condition.

**Science and education**

So now let me turn to the question of science education. When I set out to consider the state of science education in New Zealand, I had to deal on one hand with comparative evidence that New Zealand science education is in pretty good shape, other than having an unacceptably large tail, yet on the other hand many people had what appeared to be rather vague and inconsistent descriptions of their perceived concerns. This variation in concern reflects the multiple and changing nature of science education, the changing position of science in the world, and the challenges of an increasingly complex world we face.

Before projecting the future needs in science education which was my primary intent, I felt I needed to first understand the issues at hand and determine whether any steps are needed to develop a more effective and appropriate system that helps to meet the ambitious vision we have for being a smart nation. So I planned this work in three phases taking more than a year. Firstly, in conjunction with the Royal Society of New Zealand and the Ministry of Research, Science and Technology (MoRST), I commissioned a background report from the New Zealand Council for Educational Research (NZCER). This report entitled *Inspired by Science* extensively evaluated the literature regarding science education in the primary and secondary school years. The report was iteratively reviewed between the NZCER and a project management team consisting of representatives of my Office and the Royal Society.

That report takes cognisance of the evolving understandings of the purposes of science education globally, the history of science education in New Zealand, and the pedagogical and practical issues surrounding improvements in the provision of science education. By its very nature it was briefed to look at where we are now.



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Following receipt of this report, I chaired an extensive consultation with the education community, including representatives of primary and secondary schools, the Ministry of Education, and science education experts from the tertiary sector and others with an interest in science education. This led to the development of a discussion paper entitled *Engaging young New Zealanders with science*. It takes the NZCER report and the additional information we received by way of consultation and feedback and suggests some practical ways ahead in enhancing science education in the short and intermediate term in primary and secondary schools within New Zealand. It creates some challenges which if accepted can be achieved with innovative leadership from schools and the Ministry.

My own report builds on these two important pieces of work and is intentionally intended to be more forward looking. It focuses on the challenges we might want to think about if we really want to lift our capacity to use the most important resource we have, our people, to make our way in a world where knowledge will be the most important resource we have. We cannot move ahead as a nation, advance our wealth, our health, our people and protect our environment without the more intensive use of science and technology. And in a vibrant democracy this means greater science literacy. The days of linear science have been largely replaced by the complexities of climate change, of environmental sustainability, urbanisation, new ways of communicating, food, water and energy security to name but a few where a vibrant democracy requires that science is not remote from any citizen, the days of a scientific patrimony have long past but the capacity of science to contribute to assist our society is rising rapidly.

So in my report I start from considering two basic roles for what are lumped together as science education. First is the traditional focus on what I call pre-professional science education which is the provision of formal science education for those whose later lives will directly use this knowledge – be it maths, biology, agricultural, environmental or physical sciences. This is what we do now particularly in the later years of schooling.

But it is important to note that science education is not just for those who see their careers involving science but is an essential component of core knowledge that every member of our society requires.

A further issue that has emerged has been the changed sources of information, largely through the internet, which has meant that increasingly the information available to citizens is of an unfiltered nature – it may come from a reliable or an unreliable source, but the reader may not have the skill to ascertain the difference. Accordingly, what is seen to be 'information' is not necessarily dependable or useful or even safe. Given that the internet is increasingly going to be the way in which people seek knowledge that affects their lives, providing the skills to distinguish reliable from unreliable information is an important part of modern education.



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Thus I see the need for a distinct kind of education to emerge not focused in the way of traditional discipline based science education but directed at what every citizen, irrespective of ambition and capabilities needs to know. This is likely not taught in the same way or the same framework as traditional discipline based secondary science education –we already do this at primary school but somewhere along the line it runs out too soon. Science literacy will be as important as numeracy and literacy itself for living in the 21st century. I call this type of science education *citizen focused education*.

First, Primary School Education.

Most primary school children are enthralled by the world around them. They have a spirit of enquiry and an enthusiasm for life that needs to be encouraged in every way. But most primary school teachers come from a background in the humanities and are ill-prepared for the increasingly complex questions about science that primary school children might throw at them. If teachers are not able to answer children's questions at primary school with confidence and enthusiasm, then children detect that lack of confidence and enthusiasm and that spirit of enquiry can be lost.

