workingpaper

Exploring Long-term Policy Drivers in Science: A scan of international think tanks

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About the Author

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1. Purpose

The purpose of this working paper is to gain an international perspective on the future of science policy, through the eyes of a small sample of international think tanks. There is an underlying assumption that as think tanks select their own agendas, they will be drawn to the new challenges facing society. What they do and what they think is therefore likely to provide an indication of emerging issues that may shape the future of the world. This working paper looks specifically at issues that relate directly to science, since it is designed to contribute to *Project 2058's* Report 9, *Government-funded Science Under the Microscope* (SFI, in press).

The strategic aim of *Project 2058* is to promote integrated long-term thinking, leadership and capacity-building so that New Zealand can effectively seek and create opportunities, and explore and manage risks, over the next 50 years. In order to achieve this aim, the *Project 2058* team will work to:

1. Develop a detailed understanding of the current national planning landscape, and in particular the government's ability to deliver long-term strategic thinking;
2. Develop a good working relationship with all parties that are working for and thinking about the 'long-term view';
3. Recognise the goals of iwi and hapū, and acknowledge te Tiriti o Waitangi;
4. Assess key aspects of New Zealand's society, asset base and economy in order to understand how they may shape the country's long-term future, such as government-funded science, natural and human-generated resources, the state sector and infrastructure;
5. Develop a set of four scenarios to explore and map possible futures;
6. Identify and analyse both New Zealand's future strengths and weaknesses, and potential international opportunities and threats;
7. Develop and describe a desirable sustainable future in detail, and
8. Prepare a *Project 2058* National Sustainable Development Strategy.

(SFI, 2009: 3)

Project 2058's eighth report, *Government-funded Science Under the Microscope* (SFI, in press), is a direct response to the fourth point above: 'Assess key aspects of New Zealand's society, asset base and economy in order to understand how they may shape the country's long-term future, such as government-funded science, natural and human-generated resources, the state sector and infrastructure'. This working paper aims to provide a useful tool to inform Report 9.

2. Methodology

The methodology underlying this working paper is informed by that of Report 9, *Government-funded Science Under the Microscope* (SFI, in press), which is itself informed by the wider methodological framework of *Project 2058* (see SFI, 2009).

In this paper, we are not attempting to provide a rigorous or comprehensive review of all available thought in this area; rather we are trying to compile a snapshot of current thinking on the future of science, by studying relevant insights from the nine think tanks. Our exploration is illustrative rather than exhaustive, and is intended as a resource for guiding future discussion and research. Sustainable Future does not have the resources or mandate to conduct a wide discussion on all current international perspectives; therefore we have used a small sample of think tanks and selected what we believe to be their most relevant publications. This will continue the dialogue and generate further discussion of what the future of science and science policy could look like.

Definition of a Think Tank

The United Nations Development Programme (UNDP) defines a think tank as 'a civil society institution, which is funded by private resources and is organised for intensive research and solving of problems, especially in the areas of social and economic policy and technology' (UNDP, n.d.). We agree with this definition, which is aligned with our understanding of what a think tank is and how it operates. However, in the interests of advancing our purpose, we have decided to broaden this understanding and not restrict ourselves to the classical definition. We believe there are like-minded organisations and programmes which offer equally valuable insights without necessarily operating along these lines, and we are interested in their contributions. Therefore we have included the United Nations Environment Programme (UNEP), and the World Future Society.

Selection of the Think Tanks

In order to complete an overview of international perspectives we have reviewed the relevant publications of nine think tanks. We are aware that there are a multitude of future-focused think tanks around the world, all of whose work and research is relevant and could have contributed to our purpose. To narrow the field down, we selected these nine think tanks on the basis of their reputations for innovative thinking and geographical spread. They all provide accessible and provocative ideas on the state of science in the future, and do so in ways that relate to their objectives and areas of focus. The think tanks selected for assessment in this working paper are Brookings Institution (USA), the Centre for Independent Studies (Australia), Chatham House (United Kingdom), Civic Exchange (Hong Kong), DEMOS (United Kingdom), The Millennium Project (USA), United Nations Environment Programme (UNEP), the Urban Institute (USA) and the World Future Society (USA).

