

The Future of Science Governance

A review of public concerns, governance and institutional response

A literature review for the BIS/Sciencewise-ERC 'Science, Trust and Public Engagement' project

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Executive Summary

Background

- Science and technology have increased their potential to disrupt societies, cultures and politics, for good and bad. The governance of science has evolved over the last few decades to accommodate this disruptive power but vulnerabilities remain. As the recent events surrounding 'Climategate' attest, systems of governance and public expectations can remain out of step, and public credibility of science remains fragile.
- Public dialogue and upstream forms of engagement have been key ingredients in the new scientific governance, as a way of embedding public concerns and values into the scientific process, as an instrument to help avoid downstream controversy, and more recently as part of a wider set of governance responses and mechanisms.
- The Sciencewise Expert Resource Centre (Sciencewise-ERC)¹ has been at the forefront of public dialogue over the past five years. It has constructed and guided a number of important dialogue projects on issues from nanotechnology and stem cell research to the use of DNA in forensics and building low carbon communities. Yet, while Sciencewise-ERC has also done much to encourage the appetite for public dialogue within government and its agencies, the impact of such initiatives on commissioning and target institutions themselves remains unclear.

The Review

- This review forms part of a wider BIS/Sciencewise-ERC project on 'Science, trust and public engagement'. It was a precursor to and went on to inform other elements in the first strand of the project, including in-depth interviews, ethnographic research and a workshop hosted by the Royal Society (see TNS-BMRB, 2011). The overall aim of the study was to understand how institutions frame the governance issues that have been at the forefront of public concerns around science and technology.
- In this report we review the findings from public dialogues, systematically evaluating the concerns that are shared across 17 Sciencewise-ERC sponsored public dialogues projects. We then explore in detail how science and policy institutions are responding to governance challenges in the fields of genomics, nanotechnology and climate science.

¹ The Sciencewise Expert Resource Centre (Sciencewise-ERC), funded by the Department for Business, Innovation and Skills (BIS), helps policy makers to understand and use public dialogue to inspire, inform and improve policy decisions around science and technology. It consists of a comprehensive online resource of information, advice and guidance together with a wide range of support services aimed at policy makers and all the different stakeholders involved in science and technology policy making, including the public. Sciencewise-ERC also provides co-funding to government departments and agencies to develop and commission public dialogue activities (see www.sciencewise-erc.org.uk).

The Sciencewise-ERC Dialogues

- We find the Sciencewise-ERC dialogues as marking a more mature phase of government thinking towards public engagement, yet within the projects we identify three distinctive models for how dialogue can inform the policy process: *The Upstream Model*; *The Honest Broker Model*; and *The Issue Advocate Model*.
- We identify five common themes that capture the crosscutting features of public concern and that pose considerable challenges for the governance of science. These are:
 - People's considerable ambivalence towards the purposes that drive science, technology and innovation and with the motivations of those involved.
 - The relative lack of trust invested in government to act in the public interest – for example, in domains such as food and biotechnology where there is a perceived proximity between government and the interests of industry.
 - Their sense of feeling excluded from deciding what kinds of science and technology gets funded and from what values and aspirations are fed into the science and innovation process.
 - Unease that the pace of scientific and technological development exceeds its scope for ethical and regulatory oversight and that it may take us in directions that have not been adequately considered in advance.
 - Concern with whether the culture of science discourages scientists from voicing concerns over potential risks and uncertainties, or reflecting on wider social and ethical considerations.

Mapping Science Governance Responses

- Mapping the ways in which science and policy institutions are responding to these governance challenges in the fields of genomics, nanotechnology and climate science suggest the following trends:
 - Moves to go beyond formal deliberative processes towards a more diverse range of mechanisms through which scientists and institutions can be exposed to public issues – including listening to 'uninvited engagement spaces' (such as the blogosphere) and various forms of outreach, knowledge transfer and exchange.
 - Governance responses associated with more distributed and open forms of innovation – such as opensourcing, crowdsourcing, and co-design – but questions remain whether these are merely extractive processes or whether they offer the public a genuine role in shaping scientific and technological innovation.

- Explicit commitments to institutional redesign towards openness, transparency, and accountability, prevalent in the area of genomics in the 1990s, have recently come to the fore in the climate change context. The dynamic through which change materialises in practice raises questions over the role of public resistance and controversy in mediating governance responses.
- The development of voluntary codes of conduct as an alternative to purely regulatory or top-down audit practices is evident. The effectiveness of this change remains unclear, with the main emphasis being on communication and education in relation to these voluntary mechanisms.
- While the main focus of the review is on novel and emergent governance responses it is important to recognise the value of established governance mechanisms, such as ethical codes of conduct, ethics review committees, public engagement mechanisms, and culture change programmes.

Conclusions

- As a result of this review, the report concludes that while some of the governance issues identified in the Sciencewise-ERC dialogues are at least partly responded to by science and policy institutions (concerns about inclusion for example) others are less evident (such as concerns over the purposes of emerging science and technology and the speed of innovation processes).
- Responding to such issues remains a strategic challenge for government and policy institutions charged with the governance of science.
- Understanding how institutions respond to governance challenges is complex, poorly explained in past social scientific research, and understood best through in-depth and grounded research strategies. Such inquiry needs to embrace:
 - A contextual approach that allows for the complex interplay of multiple actors, intermediaries and possible influences.
 - A nuanced understanding of the processes by which organisations learn and change, including the possible barriers, drivers, and influences of institutional response.
 - An awareness of the prevailing conditions, or wider 'driving forces', that shape the governance of science and technology including: the political economy of emerging science and technologies; the increasingly globalised nature of science and technology; and power relations.

Chapter 1: INTRODUCTION

Over the course of the 20th century and into the 21st, science and technology have increased their potential to disrupt societies, cultures and politics, in positive and negative ways. The governance of science has evolved over the last few decades to begin to accommodate some of the public concerns that reflect this disruptive power. But events remind us that there is still a disconnect between systems of governance and public expectations. This has been illustrated most recently in the climate change context, where the 'Climategate' controversy and intense public scrutiny of the Intergovernmental Panel on Climate Change's (IPCC) procedures and scientific assessments has revealed the extent of demands for transparency in the practice of science among amateur scientists and others in civil society. The impact these controversies have had on public perceptions of climate science has been marked, suggesting that the public credibility of science in high-stakes areas is remarkably fragile, and prompting a range of governance responses (InterAcademy Council, 2010; Russell et al., 2010).

In the UK, the ability of institutions to anticipate and take account of public reactions to science and technological risk has been a major challenge to science governance. The controversy surrounding genetically modified (GM) foods and crops in the late 1990s, followed by mad cow disease and the uncertainties surrounding the link between bovine spongiform encephalopathy (BSE) and Creutzfeldt-Jacob disease (CJD), led to a number of influential policy reports calling for more proactive public involvement and deliberation in debates about the social and ethical dimensions of science and technology (Royal Commission on Environmental Pollution, 1998; House of Lords, 2000; HM Treasury, 2004; Wilsdon & Willis, 2004).

In many respects the resulting shift to public dialogue and upstream engagement has been a dominant governance response to this so-called 'crisis of confidence'. The Sciencewise Expert Resource Centre (Sciencewise-ERC), funded by the Department for Business, Innovation and Skills, has been at the forefront of this response, initiating innovative and comprehensive public dialogue over the past five years. It has constructed and guided a number of important projects, on issues from nanotechnology and stem cell research to the use of DNA in forensics and building low carbon communities. The Sciencewise-ERC has also fulfilled a significant role in encouraging the appetite for public dialogue within government and its agencies. However, while there has been a range of innovation in participatory processes during this time, the extent and nature of the impact of these dialogue initiatives on commissioning and target institutions remains unclear.

During this period, there have also been changes to the policy and institutional context into which public dialogue played out. The Sciencewise-ERC has moved from a focus on funding dialogue to providing other resources for policy makers – not least through the provision of opportunities for training and networking, as well as through guidance on best practice. There has been the development of the *Beacons for Public Engagement* together with greater funding and support from the research councils and HEFCE to help embed public engagement in science within universities. There have been new governmental initiatives, such as *Science for All* and *Science and Trust*, which have attempted to encourage new forms of institutional engagement – including a call for a 'public compact' on crosscutting issues of science and technology, resulting in the Concordat for Engaging the Public With Research, launched in December 2010.

These recent developments are indicative of a more general shift in institutional rhetoric and practice from a focus on public dialogue and engagement in responding to issues of public trust in science, towards a broader appreciation of the governance of science, technology and innovation² (and science in governance) system as a whole in which public engagement and science-society interactions form an important part. There are three main dimensions to this:

1. The increasing recognition that formal invited public dialogue and engagement is actually only one of many ways in which public issues and concerns in relation to science and technology can be expressed, heard, and have an influence on science and decision-making (i.e. towards an appreciation of the diverse forms of social intelligence, public dialogue and wider public debate that exist on such issues; see Marres, 2007; Wynne, 2007; Chilvers, 2010).
2. The realisation that people tend not to be for or against a particular science or technology, rather they remain ambivalent, developing views that are contingent on how the science is being governed in real world circumstances: how adequate are current patterns of regulation; who will be responsible if things go wrong; can they be trusted; is the technology seen as imposed or open to change; who is this technology for; why this technology and not another; and so on (i.e. towards a realisation that governance issues are of central importance to citizens; see Wilsdon & Willis, 2004; Kearnes et al., 2006; Davies et al., 2009).
3. An appreciation that responses to these issues involve the whole science governance system and its global connections (i.e. towards a wider appreciation of possible governance responses and mechanisms;³ see Felt & Wynne, 2007; Royal Commission on Environmental Pollution, 2008).

