

March 2010

SCIENCE AND TRUST EXPERT GROUP REPORT & ACTION PLAN

Starting a National Conversation
about Good Science

Contents

<i>Accompanying Research on our website</i>	1
<i>A Note on Definitions and Scope</i>	1
<i>Membership</i>	2
<i>Executive Summary</i>	3
<i>Introduction from the Chairs</i>	5
<i>The Group: Aim, Objectives and Activities</i>	8
<i>What is meant by Trust and is there a lack of trust in the sciences?</i>	10
<i>The Science and Trust Group Action Plan</i>	14
1. <i>Supporting Public Judgements on Sciences and their uses</i>	14
2. <i>Acknowledging risk and uncertainty</i>	17
3. <i>Government and Scientific Advice</i>	20
4. <i>Private Industry and Science Advice</i>	25
5. <i>The Ethical Contexts of Science and Research</i>	26
6. <i>Building Partnerships</i>	35
7. <i>Evaluating Science and Society Initiatives</i>	38
8. <i>Monitoring public attitudes and our progress</i>	42
<i>Conclusion</i>	44
<i>Glossary</i>	45
Annexes:	
<i>Annex 1 – List of Organisations Consulted or Involved in the Work of the Group</i>	48
<i>Annex 2 – Report of Science Advice Workshop</i>	51
<i>Annex 3 – Report of Evaluation Workshop</i>	53
<i>Annex 4 – Note of Risk Workshop</i>	60
<i>Annex 5 – Summary of The Universal Ethical Code for Scientists and the “Crisis of Trust in Science”</i>	62
<i>Annex 6 – Summary: Psychological Review of Trust</i>	65
<i>Annex 7 – Summary: Ethical Dimensions in Sciencewise</i>	67
<i>Annex 8 – Summary of The Universal Ethical Code for Scientists and Assessment by Chairs of Scientific Advisory Councils and Pilot Institutions</i>	69
<i>Annex 9 – Summary: Ethics Training in Universities</i>	71
<i>Annex 10 – Public Attitudes to Science Survey Review</i>	74
<i>Annex 11 – Ethics Training for Scientists and Engineers</i>	76

Accompanying Research on our website

The Universal Ethical Code for Scientists and the "Crisis of Trust in Science"

Tim Lewens & Stephen John

Psychological Review of Trust

Ann Macaskill & Kyle Brown

Ethical Dimensions of Sciencewise: A review of public perceptions of ethical issues from the Sciencewise dialogues

Daniel Start

The Universal Ethical Code for Scientists and Assessment by Chairs of Scientific Advisory Councils and Pilot Institutions

Richard Greenberg & Suzanne King

Ethics Training in Universities

Fiona Hill

Summary of STEM Ambassador and GSE surveys

Science and Trust Group Secretariat

A Note on Definitions and Scope

We accept and wholeheartedly support the BIS definition of science, namely encompassing research and practice in the physical, biological, engineering, mathematical, health and medical, natural and social disciplines, and research in the arts and humanities.

However, that landscape represented much too broad an area for this Group to cover effectively. So we made an early decision to consider actions with a primary focus the sciences in the STEM (science, technology, engineering and mathematics) sense of the word. We hope that the follow-on group we have proposed will have a wider remit to consider issues of trust, ethics and governance in relation to other disciplines.

Membership

Chair:

Dr Aileen Allsop

Vice President for Science Policy, Research and Development, AstraZeneca

Dr Tony Whitehead

Joint Head of Science in Government, Government Office for Science

Members:

Charles Blundell

Director of Public Affairs, Rolls-Royce

Professor Brian Collins

Chief Scientific Advisor, Department for Business, Innovation and Skills (BIS)

Dr Robert Frost

FORUM Manager, Academy of Medical Sciences

Dr Tim Lewens

Lecturer in History and Philosophy of Science, University of Cambridge

Professor Ragnar Löfstedt

Professor of Risk Management, King's College, London

Professor Ann Macaskill

Professor of Health Psychology, Sheffield Hallam University

Dr Gordon MacKerron

Director, Sussex Science and Technology Research Unit

Dr Natasha McCarthy

Policy Advisor, Royal Academy of Engineering

Professor Maggie Pearson

Academic and Training Programme Director, Office of the Chief Scientific Officer, Department of Health

Professor Steve Rayner

Director, Institute for Science, Innovation and Society, James Martin Professor of Science and Civilization, Said Business School, University of Oxford

Professor Michael Reiss

Professor of Science Education, Institute of Education, University of London

Professor Dame Nancy Rothwell

Vice-President for Research, University of Manchester

Dr Bob Sorrell

Technology Vice-President, BP

Dr James Wilsdon

Director of the Science Policy Centre, Royal Society

Executive Summary

Throughout the course of this Group's work, Group members have considered a range of evidence and opinion on whether there is a crisis of public confidence in the sciences. We have also been concerned with how the network of relationships across the wide science and society landscape can be built on and developed to strengthen both the content of scientific evidence and its application. We rejected the idea of a "crisis of trust" in science. Instead, we focused on how to support the public in developing informed opinion around the application of science and the value of expert advice.

There was a strong consensus in the Group's first meeting that it did not want to promote a blind and unquestioning faith in the sciences; rather, that a degree of healthy scepticism was preferable, and a sign of a healthy democracy. With that in mind the overarching aim was articulated as:

To enhance society's capabilities to make better-informed judgements about the sciences and their uses in order to ensure that the "licence to operate" is socially robust

To achieve progress towards that goal, we have developed our Action Plan around a number of broad aspirations stemming from it, namely:

1. Supporting public judgements about sciences and their uses and enabling publics to become more aware of scientific processes;
2. Acknowledging risks and uncertainties inherent in undertaking and interpreting scientific work;
3. Ensuring that Government and others have access to and use the best scientific advice;
4. A commitment to explore further mechanisms to generate informed and balanced opinion of the business use of science
5. Embedding good governance of science including the relevance and availability of ethical codes and ethical training;
6. Building partnerships across business, science, social science, Government, academia and the public to ensure that the impacts on science and society are considered from all available angles;
7. Monitoring and responding to public attitudes;
8. Evaluation of the impact of science and society initiatives.

We make a call for greater discussion around risk, uncertainty, and the processes involved in knowledge production, and set out a number of recommendations and actions around governance of science. Indeed, many of the recommendations are based around Government's use of science. There is evidence that the UK system is among the best in Europe, but more can be done to support ongoing work around scientific principles and advice. One of the areas where we are acknowledged¹ to be among the world's leading nations is in public dialogue and we are pleased to be able to report a commitment from Government, research councils, and the wider research community to using deliberative dialogue to enable development of more robust policies. Dialogue itself can deliver real insights into the ethical concerns around new and emerging technologies, and promotion of ethically aware scientific practice is naturally a key element of this report. We have assessed awareness and impact of the Universal Ethical Code for Scientists, and suggested a new role in and outside of Government for an invigorated and revised code.

We also put forward proposals for a shared response to evaluation of science and society initiatives, and hope that practitioners will use those to start a debate, and build good practice across the sector.

While undoubtedly we could have done more, and we are aware that we may have unwittingly, or simply through pressure of time, overlooked potentially useful organisations and individuals, we are confident that our actions bring together a broad range of activities and organisations that have not previously been considered in the round.

When the actions we have proposed are completed we expect to see change in a number of key areas including:

- Publics increasingly provided with information around scientific risk, uncertainty and the processes involved in science, knowledge generation and decision making;
- A strengthened system of scientific advice to Government;
- A network of Government scientists enabled to build relationships and discuss science openly with policy colleagues and publics;
- A continued and growing commitment to strengthening interdisciplinary relationships, and a greater willingness to bring new partners closer to the policy making process;
- A commitment to raising awareness of the ethical contexts in which science is conducted, in Government, business, academia and elsewhere;
- An ever growing commitment from business and industry to work with their local and wider communities not only to develop the next generation of scientists, but also to open up their processes;
- A focus on "community ownership" of the evaluation processes underpinning science and society initiatives;
- Government commitment to learning from this action plan (and those of our four sister Groups) in developing the next Public Attitudes to Science study.