Scanning for Insights

The concept of scanning, as discussed by Hines and Bishop (2006), involves the process of actively examining the landscape to identify trends and useful information regarding a specific issue. The objective of scanning for our purposes is to propose possibilities on both the most likely future and specific inputs that could lead to unlikely futures (ibid.: 55). Importantly, scanning can only take place once specific parameters encompassing a particular issue have been assigned. For this working paper, our scan involved publications from nine innovative think tanks during the period from January 2007 to December 2009. The process included assessing publications, identifying relevant information and trends, then systematically revisiting ideas in search of insights that might have slipped under the radar.

Organising Think Tank Ideas

Section 3 highlights ideas on the future of science that have been explored by each think tank. By narrowing our focus to include only publications and projects from January 2007 to December 2009 we aimed to ensure the relevance and timeliness of these ideas. From this selection, excerpts were taken that were relevant, timely, succinct and original.

Method

Three steps were undertaken in the process of formulating this working paper:

1. Scan of publications: sources were gathered from the Sustainable Future Institute library and an extensive literature review of material available on the internet was undertaken.
2. Compilation: ideas relating to the future of science which stood out as provocative, recurrent, and of high impact were then compiled into relevant insights. These ideas are outlined in Section 3, along with the mission statements of the nine think tanks.
3. Summary and conclusion: 24 common themes were identified, and from these, four policy drivers were generated. The common themes and policy drivers related to science foresight are summarised in Table 1, with conclusions drawn in Section 5.

We plan to use these conclusions in Report 9 to help identify the challenges that the government-funded science system in New Zealand will face in the future. These conclusions will also help to identify shortfalls in New Zealand's science policy and therefore highlight improvements that could be made to the current system.

Limitations

There are at least three limitations to this paper:

1. We have used a small sample size.
2. There may be room for error in our information collection. We are aware that, given the constraints on our time and resources, the reasonably fluid collection method that we have used is not watertight. We accept that valuable insights may have been omitted from this report as a result of the focus on the particular think tanks we have selected, and consequently the publications that were and were not scanned.

3. The possibility of bias in filtering those insights that were deemed important. There is also bias in the think tank selection. For the most part, the nine think tanks that have been reviewed are well known, Western organisations that receive wide media coverage and generous funding. In including only those organisations of which we were aware, it is likely that we may have missed valuable insights from cultures outside our Western sphere.

However, these limitations do not inhibit the intention of this working paper in any way. We still envisage that we have gathered enough useful and interesting information to inform our thought processes in Report 9.

In our analysis, we have reviewed the material and made broad generalisations and statements, so as to identify recurrent themes on the future of science across the think tanks. The interpretations made by Sustainable Future are intended as discussion points of interest, as opposed to the think tanks' principle points of view.

In the following section the mission statements of each of the nine think tanks are stated, then we have outlined a selection of their relevant insights on the future of science. In Section 4 these themes are collated into four policy drivers, in order to inform Report 9.

3. Think Tanks Reviewed

3.1 Brookings Institution (USA)

Based in Washington DC, the Brookings Institution is a not-for-profit think tank, whose mission is to:

> Conduct high quality, independent research and, based on that research, to provide innovative, practical recommendations that advance three broad goals:
>
> (1) Strengthen American democracy,
>
> (2) Foster the economic and social welfare, security and opportunity of all Americans, and
>
> (3) Secure a more safe, prosperous and cooperative international system.
>
> (Brookings Institution, 2009)

Publications Reviewed:

Opportunity 08 (O'Hanlon, 2007); *Wired for War* (Singer, 2009).

Michael O'Hanlon is a director of research and a senior fellow in foreign policy at the Brookings Institution. Peter W. Singer is the director of the 21st Century Defence Initiative and also a senior fellow in foreign policy at the Brookings Institution.