Within this changing context and shift in emphasis *from dialogue to governance*, it is no doubt important to understand, develop and innovate new governance mechanisms. It is not as simple as this however. The project for which this literature review forms the basis takes the view that, as an essential precursor to such efforts, a much better understanding of the institutional context concerning the governance of science is needed. Such understanding is crucial due to: the varied impact of past practice (including public dialogue) in influencing institutional response; the range and complexity of existing governance mechanisms already in place; and the fact that any proposed new governance mechanisms should have precisely this understanding in mind.

The objectives of this review are threefold. The first is on understanding science governance issues and concerns expressed by the public, especially those that have emerged from existing public dialogues. This forms the focus of **Chapter 2**, where we undertake a systematic review of crosscutting governance concerns that have emerged out of 17 public dialogues co-funded by Sciencewise-ERC. The second objective is to map out the diversity of governance responses emerging in complex areas of science, technology and innovation. This forms the focus of **Chapter 3**, where we review the ways in which science and policy institutions, and scientists, are responding to governance challenges in the fields of genomics, nanotechnology and climate science. The third objective of our review is to make some initial observations on the connections between public concerns about the governance of science and

² The scope of this review is the governance of science, technology and innovation. At points throughout the review the terms 'governance of science' or 'science governance' are used as shorthand but are inclusive of this broader meaning.

³ Some examples of these possible governance responses and mechanisms are given in Chapter 3 of this report.

actual governance responses. This is undertaken in **Chapter 4**, where we provide a synthesis of the key messages emerging from Chapters 2 and 3 of this report and reflect on connections between them, including the factors that shape institutional response, which will be further explored through grounded in-depth qualitative research to be undertaken in later phases of the project.

Chapter 2: THE SCIENCEWISE-ERC DIALOGUES

In this chapter we analyse the science governance issues and concerns expressed by publics in a range of dialogue processes. The focus of our review is crosscutting governance concerns that have emerged out of 17 public dialogues co-funded by Sciencewise-ERC. We begin by identifying what has been distinctive about Sciencewise-ERC public dialogue events, before characterising the different models of public engagement evident within these dialogues. We then present our analysis of the governance issues emerging from these dialogues around five main themes, each relating to a crosscutting feature of public concern on the governance of science and technology. A full list of the 17 Sciencewise-ERC dialogues reviewed in this chapter and other supporting documentation is provided in Appendix 1.

What is distinctive about Sciencewise-ERC

The Sciencewise-ERC initiative marks a distinctive phase of government thinking towards public engagement. Following earlier attempts aimed at one-way science communication initiatives (Phase 1), and subsequent initiatives aimed at changing the rhetoric from deficit models of public understanding to dialogue models of public engagement (Phase 2), the Sciencewise-ERC aims to promote public dialogue that explicitly inspires and informs better policy in science and technology in the UK. Specifically, this is to be achieved through three objectives: (1) supporting and stimulating new flagship public dialogue projects of different types to inspire and inform better science and technology policy; (2) since 2008, becoming an opinion leader and trusted source of information in the role of public dialogue; and (3) embedding public dialogue in the day to day working of policy institutions through the provision of a range of tailored guidance, tools and support. The intention is not to supersede other more traditional forms of science communication, but to complement them with public dialogue in situations where it is appropriate.

Following Stirling (2005) we can identify competing and overlapping rationales that underpin the use of public dialogue in Sciencewise-ERC projects. These can be distinguished into the normative (e.g. that dialogue is the right thing to do for reasons of democracy, equity, equality and justice), the instrumental (e.g. that dialogue provides social intelligence to deliver pre-committed policy objectives, such as those of building trust or of avoiding adverse public reaction), and the substantive (e.g. that policy choices can be co-produced with publics in ways that authentically embody diverse social knowledges, values and meanings in a substantive manner). Although this distinction is based on ideal types it nevertheless sets the context of our first observation: that Sciencewise-ERC has promoted a shift of government thinking for public dialogue from an instrumental to a substantive rationale based on valuing multiple perspectives.

Evidence for such a shift can be identified in the guidance and advice streams in Sciencewise-ERC's Resource Library on what constitutes good dialogue. This includes, firstly, continued emphasis that dialogue is not concerned with one-way communication of policy outcomes that government already is pre-committed towards. Alternatively, good dialogue is presented as involving two-way or multi-way communication between publics, scientists and policymakers. In its guiding principles

for public engagement in science and technology, in a document called 'The Government's Approach to Public Dialogue on Science and Technology' (BIS, 2009), there is explicit guidance that the *scope* of the dialogue process (i.e. the range of issues and policy options covered) must reflect the full range of aspirations and concerns held by publics, scientists and policy makers. This appeal for inclusiveness also pertains to the ways in which the dialogue is itself framed, which should be agreed, preferably through dialogue, such that it focuses on broad questions and a range of alternatives.

This appeal for broadening the scope of dialogue responds to a body of academic literature that has called for the framing of technology appraisal (e.g. the choice of policy questions, the forming of hypotheses, the inclusion of disciplines, the treatment of uncertainties), to be opened up and subjected to public deliberation and scrutiny (Grove-White et al., 2000; Stirling, 1998; Wynne, 1992, 2006). This reflects international approaches and debates aimed at real-time technology assessment, constructive technology assessment and the anticipatory assessment of technology (see Barben et al., 2008; Guston & Sarewitz, 2002; Rip et al. 1995; Royal Commission on Environmental Pollution, 2008). Of course, while institutional rhetoric may have shifted, it is less clear that this change of emphasis has been carried out across the Sciencewise-ERC portfolio in practice. Some projects appear framed by tight and fairly specific policy questions and contexts (e.g. the *Hybrids and Chimeras* dialogue was tied to specific questions on the public acceptability of different types of embryo research) while other projects were carried out within a relatively traditional and largely one-way model of science communication (e.g. a framing assumption of the *Industrial Biotechnology* project was that the public lacked knowledge and were confused, and that the objective of the dialogue was to help build confidence in the government's use, management and regulation of industrial biotechnology).

Nevertheless, across the portfolio as a whole, it is clear that an effect of Sciencewise-ERC activity and guidance is a broadening of understanding of what constitutes deliberation, and of the acknowledged relevance and value of alternative perspectives. This point is especially pertinent given that the *modus operandi* of Sciencewise-ERC is one of co-sponsorship – a notable innovation of the initiative. With the exception of *Science Horizons* all dialogue projects have been co-produced, co-funded and co-delivered with external government bodies and agencies, and to a lesser extent with industry and the third sector (while the original remit of Sciencewise-ERC was wider than government, it was subsequently decided to narrow the focus to government departments, government agencies and non-departmental public bodies). Organisations that have co-sponsored Sciencewise-ERC dialogues currently include: agencies (Environment Agency, Food Standards Agency); departments (Defra, DECC); industry (British Telecom, Hewlett Packard, Unilever); learned academies (Academy of Medical Sciences); regulators (Environment Agency, HFEA); and research councils and funders of research (BBSRC, EPSRC, MRC, NERC, Nesta, Wellcome Trust).

A second observation stems from how Sciencewise-ERC has performed a function as a corporate memory of public dialogue, with a repository of guidance notes and information on what constitutes good dialogue, alongside reports and evaluations of particular dialogue events. This has aided the professionalisation of public dialogue practice. Various notes and reports on best practice now include: how to make use of experts in public dialogue; how to work effectively with the media; how to widen public involvement and upscale public dialogue processes; how to improve the organisational use of dialogue through a Departmental Dialogue Index; how to understand, demonstrate and measure the value public dialogue; and how to enable and sustain citizen involvement over the life of a project and beyond. Through such

activity Sciencewise-ERC now arguably commands a leadership role in public engagement theory and practice. Indeed, while it is difficult to verify this claim it is difficult to locate a comparable institutionally-endorsed approach to public engagement in other Western democracies. This undoubtedly has contributed to increasing recognition from policy makers of the value, validity and legitimacy of public dialogue, such that it has become, for some, firmly woven into policy, normalised and embedded within decision-making processes.

However, as Chilvers (2010) points out, the professionalisation of public engagement has created a new set of effects, tensions and questions. Chilvers identifies four effects: an increased separation and polarisation between academic social scientists and dialogue practitioners; a growing public engagement industry whose commercial interests can compromise democratic ideals of participation; an emphasis on a limited and homogenous set of techniques; and the favouring of top-down institutional framings of public dialogue. This raises questions about what we can learn from this dynamic and possible ways in which the democratic ideals of dialogue could be promoted.