1 Sykes, Kathy. (2009). "Public Dialogue about Science: Creating Successful Experiences". *ASTC Dimensions*. September/October 2009.

Introduction from the Chairs – Aileen Allsop & Tony Whitehead



As readers may be aware, the work of this Group evolved from the 2008 Science and Society consultation and its subsequent analysis². This Group is one of five, and had a remit to examine issues around trust and governance of science. This included recognition of the importance of building relationships between key actors, and across the disciplines, as well as a requirement to examine how the interactions that result should be evaluated.

We could equally have called this report “The Sciences and Trust” to reflect the fact that it is relevant to, and captures learning from, the sciences in their broadest sense, as set out in our definition. It aims to bring together researchers from **all** disciplines to help shape the governance of science, and help explain and understand the ethical and social contexts in which science and technology are developed and applied, and ultimately shape the kind of societies in which we want to live. We would like to have been able to consider the broader research community, and reflected the broadest possible definition of science, and indeed this would have reflected the interests and inclinations of many in the Group. But we had to choose a boundary to our focus, and that has largely been around the natural and physical sciences, engineering and technology.

The five Science and Society Expert Groups have, to varying extents, been looking at why and how sciences and scientists and the wider research community engage with their publics, and how they shape the development of the future scientist. It goes without saying that science, engineering and technology will help us build the future – helping shape the economic destiny of nations, as well as improving the well-being of individuals as we move towards an increasingly knowledge-driven economy in the UK in which advanced manufacturing, the biosciences, low carbon industries, and virtual spaces will increasingly shape our lives, our work, and our life and leisure choices.

However, scientists will not create that greener, leaner, virtual world in isolation. Evidence and instinct both suggest that the best developments will be those which are based on ethically produced science; that is science which takes proper account of the ethical, moral and social contexts in which it is developed and applied, and seeks to appreciate the range of impacts which the introduction of new and emerging developments will have upon individuals, communities, societies and nations. This is recognised by major users and producers of science such as the Wellcome Trust, who recognise that they can only foster the best science by seeking to gain a better understanding of the societal and ethical contexts in which science is produced, and applied.

Science produced outside the ethical framework within which we are confident that most scientists (and researchers across the sciences, social sciences and humanities) operate, can have, in the most extreme cases, life threatening implications. Equally, there have been numerous high profile examples, some within the lifetime of this Group, that show how behaviour which is perceived to fall outside the rigorous standards expected can raise

² http://interactive.bis.gov.uk/scienceandsociety/files/A_Vision_for_Science_and_Society.pdf

concerns about the strength and integrity of whole systems. Those situations around climate change data, the use of scientific advice within Government, and the final censuring of Dr Andrew Wakefield, have been accompanied by calls for greater openness, transparency, and a greater literacy around the risks and uncertainty of the scientific process. What they also vividly demonstrate, is how entrenched opinions can be on both sides of any given debate.

The popularity of Ben Goldacre's *Bad Science* proves that there is a public appetite for and interest in what happens when scientists and those around them fail to live up to the high standards expected of them. The popularity of that book, Ben's blog³ and the *Guardian* series has undoubtedly been useful in increasing the public's exposure to the issues. But what about when science goes "right"? Why shouldn't that be celebrated, promoted and explored further? So we want to start a national conversation about "good science", and see further discussion of what that means in practice.

But the Group was equally clear and unanimous in its agreement that it didn't want publics to blindly and uncritically accept what scientists tell them; rather we want to see all actors and influencers working together to enable a greater degree of critical reasoning and discussion, and better communication of scientific processes.

We are encouraged that much good work is already taking place in this domain, with organisations like the Nuffield Council on Bioethics, the Wellcome Trust, and the Association for Research Ethics Committees, organising and facilitating discussion on both risk and ethical considerations. Given the focus of their activities, it would seem that the biomedical community is leading the game in fostering such discussion, and in setting out expected and accepted practice, but we feel confident that the actions in this report reflect a blossoming of that process, and a widening of the debate. As new and emerging technologies come on stream, organisations like the Royal Society, the Royal Academy of Engineering, the Academy of Medical Sciences, the Beacons for Public Engagement, Sciencewise-ERC, and the Responsible Nano Forum are finding new ways to consider their implications, and engage non-scientists in debate.

Anyone undertaking work of this nature would, doubtless, be simultaneously impressed with the actions already underway to build relationships between science and society, and with the resources available for building trust, confidence, and ethical awareness specifically. But, equally they should question the value of the relatively haphazard approach to communication: there are a plethora of resources available, but no overarching narrative to bring them together. Consequently, one recommendation is for interested parties in Government, industry, and beyond, to scope out commissioning an actively updated information source which can optimise the best available knowledge and learning in this arena.

That could be a web-based resource: it almost goes without saying that access to the internet, and the Government's emphasis on increasing online access, for example through Martha Lane Fox's role as Digital Inclusion Champion, the growth of UK online centres, the rollout of broadband announced in *Digital Britain*⁴, and the actions in the new *National Plan for Digital Participation*⁵ could create a real change in access to resources for that percentage of the population which is currently offline. Similarly, Web 2.0 and social media channels are already beginning to influence and open up the knowledge production and research

3 www.badscience.net/

4 <http://interactive.bis.gov.uk/digitalbritain/>

5 www.bis.gov.uk/uploads/plan-digital-participation.pdf

processes in ways that would not have been thought of even five years ago. To scientists and researchers using those channels, we would say continue to think creatively about how relationships and processes can develop, and we look forward to seeing how the landscape develops.

We are especially grateful to all our Group members, for sharing their time and their expertise, and to a number of individuals who deputised for those "official" Group members and contributed to our work. These included Rob Doubleday (currently with the Government Office for Science on secondment from the University of Cambridge); Alice Raine (Assistant Chief Scientific Adviser, BIS); Jessica Bland (Royal Society); and Lesley Paterson (Royal Academy of Engineering).

We are also grateful for the research carried out by Suzanne King, Richard Greenberg and Tara Webster from People Science and Policy (PSP) Ltd in two distinct projects. Their work was itself facilitated by a number of Scientific Advisory Committee Chairs, and by staff from the Environment Agency, the Forestry Commission, the Veterinary Laboratories Agency, and the Health and Safety Executive. Sixteen members of the public also provided input to that testing process, and the insights they, provided will prove invaluable both to this report, and to BIS as it conducts the next *Public Attitudes to Science Survey*, due for publication in 2011.

Our thanks extend to: Stephen John who, with Tim Lewens, helped the Group articulate its views on trust; Kyle Brown, from Sheffield Hallam University, who worked with Ann Macaskill on a literature review on trust; Fiona Hill, who undertook desk research on ethical training in universities; Daniel Start, a member of the Sciencewise Dialogue and Engagement Specialist team, who produced a synthesis of Sciencewise's work to date; Wendy Barnaby who summarised some of the longer commissioned reports for inclusion in this document; and Daniel Start, Steve Robinson and Viv Dyson, who all undertook facilitation roles.

Thanks must go too to the 369 STEM ambassadors, Government Science & Engineering (GSE) members, and members of the wider scientific community who took the time to respond to our surveys on Survey Monkey, and others who responded to our request for comments via our interactive site and other channels. The full list of organisations we consulted is listed in Annex 1, and we would like to extend our thanks to all of those who took the time to respond to our requests for information and/or action.

We are also grateful to the other Expert Group Chairs, who, through their own or their Secretariats' time, facilitated the development of the work carried out by PSP. In many ways, this report complements those produced by the other Groups, and, in particular, *Science for All* and *Science and The Media*, which have reported already. As Fiona Fox made clear, the media has a critical role to play as the conduit for many people's information on science issues, and the actions in her Group's report⁶ should go some way towards helping meet this Group's objectives.

