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Setting priorities for science

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Science has a broad range of meanings, although at heart it is a set of systematic processes for gaining knowledge of likely reliability about the world and beyond it. And so when one comes to a discussion of priority setting for science, one can look at it in different ways.

One can use a rather linear categorization from basic to applied to development – but that is descriptive rather than utilitarian and it can lead to misunderstandings. The presumption of linearity and pipelines has dominated in our funding system for 20 years and has led in the minds of some to expectations of specific outcomes from individual research projects that are unrealistic for either the funder or the provider and have in turn led to mutual cynicism.

Basic research may be understood by its practitioners, but what may be basic research for one discipline may have application in quite different areas. For example, in my own research what was basic research into developmental neuroendocrinology segued into very applied research related to protecting brain injury at birth. Indeed the danger of the linear model is just that – it is not how things work. As Julius Comroe and others have pointed out, much medical research has its application in an area remote from where it started. That is why a former president of the Royal Society of London, George Porter, once said there are only two kinds of research: applied and not yet applied.

Unfortunately the terms 'basic' and 'blue skies' research have in some minds been seen as implying they have no utilitarian value to society and thus are not essential – of course they do have much value, but the semantics is not always helpful. A more useful terminology might be discovery or frontier research, implying the finding of something new rather than building and applying knowledge, or perhaps we would be better just to talk about investigator-led research – a matter I shall return to. But perhaps we should focus more on another dimension – the quality of the research: after all it is the quality that ultimately determines its utility. As Dame Bridget Ogilvie said in receiving an honorary doctorate at the University of Auckland some years ago, "second rate research is a waste of money" – I would add that is the case whatever its perceived utility from cultural to economic.

As the Minister indicated last week in launching *Building Innovation*, which despite its name is an equally important document for "building science", we are about to launch a programme of reviewing science priorities. Why do we need to do this? Well, put simply no country can do everything and small countries need to be very clear about what they wish to prioritise their science investment on. That is one reason we are having a meeting of small

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advanced nations in Auckland in November. The initiative is designed so that we can see and learn from countries like Singapore and Israel how to use science better for national benefit.

And large countries and transnational bodies also prioritise – they do so when they allocate funds to different tools and agencies. The EU for example has stated very clearly what its priorities are under the Horizon 2020 document. It sees three major domains:

- firstly, excellent science (which includes frontier research, promoting collaborative research, and developing infrastructure and scientific capability)
- secondly, building competitive industry
- and thirdly, challenges for a better society (in which work will be grouped in six themes – health, food, energy, transport, climate-related and 'building an inclusive society').

It is a useful categorisation and one that has many advantages. But the Europeans start from a platform where the political understanding and the commitment to research has been long-standing. Some years ago the EU set the goal of EU countries having 1% of GDP invested in public science and 2% from the private sector, and a number of countries, especially the Nordics, are approaching it.

New Zealand has been for decades slow to embrace a science-based growth strategy, but in the last few years that has started to change – I think there has been a real inflection point, and the nature of the discussion is now very different. It is worth asking why we have been so slow to grasp the need to invest more in science as that might help to understand the discussions that are needed as we move to setting priorities.

Firstly, we are young but that is no excuse – so are Israel and Singapore.

Secondly, as a country we still do not value intellectual discourse or quality discussion – look at the conversation or lack of it around the decisions on GM a decade ago – it was almost entirely based on rhetoric and emotion rather than on ensuring the technology was first understood by the public who have the right to understand and join in the discourse – that is then their right to determine the limits of use of any technology but they have the right to be informed by facts not polemic.

Thirdly, we have used science a lot in recent decades but we do not tell the story well – look at our agricultural economy, which is entirely dependent on public science – not just in the obvious way of dairy science but in areas such as biosecurity, water and soil science.

Fourthly, we have been too lucky – over the last 50 years we have had an easy economy based on food and tourism. We have not had the existentialistic threats that have faced many other countries. We are only now waking up to the reality that the world owes us nothing and if we want the standards of living, social cohesion and quality of environment we need economic growth. To ignore economic growth as an essential part of the solution is unrealistic in a world of growing demand and expectations.

New Zealand faces many challenges, but perhaps the biggest is how does one balance resource conservation and environmental protection versus resource use and economic growth. Two important questions follow: What trade-offs are inevitably involved in these decisions, and how do we choose which technologies to use to best effect and when should

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we limit their use? As I pointed out in my report on the Transit of Venus, every decision involves trade-offs and while some find that concept uncomfortable that is the reality of everything in our lives – both individual and collective – what we spend on our own families has trade-offs for what we might donate to a good cause.

Some might argue we can ignore growth in this equation, but that is utopian – sustaining 40% more people on the planet, many of whom quite rightly expect far better standards of living, will involve more energy, more food, more medical care and more resource use generally. There is no getting away from this even when we look at New Zealand in isolation. It too has populations needing more and many with ambitions and aspirations for more. So how do fulfil what is needed while protecting an increasingly compromised planet?