The third point of distinction concerns the methods that have been deployed in Sciencewise-ERC projects. Crudely, even though all Sciencewise-ERC projects aim towards a society in which the public, the broad science community and policy makers feel comfortable with the direction taken by science and technology, the range of methods used depend in part on three relatively distinct models of the implied relationship between public dialogue and the policy process. There are:

- *The Upstream Model* – the aim of which is to develop a process through which publics can engage in complex conversations on the range of issues and questions posed by science and technology at a relatively early stage in the innovation process.
- *The Honest Broker Model* – the aim of which is to deliberate on different policy options and to determine a preferred policy outcome, with justification.
- *The Issue Advocate Model* – the aim of which is to deliberate on a shared policy goal, such as galvanising community-led participation in climate change, and to deliberate on the conditions under which this goal will be realised.

The *Upstream Model* is the most challenging in terms of the methodological difficulties it poses and is discussed in some detail below. The challenges are for three reasons: (1) the science is at an early stage and it is unclear how the technology will develop and the extent to which its promises will be realised; (2) the subsequent social and ethical issues associated with the technology are uncertain as they depend on as yet to be realised innovation trajectories; and (3) the lay public is unfamiliar with the science and thus has no ready formed attitudes. Sciencewise-ERC dialogues that have used the *Upstream Model* include *Geoengineering*, *Industrial Biotechnology*, *Nanodialogues*, *Science Horizons* and *Synthetic Biology*. The *Upstream Model* tests the limits of social science methodology, raising questions as to whether the conversation is simply too upstream for the methods to reflect reliably solid public opinion, and, if this is the case, whether the results and findings from the dialogues should be treated with caution in shaping future policy and decision making (for a version of this critique, see Rogers-Hayden and Pidgeon, 2007; for a response, see Macnaghten 2010).

Notwithstanding the above debate, it is important to note that those Sciencewise-ERC dialogue projects that have aimed to facilitate the upstream conversation have

been remarkably innovative in terms of methodology, particularly around the invited, selected and moderated small group discussion. Two influences are at work: (1) a tradition of policy-oriented academic research that uses small groups as a deliberative space where lay publics can share their experiences, values and knowledges and where social scientists can bring recognition of such local knowledge in the quest for making decision-making more reflexive and socially robust (for early examples of this approach, see Burgess et al., 1988a, 1988b; Burgess, 2005; Grove-White et al., 1997, 2000; Petts, 1997, 1999; Wynne, 1996); and (2) a market research tradition of using focus group methods to evaluate consumer preferences, attitudes and beliefs with a particular emphasis on how views and beliefs emerge in interaction with others. Reviewing the Sciencewise-ERC dialogue projects one can identify a remarkable range of group-based and bespoke deliberative methods. These include, *inter alia*, full day public workshops, citizens' juries, citizens' inquiries, reconvened deliberative groups, deliberative panels, national public conversations, self-managed group discussions, facilitated public events, regional workshops, outreach workshops, brainbox workshops, online consultation, blogs, and open access events, alongside non-deliberative interview, electronic voting and opinion poll survey techniques. In addition, there has been analogous innovation in the provision of stimulus material and expert opinion aimed at ensuring a reflective and informed discussion, typically provided in consultation with an Oversight Group.

This innovation in deliberative methodology has emerged through creative interplay between market research methods, academic social science and independent facilitator on-the-ground experience, and bears witness to the dynamism and maturity of the 'dialogue market' (Chilvers, 2008; 2010). At its most creative it has enabled genuine discussion to take place on issues that are complex, unfamiliar and at times far-reaching. It has enabled insight into the structure of public concerns and aspirations, and into the values and aspirations that people bring to bear in developing their views. While the highly managed, carefully selected and closely choreographed small group discussion has become the method of choice for public dialogue, it is worth looking at six potential criticisms. These are:

1. That this approach tends to be organised in the terms of the host decision-making institution, which may neglect other, more uninvited, alternative framings on science-related issues (Chilvers, 2010).
2. That the small group method tends to reinforce consensus and to homogenise views in ways that unwittingly irons out differences and minority perspectives (Mohr, 2009).
3. That the deliberative process can become overly structured by information, stimulus material, briefings, expert presentations, videos and so on, with insufficient time and space for participants to genuinely deliberate on the issues in their own terms (Mohr, 2009).
4. That the selection of lay publics, defined as individuals who have no prior allegiance or connection to the issue at hand, tends to reproduce a stable and malleable image of 'the public' that is conducive to government control and management (Lezaun & Soneryd, 2007).
5. That the sampling strategy, which tends to use standard demographic characteristics (i.e. age, class, gender) rather than topic-specific criteria, tends to generate weak group ties and shallow conversation given that the groups share little common experience and history.
6. That the predominantly qualitative approach to methodology, while illuminative of the deeper reasonings and contextual understandings that

underpin public attitudes, is less equipped to identify attitudinal segmentation, including the relevance or otherwise of variables of class, age, education and knowledge.

Models of public engagement

In reviewing the 17 public dialogues on science and technology that Sciencewise-ERC has sponsored since 2005, it is clear that different models of public engagement are being deployed that respond to different kinds of policy question. In Sciencewise-ERC's resource library the dialogues are organised into priority areas of science and technology, as set out in the table below.

Table of Sciencewise-ERC Dialogue Activity (by priority area)

	Biosciences	Climate Change	Environment	Food	Futures	Governing science &	Healthcare	ICT	Info Man	Nanotech	PE practice
Synthetic Biology	X			X							
Industrial Biotechnology	X										
Community X-Change	X	X		X		X					X
Big Energy Shift		X									
Low Carbon Communities Challenge		X									
Geoengineering		X									
Energy 2050 Pathways		X									
Landscape and Ecosystem Futures			X								
Science Horizons					X				X		
Risky Business						X					X
Animals containing Human Material							X				
Stem Cells							X				
Hybrids and Chimeras							X				
Drugsfutures							X				
Trustguide								X			
Forensic Use of DNA									X		
Nanodialogues										X	X

The table above illustrates the diversity and reach of the Sciencewise-ERC public dialogues, each of which has been co-sponsored by a government department, agency, third-sector body or company (with the exception of Science Horizons) and has been subjected to independent evaluation. Using the typology of three models of the relationship between public dialogue and the policy process outlined above, we can redraw the table as below:

Table of Sciencewise-ERC Dialogue Activity (by model of public engagement)

	Upstream	Honest broker	Issue advocate
Synthetic Biology	X		
Industrial Biotechnology	X		X
Community X-Change	X		X
Big Energy Shift			X
Low Carbon Communities Challenge			X
Geoengineering	X	X	
Energy 2050 Pathways			X
Landscape and Ecosystem Futures		X	
Science Horizons	X		
Risky Business			X
Animals containing Human Material		X	
Stem Cells		X	
Hybrids and Chimeras		X	
Drugsfutures		X	
Trustguide			X
Forensic Use of DNA		X	
Nanodialogues	X		

This typology follows a set of distinctions developed by Roger Pielke in his book *The Honest Broker* in which he distinguishes between different models of scientific advice in the policy process (Pielke 2007). Developing this further, the *Upstream Model* is one that is used to open up public conversations about the social and ethical dimensions of science and technology at an early stage in the innovation trajectory. The conversations tend to be exploratory, to concern the ways in which the science and technology is being imagined by social actors, to scrutinise the views and visions of actors, to articulate the social and ethical issues, and to deliberate on the factors that shape concern, hope and possibility. Such dialogue events thus tend to be tied only loosely to specific policy goals and outcomes, and are more apt to offer generic advice on the governance of science and technology.

Examples using the *Upstream Model* of public engagement include dialogue projects aimed at establishing views about the social and ethical issues raised by 1) specific areas of science and technology (*Synthetic Biology*, *Nanodialogues*, *Industrial Biotechnology*, *Geoengineering*), and 2) possible future directions in science in general (*Science Horizons*, *Community X-Change*). The *Industrial Biotechnology* and *Community X-Change* dialogues also fell into the *Issue Advocate Model* since the framing of both subscribe to a particular policy goal: that of building confidence in industrial biotechnology and that of providing a voice for local communities respectively. The *Geoengineering* dialogue also falls into the *Honest Broker Model* since the context in which the discussion took place related to a very specific policy question: that of whether, and under what conditions, geoengineering approaches have a role to play in tackling climate change.

Dialogues that fall under the *Honest Broker Model* of public engagement alternatively were tied to a prescribed policy question or dilemma, and where the role of the public is to act as a lay ethical arbiter in providing views on how to proceed, weighing up the

pros and costs of different courses of action, articulating the conditions under which different options are acceptable or not, and thus helping inform a policy decision. This model of dialogue tends to be favoured for health-related questions, where the aim is one of helping sponsors to determine whether, and under what conditions, to fund and move forward with specific and ethically-challenging research (*Animals containing Human Material, Hybrids and Chimeras, Stem Cells*). A related category of dialogue relates to projects that seek to determine the effects of advances in the sciences on issues that already pose social problems and dilemmas (*Drugsfutures*) or that pose new dilemmas for the use and management of information (*Forensic Use of DNA*). The final example is tied to policy on future land use planning in the context of climate change (*Landscape and ecosystem futures*), and where the role of the dialogue was to understand values, benefits and trade-offs in relation to future land use scenarios.