Finally, a word of thanks to our colleagues in AstraZeneca (especially Nicky Thorpe) and the Government Office for Science, whose support has been invaluable. We also welcome the support provided by the BIS Science and Society team, especially Stephen Axford, Karen Folkes, Cate Dobson and, in particular Marilyn Booth, whose efforts as Secretariat are much appreciated.

6 <http://interactive.bis.gov.uk/scienceandsociety/site/media/>

The Group: Aim, Objectives and Activities

The Group's overarching aim can be stated as:

To enhance society's capabilities to make better-informed judgements about sciences and their uses in order to ensure that the "licence to operate" is socially robust

This represents a move away from our initial remit⁷ but stands well as an overarching aim, which we were able to break down into a number of objectives and issues to consider:

1. Supporting public judgements about sciences and their uses and enabling publics to become more aware of scientific processes;
2. Acknowledging risks and uncertainties inherent in undertaking and interpreting scientific work;
3. Ensuring that Government and others have access to and use the best scientific advice;
4. A commitment to explore further mechanisms to generate informed and balanced opinion of the business use of science
5. Embedding good governance of science including the relevance and availability of ethical codes and ethical training;
6. Building partnerships across business, science, social science Government, academia and the public to ensure that the impacts on science and society are considered from all available angles;
7. Monitoring and responding to public attitudes;
8. Evaluation of the impact of science and society initiatives.

There are many links with *Science for All*, and the rationale for some of the recommendations made in this report are also linked back to Paul Benneworth's paper⁸ reviewing the evidence on the value of public engagement in the sciences. Similarly, the *Science for All* group's work suggests that one motivation for scientists' engagement with the public is to put their work in an ethical context – this in itself provides extra validation of some of the actions which we are promoting below.

Trust in science and scientists also relates beyond engagement within society to education and careers by influencing young learners in their choice of subjects to study. The depiction of scientific argument as complex and inaccessible undermines the principles of evidence-based decision making and can reinforce the marginalisation of engagement to experts only. If left unchecked, serious consequences are evident in a knowledge-based economy such as the UK for young people who might be the engineers, scientists and researchers of the future. Furthermore, it is essential that the science community endeavours to reach out to the wider audience not only to produce those future experts but also to evolve a more science aware society able to derive informed opinions.

⁷ <http://interactive.bis.gov.uk/scienceandsociety/site/trust/the-groups-work/>

⁸ www.bis.gov.uk/wp-content/uploads/2010/02/Science-For-All-Evidence-Base.pdf

Working Methods

To take forward these objectives, a number of key activities took place:

- Case study research within a number of Government agencies that had piloted the Universal Ethical Code for Scientists;
- Telephone interviews with Chairs of Scientific Advisory Committees on awareness of the Universal Ethical Code for Scientists;
- Follow-up work to the 2008 Public Attitudes Survey, including testing of questions on trust;
- A survey of the STEM ambassador cohort and Government Science & Engineering (GSE) members on experiences and awareness of ethical frameworks;
- Work to consider the appropriateness of the Universal Ethical Code for Scientists;
- Desk research on ethical training available for researchers and universities;
- A synthesis of past Sciencewise public dialogue projects;
- A workshop on the use of expert advice;
- A workshop on risk and communication of risk;
- A workshop on evaluation.

The survey of STEM ambassadors was also made available as part of wider consultation through Daphnet and psci-comm.

The Group had four full meetings between July 2009 and February 2010, supplemented by three workshops on the use of scientific evidence, risk, and evaluation. The Chairs, Group members and Secretariat expanded this activity by meeting external contacts, and following up specific workstreams.

As well as the organisations represented on the Group itself, a number of organisations have agreed to take forward actions evolving from this Action Plan, and also helped shape our thinking, for example during the workshops, through one to one meetings, telephone conversations and email exchanges. A full list is attached at Appendix 1.

One of the first priorities was to consider what kind of trust was appropriate; where current problems lay, and to define the main areas that our recommendations and Action Plan should cover.

What is meant by Trust and is there a lack of trust in the sciences?

As already mentioned above, the Group was initially divided over whether “trust” in science was an issue which needed to be “fixed” or addressed, or whether concerns suggested in survey research and beyond, and shaping the Group’s own existence, were not simply symptoms of healthy scepticism within society.

The Group were of the view that the social “licence to operate” is dependent on scientists in academia and industry, policy makers, and a range of professional bodies all working in ways that ensure that healthy scepticism does not develop beyond a point where the scientific endeavour finds itself unduly constrained, so that important areas of research and development cannot be pursued. Failure of individuals and organisations to take that seriously has led to damage to reputations, corporate image, consumer backlashes, and consequent impacts on the bottom line or even survival of individual businesses.⁹

As a concept, “trust” is naturally tricky to pin down, and for the purposes of this Group, a broad definition was used in discussion, and in developing both our thinking and proposals for specific actions. Our definition, developed by Tim Lewens and Stephen John during a project undertaken as part of the Group’s work (published in full on the Group’s interactive site¹⁰ and summarised in Annex 5 of this report), essentially relates to *a willingness of one (group of) individuals to rely on a second (group of) individual(s) to act in ways which are in the interests of the first (group of) individuals.*

If we say that there is “mistrust” in science, we might mean one of several things – that scientists’ testimony is not trusted; that they are not trusted to perform research that is beneficial (it might be obscure or considered self-indulgent); we might not trust them to tell the truth; it could be that they are not trusted to make good social policies; or we might not trust the uses that others make of science and technology. There is also a need to distinguish between scientific institutions and scientists themselves.

So, looked at in this way, we can see that there is an expectation placed on those involved in the sciences, and that trust or confidence (and hence the quality of the relationship between those directly involved in the science and society relationship) depends on people behaving in ways that are expected, and which seem logical and even beneficial. Thus, for example the individual, who has a personal interest in seeing stem cell research in particular, or advances in medicine more generally, may look at the science and scientists more favourably than a counterpart who does not have the same immediate concerns.

We noted that the RCUK/DIUS study, *Public Attitudes to Science 2008*¹¹ showed that 76% of people believe that “In general scientists want to make life better for the average person”. That survey, and others (including the interviews which PSP have recently conducted to help shape the next Public Attitudes Survey) also suggest that there is a relative lack of awareness in the general populace about what happens “behind university walls”, and how knowledge is produced. But that lack of awareness is accompanied by an appetite for greater

9 www.lse.ac.uk/collections/CARR/pdf/DPs/Disspaper8.pdf

10 <http://interactive.bis.gov.uk/scienceandsociety/site/trust/>

11 www.rcuk.ac.uk/per/pas.htm

consultation and involvement. In a 2007 deliberative study, the Wellcome Trust¹² noted this wish for a greater degree of what they termed "research literacy". Academic involvement in outreach activities, for example through attendance at Science Festivals, and the concerted efforts of the Beacons for Public Engagement, are helping break down those walls to an extent.

The Group also accepts the argument put forward by Lewens and John that "*there is no single phenomenon of the public crisis of trust in science; rather there are many different trust-related problems which arise in the public/science relationship*". They argue that "*the proper resolution of many of these problems is likely to require a general rethinking of the role of public involvement in science and of the relationship between the institutions of science, of industry, and of the State*" Interactive site paper. They also claim that there is no evidence of a genuine and generic "crisis of trust" in science. This is borne out by the IPSOS Mori "trust in the professions" data series, which suggests that scientists are more widely trusted than many others in society including business and Government¹³. Broadly comparable results emerge from *Public Attitudes to Science 2008*, and from Steve Rayner (another Group member) and his work on crisis in governance. A similar pattern also seems to exist in the USA, as highlighted in the recent *Science and Engineering Indicators 2010*¹⁴. Only time, and further assessment of attitudes, will tell if the recent issues around presentation of climate change data have impacted on those results.