The simple reality is that everything we do involves trade-offs. Trade-offs are often portrayed as binary – more of this means less of that. Actually it is much more nuanced with all kinds of interactions and feed-backs. A more sophisticated discussion is needed: science and technology are essential in informing the appropriate solutions.

But to take the best from science, we need to consider how can we move from a rather limited public understanding of new technologies where there is often accidental or even intentional confusion between science and politics, values and philosophies. In what ways can knowledge have a much stronger role to play in our society? We also have a tendency to confuse the technology itself with its application. It is generally the latter than needs to be controlled by society but we have tended to focus on the former and thus we may at times find ourselves boxed into corners we need not be in.

There are few challenges that we will face over coming decades that will not depend on science. And this does not just mean research in the laboratory or field setting, science must be owned by society as it has a critical role to play in the essential public dialogue on these matters.

But at the interface of all these decisions involving trade-offs is a complex interaction that is reflected in part by the concept of risk. Risk means different things to different people – scientists may talk in mathematical probabilities, politicians think of risk in an electoral sense, the public generally see risk through 'system one' thinking, to use the decision theorist terms i.e. that which is instinctive and emotional. For most perceptions of risk are biased by who benefits. We have different attitudes to risk if we think we can benefit, rather than if we think someone else benefits. Too often our debates have been superficial, dogmatic and ill-informed – often emotion prevails without knowledge or consideration of the trade-offs. Again science will encourage a more informed conversation.

This may seem like a lengthy diversion but I have done so because I think central to any discussion of science priorities, especially publicly funded science priorities, is a need for understanding of the many ways science intersects with society. So now let me turn to how I see research priorities.

I think it is useful to think about what is investigator-led and what is determined by the objectives of the research, which we can call mission-led. This dichotomy both informs what kind of research we should fund and the tools used to fund it.

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In terms of investigator-led research, most of which occurs within universities and to some extent in CRIs, we can see research for its cultural value and its capacity value. We should not underestimate the importance of research in the sense of creating a society that values knowledge for its own sake, for understanding our world and who we are.

A good example is a paper published last week in *Science* by a team of psychologists, linguists, evolutionary biologists and computational scientists from the University of Auckland. It puts forward the evidence that the proto-language for English arose in Anatolia, now in Turkey. The paper highlights the value of interdisciplinary research – here we have computational methods developed for molecular and evolutionary biology being applied to a very different question – where does our language come from. And congratulations to Quentin Atkinson and his colleagues for creating a website to make the work accessible to all - I wish many more scientists would do so. I think we are going to have to improve the quality of science communication drastically if the public is going to understand why discovery science is so important.

I will not focus on capacity – that is, investing in science education, science training, supporting a broad base of academic enquiry and having the appropriate infrastructure – for that would seem obvious. There is however one point, perhaps controversial in the minds of some, that must be made and that is over the need to be realistic over making early decisions about who has the capacity to be a research leader and invest in them properly. Not every science graduate need to do a PhD, not every PhD need do a postdoc and not every postdoc will become a research leader.

With the massive expansion of tertiary education and the need for science and engineering graduates across the economy this is an important issue to understand. Far more people will have the ambition to be a research leader or a research active academic than society can absorb. Thus, fair and appropriate career development may need to focus more on how we identify early those who should be invested in to be research leaders and we should invest well in these. International experience shows that investing early in the best talent and building teams around them produces a disproportionate return judged by any criteria. We have moved away from such a focus over the last 30 years with our greater emphasis on the project not the person. The project-based funding of CRIs until two years ago did not support career development – hopefully the new model will. Our contestable funding system focuses on the project not the person and careers cannot be built around that.

But I would make one other point about frontier science. In a technological age, productivity growth based on a number of strands can occur through knowledge absorption from elsewhere or by local cutting-edge innovation. Experience has shown that as countries get closer to global knowledge frontiers, it is the local cutting-edge science that matters more for growth. While knowledge absorption promotes growth in low GDP countries, in high-income countries to be competitive there must be a focus on frontier innovation. This is true even for a country like New Zealand and we should prioritise accordingly.

There is one other generic point I would make – and that is about multidisciplinary research. One of the key points that emerged from the discussions at the Transit of Venus forum was concern over the fragmentation of the science system, driven by funding models in both science and academia that limit interdisciplinary research.

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For it is from such research that so many new and innovative ideas emerge, and this should be a competitive advantage for a small country. The Centres of Research Excellence show what can be done if models that get away from a disciplinary or institutional focus emerge. Again this experience will inform how we think about national science challenges.

So, to get beyond the question of frontier research and consider other domains of research, what we might call mission-led or utilitarian research, I will use a somewhat different taxonomy – one that I think the public, officialdom and the government can understand.

I see the utilitarian side of research having a number of distinct purposes. I will list them rapidly and then go back over them with some explanation:

- Research for understanding our identity
- Research for defensive purposes
- Research for resource management
- Research for effective government expenditure and to support policy
- Research for diplomatic reasons, and
- Research for direct economic growth.