The *Issue Advocate Model* is the third category of public engagement. Dialogues subscribing to this model are characterised by adherence to a predetermined policy goal and where the aim of the dialogue is to develop new ways of achieving that goal through better understanding the views, beliefs and needs of publics. This model of dialogue is common in dialogues on climate change, responding to the policy goal of stimulating behaviour change as part of the government's commitment to a legally binding target for greenhouse gas emissions by 2050. Policy-derived questions shaping the various dialogues include: how to cut emissions at a local level (*Low Carbon Communities Challenge*), how to encourage people to change their energy behaviour (*The Big Energy Shift*), how to engage representatives of the public in local communities across the UK to run local deliberative dialogues (*Energy 2050 Pathways*), how to increase awareness in students aged fourteen and over of issues of risk in science (*Risky Business*), and how to improve cyber trust (*Trustguide*).

Common Themes and Challenges for Governance

With the exception of Daniel Start's (2010) review document there has been little attention drawn to the common themes that have emerged across the Sciencewise-ERC dialogues or to their cumulative significance for questions of governance. In this section we examine key cross-cutting themes shared across multiple dialogues, and discuss their relevance and meaning in relation to wider public engagement literature and practice.

The recent Department of Innovation, Universities and Skills/Research Councils UK (RCUK/DIUS) survey conducted in 2008 reported generally favourable public attitudes towards science in the UK (RCUK/DIUS 2008). It found that people are generally positive towards science, that this perception has increased compared to equivalent research conducted in 2000 and 2005, that almost all areas of scientific research presented to the public are seen as beneficial, that overall the public feels better informed about science than three years ago, and that concern about science and the speed of development has reduced since 2000 and 2005. The Sciencewise-ERC dialogues reinforce this picture. Across the dialogues we are presented with a public which is generally positive, upbeat and excited about science, and about its transformative potential in delivering improvements to our everyday lives and to the environment. As Start (2010) sets out, this includes: (1) medical research to create new cures (*Hybrid and Chimera; Stem Cells*); (2) environmental and energy research to promote sustainability (*Risky Business; Industrial Biotechnology; Big Energy Shift*); (3) new technologies offering novel environmental solutions (*Nanodialogues and Synthetic Biology*); and (4) investment that consolidates Britain's role as a leader in new science and technology (*Stem Cells; Industrial Biotechnology*).

However, while public attitudes towards science and technology may be positive in general, they also depend on which technology sector is being discussed as well as on a set of wider contextual and attitudinal factors. The recent RCUK/DIUS survey, for example, highlights five distinct attitudinal groups – The Confident, The Sceptical Enthusiasts, The Less Confident, The Distrustful and The Indifferent – identified through cluster analysis, which are seen to account for most of the variance in respondents' attitudes. More qualitative academic research has sought to clarify the factors that shape and structure attitudes of confidence and scepticism. The research suggests that public attitudes towards science cannot easily be segmented into those that are pro- and anti- science, and that wider contextual factors are relevant to understanding public views (for analysis of ambivalence in public risk research, see Grove-White et al., 1997; Kearnes and Wynne, 2007; Kearnes et al., 2006; Macnaghten and Urry, 1998). Five factors central to the structuring of public attitudes in the Sciencewise-ERC dialogues are discussed below.

I. The purpose of science and technology

A key factor shaping people's attitudes towards science and technology concerned their assessment of the purpose of the science and of the motivations of those involved. In whose interests is the science being developed? Are particular innovations necessary? Are there alternatives?

Medical and health technologies were seen by and large as driven by good purposes, including curing diseases, improving wellbeing and prolonging life. Research was thus accorded high importance, even when there were acknowledged ethical dilemmas. In the *Synthetic Biology* dialogue, for example, the motivations of scientists were deemed to be a key determinant in assuring acceptability: What is the purpose of your research? Why are you doing it? What are you going to gain? What else will it do? How do you know you are right? Given that the science was at an early stage, with clear potential for good and bad, ensuring that the science was conducted for good reasons (i.e. in response to societal needs rather than for short-term gain or for knowledge for its own sake) was presented as a critical question. In the *Stem Cells* dialogue, support for further advances in the science was also seen as conditional on the purposes of the research and on whether it respects human values: Would it reflect public rather than solely commercial interests? Would it respect individual rights and autonomy? Was it focusing on serious diseases? Were people involved in decision-making processes? While in the *Animals containing Human Material* dialogue, support was similarly premised on the assumption that the aims of the research would be to improve human health or cure human diseases.

The picture that emerges from the dialogues is that while there is general belief that science and scientists are motivated by the common good, supporting the findings of the 2008 RCUK/DIUS study, this level of trust depends on the science being seen as conducted for good reasons. These are whether the science is directed to societal rather than to commercial goals, with the goals of curing disease and improving health clearly the most favoured; and whether the science itself respects basic human values.

II. Trustworthiness of institutions

Common across a number of dialogue projects was the finding that people surprisingly rarely trusted the motives of government to act in the public interest (*Big Energy Shift, Geoengineering, Industrial Biotechnology, Science Horizons, Synthetic Biology, Trustguide*). The notable exception was on health related dialogues where, alternatively, there appeared to be an underlying sense of trust and confidence in

regulation, oversight and the good intentions of government (*Animals containing Human Material, Hybrids and Chimeras, Stem Cells*). Such distrust is variously seen to stem from the questionable motives of business and the perceived inability of government to regulate them (*Industrial Biotechnology*), the lack of resources and effective coordination within government (*NanoDialogues*), and the inability to enforce effective policy on the ground (*Forensic Uses of DNA*). This distrust is apparent especially in domains where there is a perceived proximity between government and industry, most notably in agricultural and industrial biotechnology. As the report on the *Industrial Biotechnology* dialogue states: 'Profit or anything associated with industry are viewed with great suspicion and there is little faith that the government will effectively resource the control and monitor[ing of] industry' (p. 4). Indeed, while the motives of scientists may be trusted, in general, the motives of government and industry are not. As Daniel Start comments in his review: "The initial public perception of government is of a regulatory structure that is weak and unreliable, vulnerable to private interests, and vulnerable to dangerous products slipping through the net" (Start, 2010: 20).

Unfortunately there has been little analysis across the dialogue reports of the reasons that underpin such generic public distrust in government, or advice on what would constitute an appropriate governance response, aside from appeals for improved communication of benefits (*Industrial Biotechnology*); for regulation to develop an anticipatory and social intelligence capacity (*Synthetic Biology*); for more attention to be given to the equity effects of scientific and technological options (*Geoengineering*); and for more inclusive and systematic dialogue (*various*). A particular absence is an account of why science and technology has become a site for political mobilisation in some spheres (e.g biotechnology and food) and not others (health); of the reasons why government is seen as not to be trusted to monitor industry or look after the long-term; and of the need to differentiate between systemic as opposed to localised forms of mistrust.

III. Feelings of powerlessness and exclusion

In 1995, in a project on public perceptions and sustainability, Macnaghten et al. (1995) observed that the pronounced fatalism and cynicism that people expressed towards national and local government was a key barrier to environmental behaviour change. They further argued that attempts by government to galvanise community action would depend on their ability to develop relational mechanisms through which a sense of inclusion and shared purpose could be established. Ten to fifteen years later, and despite a heightened institutional rhetoric on inclusion, it is clear that many people still feel they are not included in deciding what kinds of public science and technology gets funded and in whose interests: i.e. they feel 'kept in the dark'. This sense of powerlessness is expressed well in an extract from the *Synthetic Biology* dialogue report:

"There was a strong sense that scientists are a closed community – while research was scrutinised by peers, it was hard to access by others. In part, this was because scientific expertise and knowledge of a field set them apart from others. However, it was also believed there was a cultural resistance to opening up science to the views and values of the public. This was particularly problematic as participants felt compelled to trust scientists, but ultimately felt powerless to have any control. As one participant noted: '*How can I stop a whole team of scientists doing something? I feel I can't, I feel powerless.*' (Female, AB, 18-34)"
(*Synthetic Biology* 2010: 41)

Similar views were expressed in the *Industrial Biotechnology* dialogue, where participants felt that government/industry would dictate change with little power for consumer choice; in the *Big Energy Shift* dialogue where the need for a bold and overarching narrative from government was presented as the single biggest determinant in shifting energy behaviour; and in the *Nanodialogues* where one participant commented, tongue in cheek, on the peculiarity of the dialogue process: “*I feel lucky, I feel like we can make some nanoscale contribution to society*”.