The RCUK/DIUS study highlights the fact that there are degrees of trust depending on the workplace of the scientist, and the branch of science in which they are engaged, with scientists in a university setting generally seen as more independent and less susceptible to perceived business or political pressures. However, such a difference again strengthens the assertion above that many people don't recognise the interrelationships which drive university research, nor how that research is often funded.

The attitudinal data above strengthen the Lewens and John assertion that what appears to be a crisis of trust in science per se is better considered a crisis of trust in industry and government sponsored science, or in the ways in which government and industry make use of scientific advice. This has certainly come into focus in recent months, and has seen efforts by Ministers and others to try and formalise and improve the system by which scientific advice reaches Government following a high profile example of where the system didn't work as well as it was designed to. It has also shaped the work of the Group and its conclusions.

The point could equally be made that a lack of trust in these institutions, and their use of science, may be associated with a lack of trust more widely, as evidenced by the "Distrustful" attitudinal group highlighted in *Public Attitudes to Science 2008* and their counterpoint group who have a tendency to be enthusiastic and interested in a broad range of topics. A similar conclusion can be drawn from the 2005 Eurobarometer study, *Social values, Science and Technology*¹⁵, which highlights the correlation between general life satisfaction, and trust.

12 www.wellcome.ac.uk/About-us/Publications/Reports/Public-engagement/WTX038446.htm

13 www.ipsos-mori.com/researchpublications/researcharchive/poll.aspx?oltemId=15

14 www.nsf.gov/statistics/seind10 See Chapter 7.

15 http://ec.europa.eu/public_opinion/archives/ebs/ebs_225_report_en.pdf

Comparable concerns are also reflected in Daniel Start's paper, which incorporates insights from Sciencewise¹⁶ dialogue projects with more than 12,500 participants. Significantly, he also points to repeated calls to clarify the regulatory map, and open this up to public debate. His work and *Public Attitudes to Science 2008*, taken together, suggest that the public view of science and technology (as opposed to *people*) is largely positive, and that individuals are likely to be attuned to the benefits offered by new developments.

2009 research by EngineeringUK¹⁷ suggests that "trust" in engineering has seen a marked increase, with 86% of people agreeing that engineering "makes a good contribution to our society," and 91% asserting agreeing that the profession will have "a positive influence on our future". EngineeringUK point out, however, that the impact of the financial crisis may have had a positive influence on the trust placed in other sectors like engineering.

The Implications

We're not just concerned about trust for trust's sake. Yarborough et al (2009)¹⁸ point out that there are equally implications for the business community and indeed for scientific progress per se, if the relationships necessary to build trust aren't given the right degree of attention:

"The public's trust is essential to the biomedical research enterprise. Lack of trust could lead to a number of undesirable research-related outcomes, including a shortage of volunteers for clinical studies, concerns about the validity of published investigational results, increased regulation of research, and decreased public funding in biomedical research."

So, taking time to act ethically and openly is also an economic imperative. This has been recognised throughout industry, and for example the ABPI¹⁹ Code of Practice, one of many business codes, setting out expected standards of behaviour, which were brought to our attention. Rolls-Royce drives through behaviours to support its responsible business agenda with the message "Trusted to Deliver Excellence" supporting the message that reputation matters and that it is important to secure the trust of its customers, suppliers, passengers and employees.

Persistently, reviews of public attitudes to science reflect less confidence in scientific views from the private sector and the dilemma at the heart of the issue reflects the underpinning commercial considerations.

The overarching question for the private sector is how to build understanding of the applications of science (risks and benefits) so that the public is able to reach an informed view. In recent years many business sectors have become sensitive to issues around public trust and have explored different mechanisms to address concerns. The responsible business agenda is very much at the heart of many UK and global plcs. The manifestation of these strategies varies according to the business sector but all are based on at a minimum fulfilling the expectations of a reasonable member of the public and many have progressed from reactive actions as issues arise to proactive engagement to prevent problems and create opportunities for public engagement.

16 www.sciencewise-erc.org.uk

17 www.engineeringuk.com/_db/_documents/Rebuilding_the_UK_Economy.pdf

18 Mark Yarborough, Kelly Fryer-Edwards, Gail Geller, and Richard R. Sharp. (2009) "Transforming the Culture of Biomedical Research From Compliance to Trustworthiness: Insights From Nonmedical Sectors" *Academic Medicine*, Vol. 84, No. 4 / April 2009

19 Association of British Pharmaceutical Industry

The Nuclear Legacy – Engaging the Public Effectively

Established under the 2004 Energy Act the Nuclear Decommissioning Authority (NDA) is responsible for the decommissioning and clean-up of the UK's civil public sector nuclear liabilities. This involves overcoming complex scientific and engineering challenges in a safe, secure and environmentally responsible way. During set-up, Government established that stakeholders wanted local, site-based forums to discuss site-specific matters. The challenge for the NDA was to develop two-way, transparent, independently chaired communications arrangements.

In 2005, the NDA invited existing Local Liaison Committees to send representatives to an event which looked at their evolution. Following this event the existing Local liaison Committees were reconstituted as Site Stakeholder Groups with independent chairs. It was agreed that meetings were to be held out of office hours and "off-site" so that members the public could attend. The NDA also created the SSG Chairs' Forum. This allowed the SSG Chairs to meet twice a year in the margins of the National Stakeholder Group and share good practice, build relationships with each other and discuss common issues.

Following significant input from stakeholders the new arrangements are:

- *Site Stakeholder Groups are the new interface between the community, the site operator, and the NDA. They meet regularly and provide opportunities for*
 - *questioning the site operator, the NDA, and regulators*
 - *reviewing, commenting on, and influencing strategies, plans, and achievements*
- *In addition to this, the NDA's National Stakeholder Group meets twice each year. It enables stakeholders to question and challenge senior representatives*

Conclusion

Scientists and researchers from across the disciplines – whatever their specialism – have the scientific method instilled in them and that itself promotes a range of behaviours – interestingly, those are promoted through the Institute of Physics' "Are you a Good Scientist?" resource²⁰ for use in schools, which summarises the key principles of how science should be conducted for young people and their teachers. The focus is on openness, transparency and acting responsibly.

It hardly needs to be stated that there are numerous checks and balances within the system – including peer review, and the Research Ethics Committee structure. But, research shows that many people are unaware of the key ways in which scientists conduct their work – opening up that process becomes key to our first set of actions, while exploring the roles which Government and business can both play is also a focus in the actions set out below. Ethical codes and frameworks are also one of the ways in which the scientific, and wider academic establishment, have chosen to foster and encourage expected norms of behaviour, and will be considered in that context later in the report.

The Science and Trust Group Action Plan

1. Supporting Public Judgements on Sciences and their uses

Aim: Members of society are equipped to make well informed judgements about the sciences, the way they are produced, and the way they are used. Scientists will recognise that their social licence to operate is inherently linked to this, and will use all available mechanisms to enable non scientists to understand the nature of their work

Rationale:

The Group is not expecting all individuals to become expert evaluators of the quality of science; instead we are advocating a sufficient “Connoisseurship”²¹ of the sciences to enable publics to have sufficiently informed viewpoints on ongoing scientific debates and issues.

If we reject the idea that we’re trying to build “blind” trust per se, then how do we support more informed public judgements about science and their uses; what can scientists and scientific institutions do to be more transparent and open; how do we enable discussion around risk and uncertainty; how can we open up debate around the processes involved in science and knowledge production; and how can the scientist ensure that they have a sufficiently robust “licence to operate” as a consequence?

While we should treat the results from the survey of STEM ambassadors and GSE members with caution,²² a number of common themes emerged when questions were asked about how scientists themselves felt they could improve publics’ abilities to be more informed on science and technology issues: these centred around media reporting, education, and public engagement, but also stressed the need to open up research processes.