Relevant insights:

1. War correspondent Noah Schahtman notes, 'In both war and police actions you will see more and more of robots in all shapes and sizes … There is a huge growth curve with no signs of slowing down … there is zero chance of this field not increasing exponentially' (Singer, 2009: 110). (a, f)[1]
2. Already we are using robots in warfare for numerous battlefield roles. In 2009 the Pentagon's Joint Robotics programme was developing 22 different types of intelligent ground vehicle (ibid.). (a, b)
3. Robotics is changing the nature of warfare as we know it. The increasing use of unmanned systems will 'unleash a hurricane of political, legal and ethical problems' (ibid.: 203). 'In making war less human we also make it less humane' (ibid.: 433). (a, c)
4. This new military technology is being used without a clear doctrine or strategy by America (ibid.: 210). (a, c)
5. Innovative health reform could be achieved much more quickly if the government were more involved. In America there is currently little public funding of medical and regulatory research sectors. If it were increased, not only would innovation improve but so too would the diffusion rate of new drugs into the market (O'Hanlon, 2007: 312). (n, q, u)
6. Policies to improve and foster research and development in the United States should include the recruitment of many more maths and science teachers yearly, an aim to double engineering graduates and the doubling of government funding for fundamental natural and physical science research (O'Hanlon, 2007: 343). (p, q, m)
7. 'We are only at the beginning of the internet era, the biggest impact and the most groundbreaking innovations are yet to come' (O'Hanlon, 2007: 349). (b)

3.2 Centre for Independent Studies (CIS) (Australia)

The Centre for Independent Studies describes itself as Australasia's leading public policy research institute. The Centre aims to promote:

1. Individual liberty and choice
2. An economy based on free markets
3. Democratic government under the rule of law
4. An autonomous and free civil society. (CIS, 2009)

Publications reviewed:

With No Place to Go: The Federal Government's ill-conceived support for the Australian car industry (Hartwich, 2009); *The Bipolar Pacific* (Hughes & Sodhi, 2008); *China's Insecurity and Search for Power* (Lee, 2008).

Dr Oliver Marc Hartwich is a research fellow with the CIS' economics programme. Professor Helen Hughes is Professor Emeritus at the Australian National University and a senior fellow at the CIS, and Gaurav Sodhi is an adjunct scholar working in the economic and foreign policy area. John Lee is a foreign policy research fellow at the CIS and managing director of L21, a separate research and conference management firm.

[1] The letters in brackets in Section 3 correspond to the common themes in Section 4; note that some of the relevant insights can be grouped according to more than one of these common themes.

Relevant insights:

1. 'The technology of health care is going to be revolutionized in the next forty years, and many of the ailments that plague the elderly today will be treatable in the future' (Sammut, 2007: vii). (b, u)
2. 'Mobile phones have become extremely successful in developing countries as a way of connecting farmers to markets and providing communication infrastructure to transport and other services' (Sodhi, 2008: 1). This highlights the benefits and need to encourage diffusion of new technology through developing countries. (a, b, h, t)
3. It is generally agreed that climate change can be addressed through decreasing greenhouse gas emissions. This comes through transitioning to technologies which emit less greenhouse gas. Therefore, 'the goal of climate change policy should be to speed up the transition to new, "cleaner" technology' (Humphreys & Malpass, 2009: 3). (s)

3.3 Chatham House (UK)

Chatham House, which was founded in England in 1920, outlines its mission as:

> To be a world-leading source of independent analysis, informed debate and influential ideas on how to build a prosperous and secure world for all.
>
> (Chatham House, 2009)

Chatham House structures its research around three central areas:

1. Energy, environment and resource governance;
2. International economics, and
3. Regional and security studies.

Publications reviewed:

Who Owns our Carbon Future? Intellectual Property and Energy Technology (Lee et al., 2009); *Ending Dependence: Hard Choice for Oil Exporting States* (Mitchell & Stevens, 2008).

Bernice Lee is the research director of the energy, environment and resources governance division at Chatham House; her co-authors of *Who Owns our Carbon Future?* are associate fellow Ilian Ilieve and research fellow Felix Preston, from the same division. John V. Mitchell is an associate fellow in the energy, environment and development programme at Chatham House, and Professor Paul Stevens is a senior research fellow.