More positive were a number of overlapping suggestions for increased citizen participation and engagement. At the downstream end, where products and technologies are already in the marketplace, came suggestions for the provision of improved, balanced and honest information: on harms (*Drugsfutures*); on rights (*Forensic Uses of DNA*); and on the provision of guarantees in the event of mishaps (*Trustguide*). With both upstream and downstream science came calls for investment in risk and safety research: on effective governance and quality control procedures (*Stem Cells*); on long-term monitoring for unpredictable effects (*Nanodialogues*); and on the containment, control and governance of biotechnology risks (*Industrial Biotechnology*; *Synthetic Biology*). At the more upstream end, where the risks of the technology were uncertain and less understood, were calls for more open discussion of the uncertainties in the science and their potential effects: within the medical establishment (*Drugsfutures*), the judiciary (*Forensic Uses of DNA*), and companies (*Industrial Biotechnology*). A common theme was the call for a change in the culture of science that would encourage scientists to voice concerns over potential risks and uncertainties, and to reflect on wider social and ethical considerations. In the *Synthetic Biology* dialogue, participants questioned whether a dominant culture of science existed – one which emphasised curiosity-driven, basic research, coupled with a publish or perish mindset – which had the effect of unwittingly encouraging scientists to focus unduly on the positive outcomes of the science, and to miss the potential risks. Similarly, in the *Stem Cell* dialogue report, it is stated that:

“Future dialogue should focus on the cultures and practices of research within institutions. Whilst large structured dialogue events are important, it will be fundamental that the everyday practice and discussion of science is mindful of societal views. Uncertainties in stem cell science should be communicated openly if the public debate is to avoid being dominated by hype.”
(*Stem Cells* 2007: ix)

IV. Speed and direction of science and innovation

A long-standing public concern with science and technology is that research and innovation processes are being developed at a speed that exceeds their scope for ethical and regulatory oversight and that, alternatively, we should proceed with caution (for recent survey results on concerns over ‘speed’, see RCUK/DIUS 2008; see also Bingham, 2008; Stengers, 2000). There is a further and additional concern, with the direction science is taking us and whether this has been adequately considered and agreed (Stirling, 2007). Alternatively, it is proposed that we should be careful in promoting risky science that may create new dangers and dilemmas until we are better satisfied that the issues posed by current science and technology are resolved. Although a concern with the speed of scientific innovation was less evident in the 2008 RCUK/DIUS survey than in the 2000 survey, concerns of this kind were still commonplace across the Sciencewise-ERC dialogues. Examples can be seen in the *Stem Cells* dialogue (was research being pushed to deliver applications too soon?), and in the *Synthetic Biology* dialogue (what were the dangers of speeding up natural and evolutionary processes?).

Concerns were also voiced on the direction in which science is taking us. These extended beyond matters of safety and technical risk to a broader set of social and ethical issues that included: concerns over unforeseen consequences including controllability and reversibility (*Geoengineering, Synthetic Biology*); impacts on perceived naturalness (*Geoengineering, Synthetic Biology*); and impacts in terms of fairness and equity (*Geoengineering*). As the Nanodialogues report commented: “Safety was a sideshow. The real concern was with where companies are taking us” (page 63). The analysis undertaken in the reporting of the *Science Horizons* dialogue is insightful in this respect. It suggests that public views on future science and technology will be determined not simply on the benefits and risks of the particular technologies, but through the extent to which they respond to ‘social goods’, namely:

- Better health (a social good)
- Independence, especially for the elderly (a social good)
- Convenience (a social good)
- Quality of life (a social good)
- Risks to safety (a social bad)
- Scope for loss of privacy and autonomy (a social bad)
- Social divisiveness (a social bad)
- Lack of genuine human interaction (a social bad)

While each of the above points requires further differentiation and expansion, it nevertheless reinforces the observation that public views on science and technology depend critically on their ‘social constitution’, that is on the distinctive values and social assumptions that are embedded in their development (Grove-White et al., 2000).

V. Ethics, trade-offs and the social distribution of risks and benefits

A final theme concerns commonalities in lay ethical judgment. Daniel Start (2010), in his review of the Sciencewise-ERC dialogues, usefully observes that differences of ethical opinion tended to be most pronounced within the dialogues rather than between them. A primary consideration was whether there was a sense of genuine social benefit from publicly-funded science. At an individual level, where the social benefit was high, the public was prepared to accept higher tradeoffs. Thus, in the *Stem Cell* dialogue, stem cell research was seen as acceptable only in cases where there existed the potential for very significant medical breakthroughs for the treatment of incurable diseases. In cases where stem cells were proposed in cosmetic applications or for the purposes of human enhancement, where the social benefit was seen as low, the research was seen as less acceptable.

A secondary consideration was the social distribution of those costs and benefits. Across many of the dialogues was a concern that the political economy of new science and technology would disproportionately impact upon vulnerable groups, particularly the poor, the ill, the unborn and those unable to defend themselves. Concern was expressed that nanotechnologies would benefit the rich and the powerful, not the poor or the unemployed (*Nanodialogues*); that medical research would be biased towards western and affluent illnesses rather than those in developing countries (*Stem Cells*); that the National DNA database could be used by governments to further discriminate against ethnic minorities (*Forensic Uses of DNA*); while the use of new drug treatments in the management of mental health

conditions could be seen as a cheap alternative to social and behavioural therapy (*Drugsfutures*).

A final consideration was the differing and competing philosophical perspectives that people used to discuss the ethics of particular scientific and technological innovations. Start (2010) distinguishes two competing philosophies at work in the dialogues: a liberal and individualistic set of values and rights pitted against communitarian and collective values and virtues. Thus, while people were in general positive about the prospects of new technology for improving convenience, saving time and adding choice (appealing to liberal and individualistic values), at the same time they were wary that those same technologies would erode communities, devalue traditions and dehumanise relationships (*Science Horizons*). While there was strong concern about the perils of inappropriate drug use from a collective viewpoint, there was at the same time a widespread view that individuals should have the right to make their own decisions (*DrugFutures*). While there was strong support for the use of science and technology to aid national security, the public also spoke up for rights to privacy and anonymity (*Forensic Uses of DNA*).

Chapter 3: MAPPING SCIENCE GOVERNANCE RESPONSES

In this chapter we shift the review from a focus on the governance issues and concerns stated across invited public dialogues to consider the ways in which science and policy institutions are responding to governance challenges in emerging and complex areas of science, technology and innovation – namely genomics, nanotechnology and climate science.⁴ The intention is to provide an indication of the range of governance responses rather than a comprehensive review. In so doing, the emphasis is on mapping the range of actual and possible responses rather than making links to the particular public dialogues reviewed in Chapter 2. The governance responses forming part of the review cover two main categories. The first is the routes through which publics can have influence in shaping the nature and direction of emerging science and technology (including its priorities, objectives and strategies), such as through formal invited public engagement and dialogue, ‘uninvited’ spaces of engagement, forms of open innovation, crowdsourcing and co-design, and other means of understanding public views and wider ‘social intelligence’. The second concerns the mechanisms for public transparency, scrutiny, oversight, accountability and quality control (including responsible innovation, voluntary codes of conduct, moves to open data, lay advisory panels/members, peer review processes, institutional design). In order to cover a diversity of governance responses in each area of science and technology, and to contextualise the analysis of the Sciencewise-ERC dialogues in Chapter 2, we draw on international as well as UK examples.

Genomics

The field of genomics focuses on the characterisation and sequencing of the genome and the analysis of the relationship between gene activity and cell function. Rooted in the foundational work of the Human Genome Project (HGP), it has become a varied field covering areas as diverse as DNA profiling, plant and animal genetics, personal genomics, embryonic stem cell research, and synthetic biology. While these scientific and technological developments offer potential benefits, such as advances in health care, regenerative medicine, agriculture, and energy production, they also raise intense ethical and social concerns, uncertainties, and public unease. The significant governance challenges raised by this are further intensified by the rapid evolution of genomics science and technologies, their global connectedness, and the increasingly powerful role of the genomics industry and corporate interests.

In many industrialised nations the governance of genomics has shifted from a largely centralised approach based on top-down *government* regulation in the 1970s and 1980s, towards a more distributed system of networked *governance* since the 1990s where the direction and governance of genomics-related research is also influenced by multiple actors in industry and civil society (Rhodes, 1997; Gottweis, 2005). What we are now seeing is a ‘governance continuum’ with multiple genomics governance responses, where state-led regulation coexists with more participative forms of policy-making (Lyll, 2007). The latter is being promoted by principles of ‘responsible governance’, such as those espoused in the European Commission’s *Strategy for*

⁴ These areas have been selected because they represent distinct science governance contexts offering a diverse range of governance responses and because they closely link with the proposed case study areas to be taken forward in Phase 2 of the BIS/Sciencewise-ERC ‘Science, Trust and Public Engagement’ project.

Life Science and Biotechnology (European Commission, 2007), which seeks to combine goals of ethical and social responsibility with science-based regulatory oversight. Gottweis (2005) summarises this range of genomics governance responses as including:

- Top-down regulation as traditionally deployed by governments or governmental institutions;
- Bottom-up patterns of governance, where genomics-related policy-making is shaped through inputs from companies, or more general mass publics and public opinion;
- Multidirectional forms of genomics governance involving interactions and patterns of negotiation between governments, NGOs and business alliances;
- New forms of self-governance, as articulated by the rise of new actors such as patient groups or self-help organisations.