Again, *Public Attitudes to Science 2008* suggests that there is a public appetite for discussion on these issues, with 77% of respondents agreeing that “*Funders of scientific research should help scientists to discuss research and its social and ethical implications with the general public*”, and 73% agreeing that “*I would like more scientists to spend more time than they do discussing the Implications of their research with the general public*”. That research suggests that people have a genuine interest in acquiring more information about the science which is shaping their lives, while also highlighting that the British public are more informed than their European counterparts. That said, there are still significant groups who are less likely to feel informed, including women, the over 55’s and Social grades C2DE.

The approach taken by the Government’s Science: [So what? So everything] campaign²³ has been to target the latter group, for example through their work to place articles on science and technology in tabloid newspapers and magazines. It will be interesting to see whether those interventions have had any impact on the results of further attitudinal surveys.

21 As in the case of “foodies” and art lovers who won’t necessarily be able to cook or draw, but have a sufficient interest and understanding to be both appreciative and critical.

22 Due to small response rates. Out of a sample of 9,000 ambassadors there were 169 responses; while 190 GSE members (out of a possible 3,000 responded).

23 <http://sciencesowhat.direct.gov.uk/>

The Research Excellence Framework²⁴ places a new emphasis on public engagement activities, and should be a welcome addition to this area, while the work of the *Science for All* group in helping to shape the public engagement landscape should play a role here too. The new Concordat for Public Engagement will cement the existing commitment of the Research Councils to this agenda – already shown in individual research councils, and RCUK, by programmes like Researchers in Residence, and attendance at Science Festivals, blogs and other mechanisms. Indeed, we could fill this report with examples of organisations and individuals engaging in this type of activity, and would refer readers to the map of public engagement activities presented with the *Science for All* report, or indeed to the STEM Directories²⁵, which provide a useful overview of enrichment activities available for schools, and demonstrate the commitment already being made by scientists and engineers, by professional bodies, science centres and museums, science festivals and enthusiastic individuals keen to inspire and enthuse young people. We have chosen not to focus this part of the report on those generic activities. Rather we focus on specific initiatives around opening up the scientific process. Equally, those attempts to engage the public with ethics and ethical frameworks are considered in section 6.

Understanding Animal Research

Understanding Animal Research (UAR) is an organisation that aims to achieve understanding and acceptance of the need for humane animal research in the UK, by maintaining and building informed public support and a favourable policy climate. UAR has developed a speaker programme for secondary schools to discuss why animals are used for research. Speakers are volunteers who usually work with research animals and have a passion for explaining what they do and why. UAR have also developed an interactive online resources for teachers and students.

There is already a tradition within both the academic community, and the NHS for public involvement in research ethics committees, and we would encourage all sectors to consider such an approach as one way of building awareness of processes, while recognising that it may not always be appropriate. Conversely, universities and the wider academic community could do more to increase the visibility of those interactions and activities.

Business also has a role to play in public outreach and many large companies have substantial programmes to support science education (e.g. Project Enthuse) and to encourage engagement between schools and industry, e.g. the STEM Ambassadors scheme, AZ Science Teaching Trust, BP Educational Service & Rolls-Royce sponsored prizes.

All these activities are also supported by efforts within the curriculum to enable young people to understand “How Science Works²⁶” which should, at least, develop the current generation’s capacity to make more well-informed judgements in later life.

24 www.hefce.ac.uk/Research/ref/

25 www.stemdirectories.org.uk/

26 http://nationalstrategies.standards.dcsf.gov.uk/node/102671?uc=force_uj

The Research Councils

The Research Councils are all involved in this type of activity as a matter of course. Examples of their work include but are not restricted to:

- *RCUK support for the Researchers in Residence programme, which aims to engage young people with contemporary research to stimulate their interest and motivation in the social, physical, life and earth sciences and the humanities – www.researchersinresidence.ac.uk*
- *RCUK support for Nuffield Bursaries which enable young people to join a real research project with practising scientists as part of a summer placement – http://www.nuffieldfoundation.org/go/grants/nsb/page_390.html*
- *BBSRC continue to disseminate information about underlying science, potential applications and social implications through public exhibitions, events e.g. planned discussions on Bioenergy and food security at the 2010 Cheltenham Science Festival and online blogs/discussion features.*
- *ESRC is currently embedding public engagement in its grant processing structure including highlighting the importance of applicants undertaking public engagement in the design of their research questions, and including public representatives on ESRC's committee and in funding panels.*
- *MRC Science Cafes have an informal and discussion-based format which aims to improve understanding rather than simply to build knowledge. The format is informal and discussion-based.*
- *Both ESRC and MRC provide support for Debating Matters, national debating competition, which enables young people to think about societal and ethical issues facing the UK.*
- *NERC is sponsoring a Science Museum "Lates" event on Geoengineering, and three debates (including one on Climate Change and Trust) at the 2010 Cheltenham Science Festival.*

Recommendations and Actions:

Make information sources more widely available and assess the best way of ensuring that resources are made available to widest desirable range of people

- BIS, GO-Science and scientific institutions should instigate a scoping project to assess whether a web portal collating existing resources (on risk, uncertainty, ethics and more) is a practical way forward in informing and empowering publics, educators, students and scientists.

Raise awareness and provide greater opportunities for the discussion of processes involved in the production of scientific knowledge

- Universities and journals should publicise and discuss peer review processes more widely;
- BIS will assess perceptions and understanding of processes involved in knowledge production as part of *Public Attitudes to Science 2011*;
- BIS will assess awareness of the scientific method in follow up research;
- Individual research councils will continue to disseminate information about underlying science, applications and social implications – for example through public exhibitions, science festivals and blogs.

Developing skills in the academic community

- The National Co-ordinating Centre for Public Engagement (NCCPE) will support academics and researchers in addressing social and ethical issues by signposting them to practical resources, case studies and training/development opportunities.

Provide opportunities for public to become more involved with scientific decision making

- Universities and the NHS should encourage the continuing involvement of lay members on Research Ethics Committees in scrutinising their research;
- Research Ethics Committees should encourage the training of their lay members;
- The involvement of the public should be encouraged at all stages of research.

2. Acknowledging risk and uncertainty

Aim: Expert advice to Government should identify and characterise uncertainties; policy makers should communicate clearly actions that take account of inevitable uncertainties; efforts should be made to support public judgements about risks and uncertainties.

Rationale:

Risk and uncertainty are an inevitable part of life and science has an important role to play in characterising those risks and uncertainties. The public look to government to provide safeguards against undue risks from new technologies.

Evidence shows that the public is overwhelmingly supportive of ensuring that risks are adequately understood and regulated before new technologies are commercialised.²⁷ As a recent expert group report for the European Commission argued, the governance crisis associated with the innovation of certain new technologies relates to questions of risk and uncertainty, specifically the perceived failure of regulators to take account of public values and the full range of uncertainties.²⁸

Cases in which risks have been mishandled by Governments have led to a loss of public confidence in their capacity to use science wisely, as illustrated in the BSE crisis of the 1990s²⁹. This led the House of Lords in its report on Science and Society to state:

Much public policy debate is confused by an assumption that the issues reverberating around science in the public domain, especially a whole variety of risk issues, can be reduced to a set of questions capable of objective and incontrovertible answer by scientific research. Most often, in truth, the issues are complex. Scientific understanding can contribute to a resolution of these issues, but only in partnership with judgements based on people's attitudes, values and ethics.³⁰

27 Public Attitudes to Science 2008: For example 81% of respondents agreed that "New technologies should not be used until the relevant experts are sure there are no risks to people".

28 Taking the European Knowledge Society Seriously January 2007 – http://ec.europa.eu/research/science-society/document_library/pdf_06/european-knowledge-society_en.pdf

29 <http://web.archive.org/web/20001120161600/www.bseinquiry.gov.uk/report/contents.htm>

30 www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3804.htm#a22

Government has recognised the importance of the public dimensions of risks and uncertainties, leading to the establishment of the Risk and Regulation Advisory Council (RRAC)³¹. Operational between 2008 and 2009, the Council was described as “an experimental offensive against the poor handling of public risk”.