Relevant insights:

1. Hydrocarbon economies need to transition to non-hydrocarbon economies, meaning business-as-usual policies cannot continue. Policies need to focus on expanding oil reserves through exploration and technology. Research and technology is needed in order for oil-exporting countries (such as Angola, Algeria and Iran) to diversify (Mitchell & Stevens, 2008: 35). (n, x)
2. Research and technology need to be used to slow the growth of domestic energy consumption (ibid.). (x)
3. We need to decarbonise our economies. Yet there is a mismatch between the time taken for technological systems to evolve (shown historically) and the urgency needed to solve the global challenges posed by climate change and peak oil. Global technology diffusion times need to be halved, but this will only come with greater global cooperation. Analysis shows that innovation in the energy sector has usually taken two to three decades to reach the marketplace (Lee et al., 2009: vii). (m, s, w)

4. The US, Germany and Japan are clear leaders in energy innovation. Corporations and institutions are leading the way for the future of science and will continue to do so. This will affect the role governments play in science (Lee et al., 2009: viii). (n)
5. Climate policies must offer incentives to encourage the important technological companies to innovate. This could potentially be through a range of climate technology prizes to promote both adaptation and mitigation (Lee et al., 2009: x). (n, r, s)
6. 'By adopting advanced technologies and strengthening their innovation capabilities, developing countries have an opportunity to leap-frog the resource-intensive, highly polluting growth phase experienced by western countries, but they will need a great deal of help to do so' (Lee et al., 2009: vii–ix). (t)
7. 'China is in a unique position to bring new, clean-energy technologies to maturity because of the size of its domestic market and its position as a supplier of consumer and industrial goods to international markets' (ibid.). (k)

3.4 Civic Exchange (Hong Kong)

Civic Exchange was founded in Hong Kong in 2000. It is a public-policy think tank whose mission is to:

> 1. Promote civic education amongst members of the community and for such purpose to conduct research and publicize the results so as to provide objective and balanced information to the public concerning economic, social and environmental issues; and
> 2. Undertake research on development of economic, social and political policies and practices to help shape the breadth and depth of public policy debate and so to provide well-founded and reasoned argument on the issues identified above. (Civic Exchange, 2009)

Its publications and projects address three central areas:

1. Civic participation and social development;
2. Environment and conservation, and
3. Integration of economic analysis.

Publications reviewed:

Emissions Trading: Hot air or for real? (Civic Exchange, 2007); *Summary of Key Findings: Hong Kong's silent epidemic. Public opinion survey on air pollution, environment and public health* (Civic Exchange, 2008); *Analysis of the Post-2008 Scheme of Control* (Civic Exchange & WWF, 2008); *Climate Change Negotiations: An Asian stir-fry of options* (Loh et al., 2008); *Appliance of Science* (Loh, 2008).

Christine Loh is the chief executive officer of Civic Exchange

Relevant insights:

1. The people of Hong Kong are significantly worried about high levels of pollution in their city, among a host of other environmental issues, yet feel their voices and opinions are not being heard or addressed. There is an immediate need for Research Science and Technology (RS&T) to be reintegrated with civil society in addressing issues such as these and for transparency with science-based policy (Civic Exchange, 2008: 3). (j, l, o)

2. 'Hong Kong faces another decade of a regulatory system which will inhibit the introduction and spread of new technologies and energy management techniques …' (Civic Exchange & WWF, 2008: 3); instead, the current trend of sizeable infrastructure projects will continue (ibid.). (n, m)
3. The importance of government transparency must not be underestimated with regard to RS&T-focused policies such as those which address climate change or the energy crisis (Civic Exchange, 2007). (n, m)
4. Advancing technology is a critical component of decoupling development from carbon emissions. Currently there is a school of thought that developing countries should be allowed to follow their development goals. To ensure that technology diffuses quickly it is important that global technology cooperation between developed and developing countries is promoted. Ideas for this include research partnerships, global technological standards and development funding. For this cooperation to progress, intellectual property concerns must be addressed (Loh et al., 2008: 26). (h, t, w)

3.5 DEMOS (UK)

DEMOS is a UK-based think tank centred on the themes of power and politics. On its website it states:

> We search for and communicate ideas to give people more power to shape their own lives. DEMOS' vision is a democracy of free citizens, with an equal stake in society.
>
> (DEMOS, 2009)

Publications reviewed:

Knowledge Nomads: Why science needs migration (Day & Stilgoe, 2009); *The Atlas of Ideas: How Asian innovation can benefit us all* (Leadbeater & Wilsdon, 2007); *Citizen Scientists: Reconnecting science with civil society* (Stilgoe, 2009).