In the late 1990s, rising public concerns over the application of genomics-related technologies (such as GM crops), expressions of uncertainty, and attempts to regain public trust in the wake of the BSE crisis, led to a number of UK institutional innovations. In genomics-related areas three independent advisory bodies were set up at arm's length from government, all with expertise and remits to consider the social and ethical implications of genomics technologies, with stated commitments to transparency and openness, and requirements for public input (Grove-White, 2001). The Human Genetics Commission was set up by the UK government in 1999, comprising experts in genetics, ethics, law and consumer affairs, to provide advice on the social, ethical and legal issues associated with human genetics and its impacts on people and health care. It can be seen as indicative of the worldwide drive to develop ethical expertise and ethics bodies in the genomics field. The Food Standards Agency (FSA), an independent government department, was set up a year later to protect the public's health and consumer interests in relation to food, with parallel advisory responsibilities relating to GM foods. A further body, the Agriculture and Environment Biotechnology Commission (AEBC) was established in 2000 to provide strategic advice on biotechnology issues affecting agriculture and the environment until it was wound up in 2005.

The design of these bodies has involved a number of governance mechanisms to address issues of expertise, transparency, openness and public scrutiny, including:

- *Independence*: The HGC and AEBC were constituted as independent advisory bodies, while the FSA was set up as a non-ministerial government department charged with protecting consumer interests in relation to food safety and standards.
- *A diverse membership*: Each body included expertise that extended beyond immediate areas of scientific expertise, to include lawyers, social scientists, philosophers, ethicists, and representatives from industry and civil society organisations.
- *A commitment to openness and transparency*: Meetings tended to be held in public (AEBC and FSA), and bodies have been committed to openly publishing minutes, reports, and decision points on the web.
- *Mechanisms for embedded public scrutiny and representation*: Each body has attempted to embed public scrutiny within the internal workings of the advisory process: for example, the FSA includes at least one lay member on each of its ten advisory committees, while the HGC has set up a consultative panel made up

of over 100 people with direct experience of living with genetic disorders to provide feedback on reports and decision recommendations.

A dominant governance response of these UK advisory bodies, reflected also in parallel genomics-related science and policy institutions in other Western countries, has been to develop formal invited public dialogues as a way of eliciting public views and concerns over genomics developments, often on a one-off basis relating to key decision points or policy-making processes. The AEBC led the *GM Nation?* national consultation on the commercialisation of GM crops in the UK in 2003 (Horlick-Jones et al. 2007); the FSA held its own public dialogue processes on GM food in the same year to link with the government's wider public debate on GM (FSA, 2003); while the HGC has run a number of consultations including the Sciencewise-ERC sponsored Citizens' Inquiry into the forensic use of genetic information in 2008 (as discussed in Chapter 2). Although a range of stakeholders and affected publics have been involved in certain processes, the emphasis has been on representing the general public, on engaging 'innocent citizens', and on using deliberation for the purpose of knowledge extraction for policy decision-making (similar trends have been examined by Braun and Schultz (2010) in a survey of participatory governance arrangements in the area of genetic testing in Germany and the UK).

In contrast to this governance response format there are increasing moves towards more distributed forms of innovation and public interaction with genomics research, including open innovation and crowdsourcing. This can be seen, for example, in recent developments in personal genomics. Over the last two or three years, commercial companies have rapidly extended the provision of direct-to-consumer genome testing, designed to provide the public with their own genomic information. Crowdsourcing is a further technique through which patient and online communities can contribute their information directly to large research datasets (Prainsack and Wolinsky, 2010). Supporters of this model of patient-driven research see it as the "democratization of research and say they are pioneering new models that put patients in control of their data and build bridges between researchers, patients and their doctors" (Arnquist, 2009). The personal genomics company *23andMe* is pioneering this new approach where customers purchase a genome scan but are also encouraged to upload phenotypic information and lifestyle data to a larger data pool for their own commercial purposes. Other ventures, such as the Personal Genome Project (www.personalgenomes.org), are using crowdsourcing as a technique for participant enrollment, but also use open-sourcing to share the data generated from these participants in an open format.

Many more forms of open innovation and collaboration are taking shape in genomics research, often initiated by scientists, industry, or collectives of actors on open platforms (further examples include Open Source Drug Discovery (www.osdd.net/home) which fosters collaboration around genomics and computational technologies; and diybio (www.diybio.org) a community for do-it-yourself biologists). In the scientific literature at least (e.g. Ekins & Williams, 2010) the rationales for such governance responses are focused on efficiency-based arguments and knowledge gains through pooling ideas and data. Some go as far as claiming that the rise of "personal genomics companies offering online whole genome scanning services seems to have made a quantum leap in the democratization of genomic knowledge" (Knoppers, 2009: 378). Yet in the main these appear largely extractive 'citizen science' exercises where the data is not then made available in a public way that can empower citizens or allow them potentials to challenge the directions and governance practices of genomics research. There remain, in addition, concerns over issues of data protection, anonymity, and participatory ethics. The handling of these concerns, and potentials for public

involvement in governance responses, is much more developed in many national and international biobank initiatives (Gottweis & Lauss, 2010), including professional codes of conduct and additional governance responses in the form of independent oversight structures (Wallace et al., 2008).

Different forms of participation are enacted in uninvited spaces of engagement, not least forms of activism and protest, and these have long been associated with genomics-based science and technologies. The response of science and policy institutions to these alternative spaces of engagement is often one of denial, although such forms of representation have arguably had an indirect influence in prompting the above-explained institutional changes that took place in relation to the governance of agricultural biotechnology through the late 1990s. In taking a longer-term view on the role and dynamics of uninvited engagement in the agricultural biotechnology arena, Wynne has recently traced how public opposition to GMOs and uninvited public engagement played a largely indirect role in reorientating UK plant and crop science research strategies from a narrow vision concentrated on GM to a more holistic, diverse and flexible portfolio that now includes non-GM approaches to crop improvement (Wynne, 2010; Doubleday & Wynne, in press). This occurred through the UK Biotechnology and Biological Sciences Research Council (BBSRC) and other scientific actors reflecting on the reasons for public opposition, and became evident in the BBSRC's 2004 *Crop Science Review* with its emphasis on 'public-good' plant breeding. Such forms of influence remain an open question, but they do raise critical issues about the ability of science and policy institutions to acknowledge and listen to the uninvited voice (as well as reflect on their own scientific institutional cultures).

Nanotechnology

It is inevitable that concerns about the social, ethical and environmental implications of nanotechnology have been shaped by past experiences relating to the introduction of new and emerging technologies. In particular, the initial drive towards upstream public engagement in nanotechnology was at least in part fuelled by a desire to learn lessons from the experience of GM crops in Europe, where arguably there had been a failure to recognise public concerns about the development of these technologies until after public resistance to their commercialisation had solidified (Kearnes et al., 2006). In this sense, nanotechnology has been represented as an opportunity to gain public input and explore social and ethical implications much earlier on in the innovation process, when it is still possible to shape the development of the emerging technology (Macnaghten et al., 2005).

Nanotechnology has also been viewed by social scientists and others as an opportunity to move the debate from a narrow focus on risk governance, where the questions are reduced to ones of risk and safety, to 'innovation governance' (Felt & Wynne, 2007), which emphasises 'upstream questions' of the sort routinely raised by publics in dialogues (see Chapter 2), such as: "Why this technology? Why not another? Who needs it? Who is controlling it? Who benefits from it? To what ends will it be directed?" (Wilsdon & Willis, 2004). The hope was, and still is, to deepen reflection and debate about human needs and purposes associated with emerging areas of science, technology, and innovation (Kearnes et al., 2006).

These questions have driven a set of initiatives aimed at the upstream engagement of nanotechnologies and the development of governance responses. The dominant response from science and policy institutions, at least in the early stages, has been to orchestrate managed spaces of small-scale public deliberation, and citizen-scientist interaction, to negotiate the social and ethical implications of emerging

nanotechnologies. Examples of this format include: the Sciencewise-ERC sponsored *Nanodialogues* project (see Chapter 2) (Stilgoe, 2007); the ESRC-funded project *Nanotechnology, risk and sustainability* (Kearnes et al., 2006); the *Nanotechnology for Healthcare* public dialogue (BMRB, 2008); the NanoJury UK project (Gavelin et al. 2007); the Copus-funded *Small Talk* project (Gavelin et al. 2007); and the Wellcome Trust funded project *Democs* (Gavelin et al. 2007). Parallel and complementary responses can be identified across Europe and North America. The EU FP7 NANOPLAT project has surveyed a number of these deliberative processes on emerging nanotechnologies across Europe (Stø et al. 2010), which mainly take the form of heavily engineered spaces of public deliberation involving ‘innocent citizens’.