The RRAC made a series of recommendations to government on Public Risks in its final report³². These included emphasising the role of independent advice on public attitudes to risk as an important “resource to Government in helping to understand and manage the risk landscape”. There are some synergies with our work, and Government’s response to that report sets out a number of initiatives to help strengthen policy making, including setting up a new Regulatory Policy Committee, which is part of the Government’s “Strengthening Regulatory Management” programme. That Committee is tasked with external scrutiny of the policy making process, and bringing greater transparency to regulatory decision making within Government. As part of that scrutiny role, it will consider the degree to which public risk issues are considered within policy making.

The Council itself produced a number of reports, guides and tools to help policy-makers and the public tackle public risk, including the public-focused *A Worrier’s Guide to Risk*³³. We would like to see this documentation becoming more widely available, as it could provide a “way in” to discussions around risk, and understanding the processes behind knowledge production.

The Group also recognises the importance of expert advice to government being clear about the uncertainties in its advice; and also the importance of government policy makers being clear about how they will act to acknowledge the inevitable uncertainties identified during the advisory process. The Government Chief Scientific Adviser Guidelines emphasise the importance of identifying, characterising and communicating uncertainties.

The role of science as underpinning the innovation and regulation of emerging technologies is a central element in the wider context of science and society relations. For example, there have been recommendations coming from studies into potential risks from nanotechnologies for setting up bodies to consider the public risks of these technologies in broader context:

- In 2004 the Royal Society and Royal Academy of Engineering³⁴ recommended that a group be formed “*that brings together representatives of a wide range of stakeholders to look at new and emerging technologies and identify at the earliest possible stage areas where potential health, safety, environmental, social, ethical and regulatory issues may arise and advise on how these might be addressed*”.
- Similarly in 2008, the Royal Commission on Environmental Pollution³⁵ recommended: “*Government should move beyond one-off public engagement “projects” to recognise the importance of continual “social intelligence” gathering and the provision of ongoing opportunities for public and expert reflection and debate. We see these functions as crucial if, as a society, we are to proceed to develop new technologies in the face of many unknowns*”.

31 www.berr.gov.uk/deliverypartners/list/rrac/index.html

32 www.berr.gov.uk/files/file51459.pdf

33 www.berr.gov.uk/files/file51456.pdf

34 www.nanotec.org.uk/finalReport.htm

35 www.rcep.org.uk/reports/27-novel%20materials/27-novelmaterials.htm

Public Attitudes to Science 2008 also suggests that there is a substantial wish for greater communication around regulatory issues, and this is again backed up by participants in Sciencewise projects, as detailed in Annex 7.

The role of the media in increasing awareness has already been explored by Fiona Fox's Group on *Science and the Media*. Her Group makes recommendations around increasing transparency, openness and training for journalists, all of which it is hoped will have an impact on the way in which science is presented in the media, and ultimately an impact on increasing awareness of the processes involved.

Following recent interest in "Climategate", Roger Harrabin³⁶ issued a challenge to the media to facilitate a greater degree of discussion around uncertainty and risk within Climate Change reporting. We would echo and support that call. Indeed, this is something which the Science Media Centre has committed to doing on an ongoing basis, and Fiona Fox's description³⁷ of a session between climate researchers and the media makes for interesting reading, but also suggests that more work needs to be done.

Much has been written on the Climategate affair and it would be inconsistent for us to ignore it, given its potential for erosion of trust in climate science.³⁸ It would be inappropriate for us to comment on the detail of the case as it is currently under investigation. But, the situation as detailed from the scientist's own perspective³⁹ shows the pressures faced by researchers operating in potentially controversial areas, and could itself raise questions about how transparent a scientist can be expected to be in the face of entrenched opinion or views.

Opportunities for public discussion of uncertainty and risk have been provided by, for example, the British Library. The Royal Society will hold a two day event in March 2010 on handling uncertainty in science⁴⁰, sharing learning from a range of different disciplines on issues around uncertainty, including how it should be communicated.

Recommendations and Actions:

Support Government to take better account of risks and uncertainties in policy making

- GO-Science should increase awareness and availability of "Communication of Risk" document to GSE members and other policy makers.
- As part of the Government's response to the RRAC report BIS and HSE will commission a research programme to develop practical guidance that will help Government consider the appropriate response and responsibility for public risks.

Support public judgements about risks and uncertainties inherent in the scientific advisory process

- Sciencewise-ERC will continue to work across Government departments to support this process.

36 <http://news.bbc.co.uk/1/hi/sci/tech/8491154.stm>

37 <http://fionafox.blogspot.com/2010/02/thoughts-on-climategate.html>

38 <http://news.bbc.co.uk/1/hi/sci/tech/8525879.stm>

39 www.timesonline.co.uk/tol/news/environment/article7017905.ece

40 <http://royalsociety.org/Event.aspx?id=1959&terms=uncertainty>

Support policy makers to take better account of public attitudes and values to the risks, benefits and uncertainties in the governance of emerging technologies

- GO-Science and Sciencewise-ERC should follow up WIST⁴¹ process to develop ongoing monitoring of issues emerging from development of new technologies, incorporating public values and assessments of risks, uncertainties, and benefits.

Enable wider discussions in the media and elsewhere on uncertainty inherent in the scientific process

- The Science Media Centre, National Academies and others will support scientists to communicate uncertainty with journalists and others.
- The Government Chief Scientific Adviser (Professor John Beddington) and the Science and Innovation Minister (Lord Drayson) should challenge journalists and the media to adequately reflect the uncertainty of scientific evidence.
- GO-Science should promote a leaflet on uncertainty, similar to a "A Worrier's Guide to Risk".

Enable greater discussion of risk

- GO-Science and BIS should make "A Worrier's Guide to Risk" available in public spaces (science and non science venues including science centres, advice centres, and libraries).
- Government should assess how risk can be better addressed in the curriculum in both STEM and non-STEM subjects.
- The Northern Ireland Centre for Public Health (with Wellcome Trust funding) will work with W5 to produce an A-level teaching resource/toolkit on how health risk is perceived. This will be targeted at sixth form biology and social science curricula.
- BIS/GO-Science should commission and publicise a map of the UK science regulatory system.
- BIS should explore the development of a more streamlined, transparent and well-publicised regulatory architecture with clear clearer links between policy and practice to address poor public perceptions about approaches to regulation.
- BIS should pilot provision of a one paragraph *plain English* statement for each new policy and regulation – with a view to wider adoption of this approach across Government in due course.

3. Government and Scientific Advice

Aim: Scientific evidence (and research evidence more widely) is effectively incorporated into policy making, independent scientific advice is respected by all, and there is a commitment to openness and availability of data.

Rationale:

Despite the fact that principles are already in place relating to the use of scientific advice within Government, the value placed on that advice has come under scrutiny, with researchers across a range of disciplines questioning whether Government values their input.

41 Wider Implications of Science and Technology – www.foresight.gov.uk/Horizon%20Scanning%20Centre/WIST.asp

The work of this Group coincided with the sacking of Professor David Nutt from the Advisory Committee on the Misuse of Drugs, and subsequent enquiries raised many arguments that have been rehearsed previously on the scientific advice system. Lewens and John, in their work for the Group, for example, suggest that there is a belief that the scientific endeavour and the policy making process may be ultimately at odds with each other.

Involving the public in the scientific advice debate

Edinburgh Cafe Scientifique ran an event in February 2010 asking “What should Government do with scientific advice?”

The event was presented by Professor Anne Glover (Chief Scientific Adviser for Scotland), and those present were able to learn more about how science shapes what Governments do. Attendees also were able to discuss how evidence informs policy, how that evidence is collected and how is it used, and put that into the context of other influences on policy making.