Natalie Day and Jack Stilgoe are senior researchers in the science and technology field. Natalie Day is also project manager for the Atlas of Ideas, a project assessing innovation around the world. Charles Leadbeater is an authority on innovation and creativity. James Wilsdon worked at DEMOS as head of science and innovation until 2008, when he took up the position of director of the Science Policy Centre at the Royal Society.

Relevant insights:

1. The rise of China, India and South Korea will remake innovation. Rather than emerging, these countries are re-emerging, which means they are likely to blend old with new rather than focus on the distinctly modern (Leadbeater & Wilsdon, 2007: 5). (k, m)
2. These Asian superpowers are approaching RS&T differently: at the end of 2006 the research and science industry in China included 53 knowledge parks which employed 3.5 million people. Both Korea and China have 'Science Cities' and science-based university-clusters (ibid.: 31). (k, m)
3. Science is about to go global the way finance did a decade or so ago (ibid.: 38). (h)
4. Scientists of the future must be citizen scientists who do not disconnect their roles as scientists from their roles as citizens. They are working with new people, developing new connections and acknowledging that science is increasingly integral to everyday life (Stilgoe, 2009: 11). (i, l)
5. This sort of citizen engagement is vital to ensure that science and technology respond to the international challenges of development (ibid.). (l, t, j)

6. Ensuring that these new 'citizen scientists' are encouraged requires rethinking about how science is supported and who is involved (Stilgoe, 2009: 25). If the culture of science is getting more narrow-minded, citizen scientists are re-opening it (ibid.: 44). They are doing things radically (ibid.: 39). (j)
7. The new scientist is also a 'knowledge nomad', someone whose career spans a variety of jobs in a variety of places because science and innovation are increasingly part of a global network which transcends national borders. This is crucial to the development of knowledge economies (Day & Stilgoe, 2009: 73). (h)
8. We face a new geography of science. Emerging 'hot spots' offer multiple ways to approach scientific research. 'If the UK is going to continue to be a scientific leader, its scientists should be encouraged to move more freely through this new geography' (ibid.: 11, 78). (g)

3.6 The Millennium Project (USA)

The Millennium Project is an 'independent non-profit global participatory futures research think tank' (Millennium Project, 2009a). The project was established in 1996, following a three-year feasibility study initiated by the Smithsonian Institution, The Futures Group International, and the United Nations University (UNU). The feasibility study was funded by the US EPA, the UNDP, and UNESCO (ibid.). The project's website describes its function the following way:

> The project is not a one-time study of the future, but provides an on-going capacity as a geographically and institutionally dispersed think tank. (ibid.)

Publications reviewed:

2009 State of the Future (The Millennium Project, 2009b) and accompanying CD Rom.

Relevant insights:

1. The risks from accelerated global science and technology are enormous. They are not isolated to one country, therefore science would benefit from global management. The future of science requires an international science and technology organisation which connects world S&T knowledge so that it can be used in R&D priority-setting and legislation (The Millennium Project, 2009b: 39). (h, m)
2. The funding of R&D for societal benefits will be adequate when it is in parity with or exceeds weapons and warfare funding (ibid.). (q)
3. In 2008, for the first time it was a Chinese company that lodged the greatest number of patent applications. China has the second largest R&D system in the world, while Japan has the highest R&D budget per GDP. The EU has plans to significantly increase R&D expenditure per GDP. There are more IT engineers in Bangalore than in Silicon Valley. All the while this spending means that science and technology continue to rapidly alter the future outlook for civilisation (ibid.). (b, g, k)
4. The design economy is already underway: genetic codes are being written to create new life forms, synthetic chromosomes have been created from laboratory chemicals, nano-particles and fibres stimulate neural growth, mini bio-computers help treat specific individual cells and surgical robots are now used routinely in operations (ibid.: 38). (e, f)
5. The future of science is open to opportunities but also catastrophes. These could include rapid dissemination of potentially dangerous information, biological and climate-change warfare, super-intelligent viruses, and the unintentional build-up of toxic substances, among other unpredictable events (ibid. CD Rom: 397). (a, c, d)
6. We need immediate education and training to bridge the S&T gap between developing and developed countries (ibid. CD Rom: 32). (p, t)