A further nanotechnology governance response, initiated to a large extent by the social scientific research community, has been the development of integrated systems of ‘real-time technology assessment’ (Guston & Sarewitz, 2002) and ‘anticipatory governance’ (Barben et al 2008), as demonstrated in the work of the Centre for Nanotechnology in Society at Arizona State University. Here forms of public engagement and dialogue such as those noted above, foresight practices, and reflexive collaboration between natural and social scientists are brought together in a comprehensive framework. This offers an integrated and systematic approach to building in continuous reflection on the social and ethical implications of nanotechnologies as they are being developed. It also highlights the importance of encouraging and building the capacity of nanoscientists in the laboratory to enact such reflection themselves with the help of, and in collaboration with, social scientists (Doubleday, 2007).

These largely discrete and contained experiments have led recently to institutional responses that are beginning to consider the wider governance system, and that seek to bring about the responsible development of nanotechnologies through more distributed and self-regulated means. This includes: (1) voluntary reporting schemes, such as the *Voluntary Reporting Scheme for Engineered Nanoscale Materials* developed by Defra as a mechanism for building evidence on possible risks; and (2) voluntary codes of conduct and emerging mechanisms aimed at the responsible development of nanoscience and nanotechnologies. In the UK, the Royal Society, Insight Investment and the Nanotechnology Industries Association (NIA), developed the ‘Responsible NanoCode’, aimed at ensuring responsible practice. At the European level, a ‘Code of Conduct for Responsible Nanosciences and Nanotechnologies Research’ has been developed, based on seven underlying principles: meaning, sustainability, precaution, inclusiveness, excellence, innovation and accountability (European Commission 2008). The principles are defined below.

- *Meaning*: N&N research activities should be comprehensible to the public. They should respect fundamental rights and be conducted in the interest of the well-being of individuals and society in their design, implementation, dissemination and use.
- *Sustainability*: N&N research activities should be safe, ethical and contribute to sustainable development serving the sustainability objectives of the Community as well as contributing to the United Nations' Millennium Development Goals. They should not harm or create a biological, physical or moral threat to people, animals, plants or the environment, at present or in the future.
- *Precaution*: N&N research activities should be conducted in accordance with the precautionary principle, anticipating potential environmental, health and safety impacts of N&N outcomes and taking due precautions, proportional to

the level of protection, while encouraging progress for the benefit of society and the environment.

- *Inclusiveness*: Governance of N&N research activities should be guided by the principles of openness to all stakeholders, transparency and respect for the legitimate right of access to information. It should allow the participation in decision-making processes of all stakeholders involved in or concerned by N&N research activities.
- *Excellence*: N&N research activities should meet the best scientific standards, including standards underpinning the integrity of research and standards relating to Good Laboratory Practices.
- *Innovation*: Governance of N&N research activities should encourage maximum creativity, flexibility and planning ability for innovation and growth.
- *Accountability*: Researchers and research organisations should remain accountable for the social, environmental and human health impacts that their N&N research may impose on present and future generations.

Innovative experiments in responsible innovation are now underway within particular institutional contexts, such as the Engineering and Physical Sciences Research Council's (EPSRC) Nanotechnologies Grand Challenge for Environmental Solutions, which has trialled new anticipatory risk governance approaches in the form of risk registers. The research programme, on the use of nanoscience for carbon capture and utilisation, asked applicants to submit a 'risk register' to accompany the application, aimed at identifying the wider potential impacts (social, environmental, ethical) of their proposed research (Owen and Goldberg, 2010). Although applicant responses tended to focus conservatively on considerations of technical risk, either to the environment or to human health, rather than a consideration of broader societal issues and effects, this was not always the case. A minority of bids did address wider social and ethical aspects through building multidisciplinary teams that included social scientific expertise; the adoption of frameworks of real time technology assessment; and building public and stakeholder engagement into the research design (Owen and Goldberg, 2010).

While the above initiatives point to a new governance landscape, the extent to which they have impacted on institutional culture is less clear: the Defra Voluntary Reporting Scheme had only limited take-up; the European Code of Conduct has reportedly been met with resistance by various Member States; the UK Responsible NanoCode has been dormant for a couple of years; and so on (for wider analysis see Davies et al., 2009). Nevertheless, these initiatives suggest an important rhetorical shift in policy rhetoric towards anticipation and responsibility, accompanied by institutional moves aimed at considering the wider ethical and social dimensions of nanotechnology earlier on in the innovation process.

Climate science

Ever since the earliest stages in the formation of international action on climate change, the framing of the debate has been dominated by climate science, which has assumed a linear relation to policy development (Pielke, 2010). This has shaped the governance of climate science, with appeals to scientific consensus seen as central to the policy goal of promoting action, and through a largely distant relationship between climate science and society, with interaction mainly occurring through the media.

This seemingly cosy relationship between climate science, policy and society has been shaken over the past year in the wake of the UEA hacked emails affair and questioning of the impartiality, accuracy and balance of IPCC scientific assessments. Recent events have led, in certain instances and in conjunction with other factors, to increasing public scrutiny and an erosion of public trust in climate science. Ongoing developments in the governance of climate science have been brought to a head and in some cases accelerated post-‘Climategate’, potentially providing an opportunity to reconfigure the climate science-policy relationship and leading to a new wave of governance responses both in the UK and internationally.

The possible nature and scale of these responses has been indicated in a series of reviews and independent inquiries. For example, recommendations from the Muir Russell independent review into the UEA hacked emails emphasise the need for openness and transparency in relation to climate science, models and data, as well as improvements in communication, peer review processes, and the handling of uncertainties in climate science (Russell et al. 2010). Similarly, recommendations from the InterAcademy Council’s recent international review of climate change assessments focus on the IPCC’s governance and management, including its review process, characterisation and communication of uncertainty, communications, and transparency in the assessment process (InterAcademy Council, 2010).

In addition to moves to improve the communication of climate science both in terms of how scientists relate to non-scientific audiences and the handling of uncertainties, the most widespread and high profile responses have been initiatives to open up climate science data and codes (Kleiner, 2011). A number of open data projects have been initiated, including a JISC-funded project being carried out by the Climatic Research Unit at UEA, in partnership with the Science and Technology Facilities Council (STFC) e-Science Centre. Another significant development has been initiatives to open up the codes that underpin climate change models to wider access by scientists and non-scientists, such as work by The Climate Code Foundation which is seeking to rebuild “trust and support [in climate science and policy], by improving the transparency and communication of the science, and especially the software used in the science” (The Climate Code Foundation, 2010).

There is no doubt that recent events are leading to changes in the practice and governance of climate science. As the Muir Russell review team state: “Like it or not, this indicates a transformation in the way science has to be conducted in this century” (Russell et al. 2010: para 36). But what is the nature and extent of change needed to properly address the issue of waning public trust in climate science? Is it enough to enhance climate science communication and to open up data as reflected in the dominant response to the crisis so far? Although constructive and necessary, such moves are science-centred and arguably leave the dominant framing of climate change, and the linear relationship between climate science and policy/action (as outlined above), untouched.

A collective of leading thinkers on climate change from the sciences and humanities have recently argued for a more radical reframing of climate science and policy in *The Hartwell Paper: A new direction for climate policy after the crash of 2009* (Prins et al. 2010). The group suggest that the popular view of science, which assumes a linear relationship between climate science and policy and adherence to a ‘deficit model’ (Wynne, 1991) where communicating more information in more effective ways is expected to enhance public trust and pro-environmental action, represents a misunderstanding of the science of earth systems. They suggest it is based on a

“...flawed assumption that the solutions to climate change should be ‘science driven’ as if a shared understanding of science will lead to a political

consensus. Rather, as we have seen, the diverse political framings reveal themselves in alternative views of science. The consequence is that debates about climate politics are then waged in the guise of debates about science, to the detriment of both” (Prins et al. 2010: 17-18).

The Hartwell Paper calls for a more humble and practical way of thinking about climate science that acknowledges the multiple framings inherent to debate on climate change (Hulme, 2009), and the role of value-judgements including their relation to science (Pielke, 2007), which need to be opened up to democratic deliberation. The group argue that the framing of the climate issue needs to be inverted: from a focus on sin to that of human dignity; from viewing climate change as a conventional tractable environmental problem to understanding it as a persistent condition that must be coped with; and from seeing ‘climate policy’ as a single, target driven, coherent and enforceable thing under which multiple issues reside to one where “multiple framings and agendas are pursued in their own right, and according to their own logics and along their own appropriate paths” (Prins et al., 2010: 10).

In short, it is suggested that the restoration of trust in expert organisations depends on a radical reframing and reconfiguration of the relationship between climate science, climate policy and societal change. In addition to practical changes relating to three overarching objectives, this reframing can be seen as involving recognition that “to be validated, knowledge must also be subject to the scrutiny of an extended community of citizens who have legitimate stakes in the significance of what is being claimed” (Hulme & Ravetz, 2009). The significance of this is further emphasised by debates over the credentials of traditional forms of peer-review following recent climate science controversies. Possible governance responses include widening representation on expert committees, scientists engaging in discussions on the blogosphere, through to opening mechanisms of extended peer review. Beyond this, responses could take the form of co-produced forms of knowledge production with climate scientists working in collaboration with social scientists and non-scientists; upstream public engagement on climate change related technologies (such as the case of geoengineering discussed in Chapter 2); the contribution of expertise and insights from non-scientific disciplines in the arts and humanities; distributed forms of climate science; and recognition that other knowledges and ways of living with and acting on climate change are a necessary part of the innovations needed to form a low-carbon future.