There are many ways in which advice is integrated into Government policy, and it can be both a reactive and a pro-active process. The Scientific Advisory system is one facet of that, and a range of other expert and advisory groups exist to provide Ministerial advice across a range of topics. All bodies acting in this type of public context are subject to guidelines and rules stemming from the Office of the Public Appointments Commissioner⁴² regulations, while Scientific Advisory Committees have their own Code of Practice⁴³.

This Group held its own workshop on scientific advice, taking on board the experiences of the National Academies represented on the Group, from business (which has its own particular set of issues) and from the American system. Kieron Flanagan (from Manchester University) was able to provide detail on the European context. We concluded that:

- Private industry has much to offer the Government advice system in terms of learning. The three companies represented on the Group have a variety of mechanisms for bringing external advice, innovative approaches and scientific challenge – these are all highly valued. Transparency of engagement, and “expenses only” payments help to legitimize the public’s view in controversial areas. Also if data are generated, publication in peer reviewed journals is important.
- There is evidence to show that the UK Government system has improved over recent years, and may actually be the best in the EU⁴⁴. However it should be streamlined, more transparent and managed across departments. There are concerns that appointments of statutory advisers can lead to a personalization of the system, with obvious consequences. Concerns were also expressed about the relative lack of proactive management and evaluation of the system as a whole. This led to our recommendation that Government review the impact of Lord Drayson’s advice on the use of scientific principles on an ongoing basis.

42 www.publicappointmentscommissioner.org/

43 www.dius.gov.uk/office_for_science/science_in_government/strategy_and_guidance/~media/publications/F/file42780

44 <ftp://ftp.jrc.es/pub/EURdoc/eur19830en.pdf> Steven Glynn, Kieron Flanagan and Michael Keenan (2001). Science and Governance: describing and typifying the scientific advice structure in the policy making process – a multi-national study. An ESTO Project Report Prepared for the European Commission – JRC Institute Prospective Technological Studies Seville.

Science Advice in Government: Where Next?

The Home Secretary's dismissal of Professor Nutt as Chair of the Advisory Council on the Misuse of Drugs (ACMD) in October 2009, and the subsequent commentary and associated media coverage all prompted significant concerns in the scientific community that there was a fundamental lack of understanding within Government of the nature of scientific advice and a lack of respect for the independence of scientific advisers. These concerns arose despite the hundreds of scientists involved in around 75 scientific advisory committees that continue to work very effectively across Whitehall.

In response to the concerns of the scientific community, the Minister for Science and Innovation, Lord Drayson, and the Government Chief Scientific Adviser (GCSA), Professor John Beddington, took forward a programme of work to establish a statement of high-level Principles to ensure continued effective engagement between the Government and those who provide independent science and engineering advice. These Principles set out the behaviours and responsibilities expected from both government decision-makers and independent science and engineering advisers.

In developing the statement of Principles, Lord Drayson and the GCSA consulted representatives of: the National Academies and Learned Societies; Scientific Advisory Committees and Councils; science communicators and the media; as well as colleagues across Government.

The draft Principles were published in December 2009. Comment was invited through the GCSA's public consultation on his Guidelines on Scientific Advice in Policymaking. The consultation closed on 9 February and the Government is now considering the responses to this consultation, and expects to publish updated Guidelines on Scientific Advice in policymaking and a finalised statement of Principles in the Spring.

The Science and Trust Group concluded that these issues were being comprehensively covered as set out above and consequently that we would not add value by addressing them further.

We want to see a situation where research across the broad range of the sciences is seamlessly integrated into the policy making process. We have made recommendations that will impact on the use of evidence, through its collation, dissemination and use within Government, as well as stressing how policy can be strengthened through public involvement and expertise from the fullest possible range of sources.

The Group were also able to consider the scientific advice landscape within the NHS. The Department of Health has established robust systems whereby scientific advice is provided to inform decisions and policy recommendations for the NHS. For example, scientific advice on the risks and public health benefits of specific medicines and medical devices is provided to the Medicines and Healthcare products Regulatory Agency (MHRA), an executive agency of the Department of Health which enhances and safeguards the health of the public by ensuring that medicines and medical devices work and are acceptably safe. Recognising that no product is risk free, the entire Agency's work is underpinned by robust and fact-based judgments to ensure that the benefits to patients and the public justify the risks.

Public involvement in health and social care research

INVOLVE (<http://www.invo.org.uk>) is a national advisory group, funded by the National Institute for Health Research (NIHR). Its role is to support and promote active public involvement in NHS, public health and social care research. Involve believes that involving members of the public leads to research that is:

- *more relevant to people's needs and concerns;*
- *more reliable;*
- *more likely to be used.*

INVOLVE believes that training is a cornerstone of effective public involvement in research, and recognises that one style of learning does not suit all, and so encourages several methods/styles (<http://www.invo.org.uk/Training.asp>).

The Agency's Commission on Human Medicines, which includes two "lay" Commissioner members, advises the Licensing Authority (LA) in relation to the safety, quality and efficacy of human medicinal products. Each of the Commission's Expert Advisory Groups (EAG) includes at least one lay member, and there is an EAG specifically addressing patient information. The National Institute for Health and Clinical Excellence (NICE) similarly includes lay members on its scientific advisory committees.

That tradition within the Department of Health and the NHS of lay membership of scientific advisory and research committees extends to an active commitment to public involvement.

That focus on public involvement shows that scientific advice is, of course, only one element of the advice and evidence which Government uses to shape science and technology policy. As highlighted earlier, engagement and more sustained forms of dialogue are increasingly becoming a feature of the policy making landscape within the UK (the approach is dependent on the situation). We would reiterate the call made in the *Science for All* report for public engagement to be further embedded, and recognised for the role it can play in enabling more socially robust decisions to be made. The annexes to the *Science For All* report show the scale of the challenge involved.

The Sciencewise-ERC was explicitly establishing to strengthen policy making by building capacity for public dialogue across Government. Daniel Start's synthesis (summarised in Annex 7) shows the range of projects that have already been completed with this approach. Future direction will be shaped by the Actions outlined in the *Science for All* report.

Recommendations and Actions:

Ensure all voices and views are taken on board during policy development through a commitment to public dialogue and engagement

- BIS will continue commitment to the Sciencewise-ERC to ensure that public perception is taken into account during the policy development process, and to build further capacity for public dialogue within Government Departments, agencies and non-departmental public bodies across the UK.
- Sciencewise-ERC will continue to ensure that participants involved in dialogue projects are able to see clearly how policy develops after their formal involvement in projects has ceased.
- National Academies and Research Councils will continue to include public engagement and dialogue in projects where appropriate to ensure advice shaped by expert opinions and hopes and concerns of wider society.

Strengthen the Science Advice Process within Government

- **BIS** will play a leadership role in adopting a new "STEM assurance scheme" to encourage greater appreciation, and use of scientific advice, when making policy decisions⁴⁵.
- **BIS and GO-Science** will publish and promote new Principles of Scientific Advice, and should ensure that both scientific and non-scientific staff involved in policy making are aware of them.
- Individual scientists and engineers, and those working on science and technology policy should be encouraged to commit to these principles through Departmental appraisal systems.
- Government should explore how it can evaluate the scientific advice system, and consider assessing the impact of the advice process on an ongoing basis.
- BIS and GO-Science should use a refreshed Universal Ethical Code for Scientists to communicate responsibilities of scientists and researchers to policy colleagues.

Build a stronger Scientific Advisory Committee Structure

- GO-Science should undertake an awareness raising campaign to ensure that Scientific Advisory Committee Chairs and members are all fully aware of current and future codes of practice.
- GO-Science should explore whether further training for Secretariats supporting scientific advisory committees is necessary.

Increase the Availability of Government Data

- Government scientific data, suitably anonymised where necessary, should be made publicly available for re-use, following the principles set out in "Smarter Government"⁴⁶
- BIS will make future anonymised data from Public Attitudes to Science 2011 freely available as a matter of course.