A well prepared primary school teacher will integrate excitement about the natural world and scientific forms of thinking into literacy and numeracy teaching, and into general educational processes. The challenge is how to provide primary school teachers with the skills to do so, given the background of most primary teachers is not one well anchored in the sciences. It seems to me that this is a particular issue for primary school educational training and there is a need to ensure that within every primary school there are resources and champions able to assist teachers less confident in providing that sense of scientific enquiry and scientific enthusiasm to young minds. I note that there are several proposals in development for in-service training to provide primary school teachers with such skills and the potential for regional approaches is obvious.

Second, Secondary Education.

As I have already stated, there are at least two distinct objectives of science education at secondary school – the first is that of pre-professional education which is traditionally for careers needing science, usually arranged around mathematics, physics, chemistry, biology and perhaps general science. Pre-professional science education itself will have to morph as the traditional boundaries of physics, chemistry and biology are changing – the scope of biology in particular has broadened enormously to include ecology, environmental sciences and molecular biology in addition to the traditional areas of botany and zoology. And in general the nature of science is changing from reductionist and linear to integrated and non-linear.

The biggest challenge is to ensure the relevance of knowledge and its application and ensuring access to scientific technology; not just ICT and the opportunities it creates, but access to the tools of science. Modern science technologies are often expensive, and yet to



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teach about a subject such as DNA without the student or the teacher having access to laboratories to demonstrate key points about DNA is in fact very inhibiting. And the rate of change in scientific technologies means that no school can cope. Yet science must be kept vibrant and current for it to enthuse our best students.

The second purpose is the citizen-focused need for all children as they mature to have a clear understanding of the complex world of science that they will confront as citizens over the next 60 years of their lives. Whether these two sets of objectives can be met with one pedagogical approach and one curriculum is uncertain. I suspect that over the next ten years we will see these two curricular purposes diverge and somewhat provocatively I consider that potential challenge in some detail.

A particular problem at secondary schools is recruiting and retaining well qualified science teachers. I suggest that changes in the way in which science education will evolve over the next decade offers opportunities for this to become a more personally rewarding career. The biggest problem a science teacher has is that no matter how well qualified they are when they leave university, given the pace of change in science – particularly in biological sciences – their capacity to maintain knowledge of relevance to what they need to teach is limited by time. What a biology graduate knew twenty years ago is of little relevance to the biology of this decade. If teaching does not occur within the realm of relevance then the pupil cannot be engaged and encouraged by it. Opportunity for significant on-going professional development in science as well as in education is essential.

These various challenges are at the heart of the need to develop a new form of secondary school science education. This will increasingly depend on both teachers and students having a closer relationship with the science community and I discuss innovative but practical and realistic ways this might be achieved.

There are many informal relationships in place. But these partnerships need assessment and from that stable arrangements need to be put in place – rather than continuing dependence on these informal associations which are disconnected from pedagogical assurance and the structured curriculum.

Lastly I briefly consider issues of equity. At the top end of the system, our science educators produce very fine students well prepared for tertiary education who we tend to be too ready to export, but as in other countries we have a long tail of children who do not get adequate exposure to science, who are turned off science and who do not have even the most basic of scientific literacy skills. Unfortunately this tail is disproportionately long in areas of socioeconomic disadvantage with high Māori and Pasifika populations. I discuss the challenges here.

The opportunities created by the new technologies of communication offer partial solutions to each of these challenges and we need to be lateral thinking in how we apply them.



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My report by its very nature is throwing down a challenge or a set of challenges – I am not a science educator – how these challenges are responded to is a matter for the education system. For the same reason you may note I make no specific recommendations. That should be no surprise. The role of a science advisor is primarily to proffer advice and stimulate discussion and suggest options. It is for policy makers to decide how best to use.