Chapter 4: SYNTHESIS AND CONCLUSIONS

Our review of the science governance issues emerging from Sciencewise-ERC sponsored public dialogues in Chapter 2 identifies five main themes that capture the crosscutting features of public concern on the governance of science.

1. *The purpose of science and technology.* Across a number of dialogue projects people expressed considerable ambivalence towards science, technology and innovation. A key issue that underpins their ambivalence was their concern with the *purpose of science and technology* and with the underlying motivations of scientists. What are the motivations for the science? Whose interests are they serving? Is it necessary? Is there a clear rationale? Are there alternatives?
2. *Trustworthiness of institutions.* A second issue relates to the relative *lack of trust in government* to act in the public interest. While this differs across science and technology areas – such as between health and food – key issues relate to the perceived proximity between government and the interests of industry, how relationships between them are governed and how trustworthiness is earned or developed.
3. *Feelings of powerlessness and exclusion.* Third, people tend to feel that they are *not included* in deciding what kinds of science and technology get funded, and feel they are ‘kept in the dark’. They also express a desire to feed their values and aspirations into the science and innovation process.
4. *Speed and direction of science and innovation.* The fourth theme relates to the *speed of research and innovation*. Specifically, that the pace of scientific and technological development exceeds its scope for ethical and regulatory oversight and that it may take us in directions that have not been adequately considered. These concerns raise questions about how regulatory frameworks can become more flexible and adaptive in order to keep up with the new directions science may take us.
5. *Ethics and the culture of science.* Finally, people were concerned with whether the *culture of science* discourages scientists from voicing concerns over potential risks and uncertainties, or to reflect on wider social and ethical considerations. Key issues include how organisational culture encourages, or not, discussion, reflection and communication of these dimensions of science and technology.

A brief mapping of governance responses across three distinct science and technology areas in Chapter 3 suggests the following trends.

- An identifiable move to go beyond formal deliberative processes – which remain a dominant and important governance mechanism – towards a more diverse range of ways in which scientists and institutions can be exposed to public issues. These range from moves to understand perspectives emerging from ‘uninvited engagement spaces’ (such as the blogosphere) and various forms of outreach, knowledge transfer and exchange, through to crowdsourcing and data mining.
- Governance responses associated with more distributed and open forms of innovation – such as opensourcing, crowdsourcing, and co-design –

are rapidly emerging and hold much potential. In some instances questions remain over whether they are merely extractive processes or whether they offer the public a genuine role in shaping the framing, direction and governance of particular scientific and technological innovation.

- Explicit commitments to institutional redesign towards openness, transparency, and accountability. Such innovations, which were evident in the governance of genomics-related issues during the late 1990s, have recently come to the fore in the climate change context. The dynamic through which change materialises in practice raises questions about the role of public resistance and controversy in mediating governance responses.
- The development of voluntary codes of conduct as an alternative to purely regulatory or top-down audit practices is evident, although the effectiveness of this change remains unclear. The emphasis of voluntary mechanisms on communication and education in relation to codes of conduct – rather than supporting their implementation through changes to infrastructure or the research environment – has potentially slowed their uptake.
- In attempting to map the diversity of governance responses in this review the relative emphasis has leant towards those that are novel and emergent. It is worth noting that there are a number of more established governance mechanisms evident in these science and technology areas – such as ethical codes of conduct (e.g. the Universal Ethical Code for Scientists), ethics review committees and public engagement mechanisms, alongside training and culture change programmes that seek to build capacity in these aforementioned areas.⁵

It has not been our intention to trace direct causal connections between the governance concerns emerging from particular public dialogues analysed in Chapter 2 and the governance responses reviewed in Chapter 3. We are able to make some general observations at this point, however, that while some of the governance issues identified in Chapter 2 are at least partly responded to in governance practices (concerns about inclusion for example) others are not so evident (such as concerns over the purposes of emerging science and technology). For instance, in the case of nanotechnology, upstream questions relating to human needs and purposes are often reduced to ones of risk and impacts in actual governance practice. The emphasis on human health risk to researchers and omission of social implications in responses to EPSRC's risk register is just one example.

The influences at play here and the processes of institutional response are clearly complex and have been 'blackboxed' to some extent in past social scientific research. In order to understand these complexities it is important to adopt a grounded research strategy based on an in-depth qualitative approach that openly allows competing explanations to emerge. Having said this, the following issues should be examined or acknowledged in any inquiry that seeks to understand how institutions and governance systems respond to public concerns.

- An explicitly sociological and contextual approach – as adopted in this review – can offer an understanding of governance responses in the context of a complex interplay of multiple actors, intermediaries and

⁵ Recommendations and actions in these areas have been outlined in the March 2010 report of the BIS *Science and Trust* Expert Group.

possible influences. This suggests that an exploratory and grounded research approach is appropriate.

- Theories of organisational learning and change (Argyris & Schön, 1996; Schein, 1995), are also instructive in outlining possible barriers, drivers, and influences of institutional response including factors such as: leadership, organisational culture, stakeholders, resources, learning processes, experience, and values/beliefs. These have been directly applied to understanding organisational behaviour in relation to participatory governance and public engagement practices (e.g. Chess and Johnson, 2006), including in the UK (Colbourne, 2010; Wolcott & Sengupta, 2010).
- Related to this is the inability of scientific institutional cultures to reflect on their own cultures and their assumptions about others, including the public. In this sense the problem of public trust in science can be seen as “a symptom of a continuing failure of scientific and policy institutions to place their own science-policy institutional cultures into the frame of dialogue” (Wynne, 2006: 211). The “deeply-entrenched habitual tendency in science and governance to imagine possible learning as instrumental only” (Felt & Wynne, 2007) – as has been shown to be the case in participatory governance of science and technology in the UK (Chilvers, 2010) – can limit the ability of institutions to fully understand and respond to the sorts of governance concerns outlined in Chapter 2, which could be made possible through more transformative, reflective and relational forms of learning (Schon, 1983).
- Finally it is important to emphasise the prevailing conditions, or wider ‘driving forces’, that shape the governance of science and technology (as alluded to in the genomics case in Chapter 3 and as implicated in discussions of powerlessness and personal agency in Chapter 2). These include: the political economy of emerging science and technologies, national economic competitiveness, and corporate interests (Irwin, 2006); the increasingly globalised nature of science and technology (Leach et al. 2005); and power relations. This resonates with governance concerns in Chapter 2 about how science and technology can reinforce patterns of inequality and exclusion, and with situations where governance instruments are seen as likely to be used by powerful actors as a means of justifying particular positions, decisions or outcomes (Stirling, 2008).

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Appendix 1. Sciencewise-ERC Publications (all available at <http://www.sciencewise-erc.org.uk>)

1. Sciencewise-ERC Dialogue Projects

- i. Animals containing Human Material (2010)
- ii. Big Energy Shift (2008-2009)
- iii. Community X-Change (2005-2008)
- iv. Drugsfutures (2006-2008)
- v. Energy 2050 Pathways (2010-2011)
- vi. Forensic Use of DNA (2007-2008)
- vii. Geoengineering (2010)
- viii. Hybrids and Chimeras (2006)
- ix. Industrial Biotechnology (2008)
- x. Landscape and Ecosystem Futures (2011)
- xi. Low Carbon Communities Challenge (2010-2011)
- xii. Nanodialogues (2005-2007)
- xiii. Risky Business (2005-2006)
- xiv. Science Horizons (2006-2007)
- xv. Stem Cells (2007-2008)
- xvi. Synthetic Biology (2009-2010)
- xvii. Trustguide (2005-2006)

2. Sciencewise-ERC Reports

- i. Project Guidance: □The Road Ahead □Guiding Principles
- ii. What is Sciencewise-ERC?
- iii. Sustainable Participation
- iv. Ethical Dimensions in Sciencewise-ERC
- v. What the public say: Public engagement in national decision making
- vi. What the public say about designing climate change and low carbon interventions
- vii. Organisational Learning and Change for Public Engagement. Consultation and communications in relation to motivational needs
- viii. International Comparison of Public Dialogue on Science and Technology

3. Sciencewise-ERC Research Publications

- i. Evidence Counts Report
- ii. Evidence Counts Summary
- iii. Use of Experts in Public Dialogue Report
- iv. Use of Experts in Public Dialogue Summary
- v. Working with Media Report
- vi. Working with Media Summary
- vii. Widening Public Involvement in Dialogue Report
- viii. Widening Public Involvement in Dialogue Summary
- ix. Departmental Dialogue Index Tool
- x. Departmental Dialogue Index Summary
- xi. Departmental Dialogue Index Background Report
- xii. Enabling and Sustaining Citizen Involvement Summary
- xiii. Enabling and Sustaining Citizen Involvement Report