3.7 United Nations Environment Programme (Global Organisation)

The mission of the United Nations Environment Programme (UNEP) is:

> To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations. (UNEP, 2009a)

The UNEP outlines six priority areas which define future challenges: climate change, disasters and conflicts, ecosystem management, environmental governance, harmful substances and resource efficiency.

Publications reviewed:

2009 UNEP Yearbook: New science and developments in our changing environment (UNEP, 2009b).

Relevant insights:

1. Science needs to focus on immediately minimising and controlling the production and distribution of hazardous substances. This includes research into alternative, less aggressive substances. Dealing with e-waste and nano-waste, byproducts of technological progression, is of growing concern (UNEP, 2009b: 19). (c, d)
2. Climate change is already occurring. Science and research must be focused on adaptation as well as mitigation (UNEP, 2009b: 29). (r, s)
3. Resource efficiency is a huge issue. Science and research are needed to learn how Earth's systems function in producing resources and recycling byproducts. That way we can live with, rather than against, nature. Could the future of science see humans replicate nature's systems perfectly? (UNEP, 2009b: 51). (v)

3.8 Urban Institute (USA)

The Urban Institute was founded in the US in 1968. Its mission statement notes that:

> The Urban Institute gathers data, conducts research, evaluates programs, offers technical assistance overseas and educates Americans on social and economic issues – to foster sound public policy and effective government. (Urban Institute, 2009)

Publications reviewed:

The Real Global Technology Challenge (Lynn & Salzman, 2007a); *'Innovation Shift' to the Emerging Economies: Cases from IT and Heavy Industries* (Lynn & Salzman, 2007b).

Leonard Lynn is a professor of management policy at Case Western Reserve University and Hal Salzman is a research associate for the Urban Institute.

Relevant insights:

1. The US is no longer an elite technology and innovation hub: scientists are following the more challenging projects which now occur in places such as China and India (Lynn & Salzman, 2007a: 9). (g, k)
2. An 'innovations shift' to emerging economies, away from multinational firms, is under way. This trend will continue because emerging economies have increasingly desirable attributes beyond just low costs and huge access to human capital. They now also have unique approaches to technological innovation and engineering frameworks which draw on different traditions and are already making a valuable global contribution (Lynn & Salzman, 2007b: 17). (i, m)

3. It is not a matter of how many graduate engineers a country produces but how these engineers are educated and how they are supported by a country's innovation policy (Lynn & Salzman, 2007a: 10). (n, p)
4. In the United States a deficit in science and maths education at all levels is often blamed for technological insufficiencies. The real issue is instead market demand. The need for new types of technology and innovation are not being met by the current direction of public policy (ibid.: 12). (i, j, n)
5. In educational institutions there should be emphasis on understanding the 'new' job in the innovation sector and this in turn should influence curricula. As indicated by those being hired, the engineers and scientists of the future have different characteristics. They have allegiances to multiple countries through birth, education, citizenship and residency, resulting in multiple identities. They have the ability to transcend cultural, disciplinary and organisational boundaries and want to deal with emerging economies (ibid.: 13). (i, h, p)

3.9 World Future Society (USA)

The World Future Society is a non-profit, non-partisan scientific and educational association of people interested in how social and technological developments are shaping the future. The society holds annual conferences and publishes a bi-monthly magazine, *The Futurist*, and strives to:

> serve as a clearing house for ideas about the future … These ideas, forecasts and scenarios help people to anticipate what may happen in the next 5, 10 or more years ahead. When people can visualise a better future they can begin to create it.
>
> (World Future Society, 2009a)

Publications reviewed:

Publications reviewed: editions of *The Futurist* published during 2008 and 2009.