There are matters yet to be considered – what is the role of informal science education through museums, science centres etc; how do we address better the career opportunities in science and technology and improve the transition, what is the state of tertiary science education, how do we fill our capacities needs in core areas such as agricultural science, how to we persuade middle class New Zealand that our brightest graduates need not go offshore for undergraduate education; this increasing number is a real concern.

New Zealand must embrace science and technology and innovative thinking as a core strategy for its way ahead. I believe that by encouraging innovative thinking by educational policy makers, teachers and the science community, and by thinking more laterally about how science education might be conducted, we might move from what is an adequate but promising situation to one that could be outstanding.

The application of science to the issues of adolescence.

We have time so let us return to the *Adolescence* report. On purpose the report does not attempt to make specific recommendations. The key element in my mind is to provide a comprehensive summary of the evidence so that the public and policy maker can reach some decisions that need to be made and sustained over several electoral cycles if we are really to have impact on the very high rate of adolescent morbidity New Zealand faces.

In a few minutes I cannot do justice to a 308 page report. One dominant message comes through – that the failure to use social science evidence properly is a core failing that must be addressed. The funds being wasted on unproven and in some cases harmful programmes can be better used elsewhere. Too many programmes are started on the basis of advocacy and even if they can work at pilot level, they do not scale or the success factors enabling them to scale are not understood.

So what are some of the key messages?

Certainly New Zealand has an unacceptably high rate of adolescent morbidity although about 80% of our young people safely transition this phase without long-term consequences affecting the rest of their lives. Prolonged adolescence is a new phase in the life course, not seen until perhaps 50 years ago, reflecting the declining age of physical maturation, itself a reflection of better health, and a delayed age of acceptance as an adult for a mixture of biological and social reasons. Brain maturation is a long process and the period of adolescence is characterised by a phase in which risk taking behaviour is more likely due to immature impulse control systems.



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As such the young person is naturally more likely to engage in risk taking behaviours and alcohol and cannabis can put the young person at particular risk. The immature brain is far more likely to suffer long-term adverse effects of these toxins and society needs to develop strategies to reverse the increased use of these toxins by young people. Beyond that the changed social milieu of young people in a highly wired and connected society is having effects on the young person we still do not fully understand – the data on the impact of a more explicit media is not well understood. However what we cannot deny is the changed sexuality of young people is inevitable given their earlier sexual maturation.

Deficient self-control which is common in young people for biological reasons and is aggravated by social and developmental factors is at the heart of the problems many young people face and the behaviours they exhibit from bullying to binge drinking. The research shows that the best way of advancing self-control and protecting the young person in their transition to adulthood lies in focusing on the preschool years. Quality early childhood environments and education, targeted as appropriate to the most disadvantaged and with specific success criteria underpinning the programmes offered offer the best chance of reducing adolescent morbidity and economic analyses show the cost-benefit of doing so. Such approaches in general are more likely to be effective than remediation but where remediation is necessary the evidence suggests that punitive approaches are not effective – the report reviewed the more effective remediation approaches.

There is a gross under-recognition of depression in adolescents and this is an area requiring health professionals, teachers and parents to be more aware and better services to be available.

There is an extensive discussion of the need to find general solutions to the issues of adolescent morbidity but acknowledge the context many young Maori and Pasifika find themselves in puts them at particular risk. Accordingly while the issues are not ethnic specific the solutions must be context and culturally relevant to be likely to succeed.

The report does not pretend there is any magic bullet – there is none – rather it points out that a holistic approach taking a life course investment focusing on the earlier phase of development is likely over a decade or so to pay real dividends for our young people. There will always be a tension between targeted interventions and universalism and the data points to the benefit of both approaches – the policy issues of targeted interventions are complex but there can be no doubt that for young people in situations of disadvantage from early life, different levels of intervention can be shown to have long-term benefit and to be highly cost-effective.

What I have tried to do today is give you a flavour of some of the many dimensions by which science and the future citizen interact.



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Young people spend a significant portion of their life in the hands of teachers, from kindergarten, pre-school, through to university and therefore the future of New Zealand requires that scientific literacy is a key domain for all our children.

Thank you.

ENDS.



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