Broadly, we need research that enhances our national identity, be it to understand our peoples and their history, or our indigenous flora and fauna, or our environment. I do not think this needs to be expanded on beyond stating that it is a fundamental cultural need to understand who we are, what we are, where we are, where do we come from and where are we going?

Governments have the primary role of defending us, and science is essential in that battle. I am not talking about our military needs, I am talking about biosecurity, public health, some social science research, natural hazards and related areas. Without biosecurity research we would not have a viable agricultural economy – it simply is not understood how vulnerable we are and PSA is minor compared to anything that might affect four critical species – ryegrass, clover, cows and sheep. All of you understand foot and mouth disease. The two forage species are very vulnerable to weevils and the like and we rely on imported parasitoids to keep them under control – an exceptional bit of research from AgResearch. Similarly, public health research and much social science research is essential to protect the human species. And need I say anything about GNS and the other groups involved in natural hazards research or the associated engineering community – we have learnt how important they are.

We need research to understand and best manage our natural resources for both economic and conservation reasons. We have a vast offshore estate and we need to understand it to manage it, use it and conserve it. I have already talked about the need to use science to understand the trade-offs to inform decisions about how and when we can extract resources or use technologies and when we should be limiting them. This was the subject of an extensive speech last week and I refer you to my website as it is a subject that needs considerable expansion to do it justice.

Conservation science is complex and can lead to important but not necessarily intuitive decisions. Again we come back to the issue of trade-offs. At a high level, think about some of the trade-off decisions that might face us. Genetic modification has a difficult history in this country, but could we accept genetic modification approaches that would enable

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nationwide eradication of possums or a solution to the problem of kauri dieback? I do not know how we would handle that hypothetical.

Let me drill down a bit on conservation research. Many decisions made about conservation are somewhat arbitrary – a line on a map is drawn and that defines a reserve. But there is in fact a large body of science that can be brought to bear in shaping such decisions. Has an ecosystem been preserved? Is there sufficient biodiversity and population density to be able to handle environmental change? Are buffer zones needed? How do we exclude pests and diseases from designated areas? These are real issues with real solutions based on science.
Ultimately the primary discussion at any level, from global to local, will be about the balance between resource conservation and resource exploitation, using these terms in the broadest sense. A mature conversation will depend on a solid evidential base which only unbiased science can provide, whereas the weighting of paths and priorities leading to decisions must be based on values that the whole community must own.

The next category in my research taxonomy is research that supports decisions about government expenditure and policy development. This has been an area to which I have been giving focus. A significant part of my role is trying to promote the use of evidence appropriately in policy formation. I have spoken at length about this previously and I do not have the time to go into it in detail. Suffice to say policy is largely and appropriately a values-driven set of decisions about trade-offs between fiscal, public and political views, but policy made in isolation from the understandings science delivers is more likely to be based on dogma and belief and be less effective.

We still introduce too many programmes without piloting or evaluation. We still conflate scientific evidence with other inputs, seemingly believing that science is no different from opinion, whereas good science should be values-free and should provide the knowledge on which values are appropriately overlaid. In this regard, I am pleased that last week the Ministry of Primary Industries announced the appointment of a departmental science advisor, with terms of reference similar to mine, to add rigor and quality to a Ministry that depends on science. Equally, I am excited by the Bill currently going through the House to establish, in association with the Families Commission, a Social Policy Evaluation and Research Unit. Both initiatives reflect suggestions made in my report to the Prime Minister two years ago.

New Zealand is a small country that has a real challenge to maintain its relevance to the world. Increasingly we recognise that science and diplomacy are intertwined in multiple ways – whether it be in promoting international research for collective benefit such as in the New Zealand-led Global Research Alliance to reduce greenhouse gas emissions from agriculture, or for bilateral purposes as highlighted in some “NZ Inc” strategies. Science is also important in protecting our national interests, be it in Antarctic research, in research associated with and part of foreign aid, or in supporting phyto-sanitary agreements associated with trade.

And that brings me to the category we all understand and we are understandably giving focus to – science for directly driving innovation and economic growth. The science system and the innovation system are not the same, but clearly science-based innovation is a critical and indeed increasingly central part of economic strategy. We have seen other advanced small nations use science very effectively to drive innovation and we have seen this government focus on this strategy and commit to it.

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The challenges implicit in this strategy – how to get science from the public sector to the private sector, how to encourage business to make their own investment, how to build the quantum of private sector research – have been the subject of an enormous amount of commentary. I would only make one point that often gets forgotten – incentivising small companies is not the same as incentivizing large companies, and we are a country of very small companies.

We really need to ask two questions about science for economic growth. First, what science do we do now that drives economic growth and how should we capitalise this better? And second, what is it we are not doing or, at least, not doing enough of, that provides competitive advantage? There is a third question that is now emerging, what do we do to bring multinationals back to New Zealand to do their research? It is clear that an innovation ecosystem is healthier if such companies are present to create a nidus around which local companies thrive.

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

Thank you.

-ENDS-

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