Relevant insights:

1. The design economy is underway. This is evident in the huge range of possibilities that are now being mooted, from new artificial skin which could be produced rapidly using factory-like techniques, to artificial islands (World Future Society, 2009b: 8). (f)
2. 'Lowly, single celled microalgae may eventually be used to make large quantities of biodiesel, ethanol and even hydrogen' (McIntyre, 2009: 26). 'Affordable and reliable electricity from the ocean might be possible with the VIVACE, a new machine being built by University of Michigan engineer, Michael Bernitsas' (World Future Society, 2009b: 3). 'Bacteria could convert trash into hydrogen fuel if scientists at the University of Birmingham have their way' (ibid.: 2). We must explore all options for alternative energy sources. (w)
3. There is a scientific, perfectionist mindset that we can and should make all things better, if we can only work out how to do this. We are engaging in evolutionary design which treats each element of production as a gene, which it randomly mutates and breeds until the best possible product is created. Developments like this are providing individuals with the tools that will eventually enable them to carry out do-it-yourself bioengineering, a potential characteristic of what has been dubbed the 'biology century' (Brown, 2008: 27). (f)
4. The theory of 'transhumanism' is developing. We are attempting to upgrade our bodies to a better model because the old one needed improvements – longer lifespan, better cognitive abilities and improved happiness (Gelles, 2009: 35). (e, f)
5. We need a social and mental revolution to accompany the accelerated technological and scientific change we are experiencing/anticipating, otherwise adapting to it will be difficult (Halal, 2009: 39). (j)
6. Space exploration technology and research will eventually (sooner rather than later) confirm or deny absolutely whether extraterrestrial life exists (World Future Society, 2009b: 8). (b)

7. The unlikely is still interesting to discuss and think about. Undersea habitation is one example of an extremely remote possibility. Yet why rule things out? (Docksai, 2008). (b)

4. Common Themes and Policy Drivers

In this section we state recurrent ideas on the future of science that stood out across the nine think tanks. These statements describe the key issues at the heart of the publications reviewed, and are a tool for generalising issues that are likely to influence the direction of science in the future. We have labelled these 'common themes', and have identified 24. We believe the following table illustrates the global scientific landscape at the end of 2009, while providing ideas for future directions in science policy that are being considered.

When the common themes underpinning the publications of the nine think tanks are listed, it becomes clear that the future direction of science is dependent on four policy drivers. These four overriding drivers, which are explored further in Section 5, will be discussed further in Report 9.

Table 1 Common Themes and Policy Drivers Related to Science Foresight

24 Common Themes	Four Policy Drivers
a) Science has the potential to alter international relations significantly, particularly with regard to warfare (x 6)[2] b) We face breakthroughs in RS&T which would significantly change the era (x 7) c) Science requires significantly more stringent management policies as it develops (x 4) d) One of the central risks of accelerated science is waste build-up (x 2) e) Genetic modification: risk or opportunity? (x 2) f) Technology is developing increasingly, allowing us to create anything artificially. We are on the verge of a design economy (x 5)	1. RS&T is an exciting opportunity but is not without risk
g) The roles of Europe and the US in RS&T are changing (x 3) h) RS&T is becoming an increasingly global network (x 6) i) The role and characteristics of scientists are changing or require change (x 4) j) For science to progress a significant change in mindset is required at academic and societal levels (x 5) k) Asia cannot be ignored as an innovating superpower (x 5) l) In order to progress, science must be reintegrated into daily life (x 3)	2. Science requires a unified global outlook
m) Systems and processes behind RS&T are evolving or need to evolve (x 8) n) The role of government is changing, and must become an increasingly active one (x 8) o) Are supposed RS&T policies actually being implemented? (x 1) p) The importance of improving education and tailoring it towards RS&T (x 4) q) Science funding needs to increase significantly (x 3)	3. Processes and systems which support RS&T must be effective
r) The importance of RS&T for adapting to, as well as mitigating, global challenges (x 2) s) The importance of RS&T for climate change (x 4) t) The importance of RS&T for developing countries and development (x 5) u) The importance of RS&T for healthcare (x 2) v) The importance of RS&T for our ecosystems and biodiversity (x 1) w) The importance of RS&T for peak oil alternative energy sources (x 3) x) The importance of RS&T for the oil crunch (x 2)	4. RS&T needs to take immediate responsibility for the global commons, challenges and developing economies

[2] Bracketed numbers in the table represent the number of times each of the common themes occurs in Section 3.

5. Conclusion

Four policy drivers have been identified which are likely to significantly influence the future of government-funded science internationally. These policy drivers will need to remain under consideration as New Zealand plans for an improved system for government-funded science. The four policy drivers are:

1. RS&T provides an exciting opportunity but is not without risk.
2. Science requires a unified global outlook.
3. Processes and systems which support RS&T must be effective.
4. Science needs to take immediate responsibility for global commons,[3] challenges and developing economies.

These policy drivers will be taken into consideration in Report 9, and will provide the basis for identifying future challenges to government-funded science in New Zealand.

Policy Driver 1: RS&T is an exciting opportunity but is not without risk

As science develops it promises an exciting future. There is the likelihood that unprecedented breakthroughs will occur which would significantly alter the outlook for civilisation. These breakthroughs could be either positive or negative, and it is crucial that there is control, transparency and public engagement at policy level so as to maximise the positive effects and minimise negative effects. There is a fine line between careful management and allowing uninhibited, explorative development. Risk needs to be calculated, managed and, sometimes, avoided.

Policy Driver 2: Science requires a unified global outlook

Nationalistic science is a concept rooted in the past. RS&T is usually a source of competition between countries, and is underpinned by nationalistic agendas that range from being the first (man on the moon) to fear of being the last (arms build-up). If RS&T is going to be effective in helping to solve global challenges, and if it is going to develop safely, then shared international goals, collective intelligence and working in unison should be priorities. As the geographical landscape of science and the attributes and expectations of scientists transform, RS&T has the opportunity to form an increasingly global network. This global scientific network is already developing and needs to be fostered rather than fought; if not, countries will miss out on valuable information and opportunities.

[3] Global commons, as defined by the World Conservation Strategy, are 'those parts of the earth's surface beyond national jurisdictions'. Notably, assets outside jurisdiction include oceans, outer space, Antarctica and the atmosphere. (IUCN, 1980).

Policy Driver 3: Processes and systems which support RS&T must be effective

The roles of government, companies and educators are all pivotal as RS&T progresses, and these roles must be proactive and forward-focused. Importantly, there needs to be a change in educational direction which mirrors the change of direction that RS&T is taking. If the two do not move together there will be a problematic and gross mismatch. It is critical that procedures for government-funded science are carefully considered and supported by generous funding.

Policy Driver 4: **Science needs to take immediate responsibility for global commons, challenges and developing economies**

The mentality that someone else will take responsibility for the global commons is not working, and nor is the waiting game of 'I'll do it when they do it'. National systems and processes that influence government-funded science need to take immediate ownership in addressing the global challenges that are currently impacting on the world and that will grow in size if left. There is an urgency here that offers opportunity. There is also the need to recognise developing countries that are unable to defend and support themselves when faced with such challenges. Technology needs to diffuse to these countries at a faster rate, particularly technology that is health-related.

Summary

To conclude, it is important to note that the four policy drivers are entwined and should not be disentangled; we have only separated them here for ease of discussion. Essentially the future of science is uncertain, but the one thing we do know is that the impact is going to be significant. This uncertainty means that government funding processes and systems supporting RS&T need to be more rigorous, flexible and robust than ever before, while also being globally unified in order to address world challenges.

Discussion on these four policy drivers will be continued in Report 9, *Government-funded Science Under the Microscope*, as we progress towards the formulation of a National Sustainable Development Strategy for New Zealand.

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