⁴⁵ The principles of this scheme have been shared with CSAC who have set up a working group to take this issue forward across government. Initial work on this will commence in early 2010

⁴⁶ www.hmg.gov.uk/media/52788/smarter-government-final.pdf

4. Private Industry and Science Advice

Aim: Assess the issues affecting business' use of science, and seek to develop a plan to improve perception and practice.

Rationale:

Persistently, reviews of the public's attitudes to science reflect low levels of confidence in scientific views from the private sector, and the dilemma at the heart of the issue reflects the underpinning commercial considerations. In recent years many business sectors have become sensitive to issues around public trust and have explored different mechanisms to address concerns, as reflected below.

In the private sector, access to external innovation and scientific expertise is part of routine business in the majority of science-based companies. This can be facilitated by a variety of mechanisms depending on the issue and the business need. In many companies this process is inextricably embedded within accessing external innovation and therefore is based on sponsorship or collaboration. In other cases scientific review is initiated through external consultants as a distinct process, although frequently consultants are reimbursed for their time or at least expenses.

Pharmaceutical Industry & Transparency

Drug companies routinely collaborate with the scientific and medical research communities to ensure that their drug discovery and development activities are addressing the needs of patients and doctors. In many cases these collaborations advance the scientific knowledge underpinning a disease process and result in peer reviewed publication and therefore open access to new data. A frequently voiced concern from the public is the possibility that such investments may influence the prescribing habits of physicians. The perception of this problem is most acute where key opinion leaders are consulted on products close to, or in, the clinic. Although the benefits of shaping drug evaluation programmes to address unmet medical need is obvious, until recently, the checks and balances employed by individual companies to ensure unbiased views and protect academic independence have not been understood. Industry-wide initiatives, as typified by the ABPI Code of Practice, have set standards aimed at eliminating behaviours that give credit to the perception that the industry inappropriately influences prescribing⁴⁷. At the same time, those initiatives drive up the level of transparency to provide evidence of practice.

Recommendations and Actions:

Create structures to promote the transparent use of science within business and industry

- A Science Ethics in Business and Industry Working Group should be established to challenge industry to be more open and transparent in its use of science and share good practice between large companies and SMEs. There should be mechanisms to deal with poor performance in this area.

Science, technology and engineering businesses should recognise the value of opening up their approaches as part of a commitment to corporate social responsibility

- BIS will encourage a selection of key organisations, that have not yet been involved, to take industry leadership roles in STEM enrichment and enhancement within their local community, with STEMNET and others through participation in programmes including STEM Ambassadors and STEM Clubs.
- Industry should incorporate transparency and communication around use of science into their corporate responsibility agenda.
- The CBI, the Federation of Small Businesses and other relevant organisations should work with industry to communicate and celebrate good practice in business use of science;
- Regional Development Agencies, Business Links and trade associations should work with Small and Medium Enterprises (SME's) to help develop commitment to transparency and openness.

Assess whether there is a need to address issues of negative perceptions around business' use of science

- As part of Public Attitudes to Science 2011, BIS will hold facilitated discussions and use the quantitative survey to establish scope of the "problem" relating to business use of science.

Business should ensure that their advice takes on board public and other perceptions

- Businesses in the science and technology landscape should commit to learning from public dialogue and engagement, to ensure that policies and processes take on board the hopes, fears and concerns of publics.
- The Academy of Medical Sciences' FORUM will continue to promote interaction among scientists from industry and the wider medical science community, including members of the public and representatives from academia, research councils and charitable research funders.

5. The Ethical Contexts of Science and Research

Aim: Ethical behaviour is encouraged at all stages of exposure to science and technology (from school through to careers) and the public has a greater appreciation of the ethical context in which scientists work, and in which the sciences are used, produced and applied. Good ethical practice is effectively supported.

Rationale:

Just as we can debate concepts and meanings of trust, if we asked anyone what they actually mean by "ethics" it is likely that they will find it difficult to verbalise or articulate what they themselves understand by the concept. Daniel Start's paper (summarised in Annex 7) also gives a valuable insight into individuals' common ethical concerns in the science and technology landscape, as well as highlighting the very real tradeoffs and balances which people make in their ethical judgements.

Returning to the Lewens and John definition explored earlier, the ethical (or equally moral) framework in which research is conducted has a role to play in setting out the expectations of behaviour between "trustor, trustee and trusted", and that applies not only in educational settings, but also in industry, Government, and in the wider public consciousness.

Ethics in Schools

Group member Michael Reiss has written extensively on ethics in the curriculum (and a shortened version of one paper on why and how ethics should be taught is reproduced as Annex 11). He argues that there is a growing expectation among aspiring scientists and engineers that ethics should be taught formally, and that there is an appetite for knowledge and discussion around ethical issues.

Science courses for 11-18 year olds increasingly include material on the social and ethical implications of science. For example, we are aware that the national network of Science Learning Centres has increased its provision of Continuing Professional Development courses in ethical aspects of science for school teachers, and that the Science Diploma is being designed to contain material on the ethical dimensions of working in the sciences.

Teachers would not seem to be short of resources to enable them to address ethical issues – for example, we are aware that the DEMOCs⁴⁸ card game has been developed further since its inception as an early Sciencewise project, and can be used in facilitated discussion on new technologies, for example. We have already mentioned the IoP's "Are you a Good Scientist?" resource for schools. This is backed up by the "Physics Ethics Education Project⁴⁹ (PEEP) internet-based resource. An equivalent for Biology, the Bioethics Education Project (BEEP)⁵⁰ has also been developed by the University of Bristol, while bioethics is also the focus for the Nuffield Council on Bioethics' most recent resource pack for schools on the forensic use of bioinformation⁵¹. In Northern Ireland, the University of Ulster's Science in Society Unit has a specific project entitled "Forward Thinking⁵²" to enable Key Stage 3 students to discuss contemporary research which raises issues for society. An interim evaluation of the three year project is due for publication shortly. BBSRC, with MRC, the Scottish Initiative for Biotechnology Education, the University of Edinburgh, researchers and an independent bioethics consultant are also working in this domain, and will shortly update and re-publish a discussion document aimed primarily at post-16 students on stem cell science and ethics.

Recommendation and Actions:

Embed Ethical Awareness in School and College STEM courses and enrichment opportunities

- The Nuffield Council on Bioethics Education Advisory Group will promote discussion of bioethics issues among young people through production of resources for teachers and work with other organisations on their education activities.
- The TDA should embed provision of courses on ethical aspects of science in the initial teacher training process.
- Ofqual and the QCDA should ensure principles of ethics and their application to science, engineering and technology in all science and engineering are included in 16-19 courses.

48 www.neweconomics.org/projects/democs

49 www.peep.ac.uk

50 www.beep.ac.uk

51 www.nuffieldbioethics.org/go/aboutus/externalactivitiespage_1018.html

52 www.ulster.ac.uk/scienceinsociety/forwardthinking.html

- The University of Bristol will explore further development and funding of CHEEP, Chemistry Ethics Education project, a resource similar to BEEP and PEEP.
- BIS should work with the Learning and Skills Improvement Service (LSIS) to ensure that ethical considerations of science and technology are considered in FE colleges.
- SCORE Evaluation of “How Science Works” curriculum will include evaluation of assessment of ethics component.
- ESRC & MRC will continue support for the *Debating Matters*, national debating competition, which enables young people to think about societal and ethical issues facing the UK.
- STEMNET and individual employers will encourage STEM ambassadors to talk about ethics and ethical decision making in their interactions with schools.

Ethics in the University Setting

There have been significant developments in ethical scrutiny of research in Universities in recent years, influenced by initiatives from the Wellcome Trust, ESRC, the Universal Ethical Code for Scientists, RCUK and NHS Research Governance, amongst others. Indeed, we asked Fiona Hill⁵³ to examine a range of websites, and she concluded that, “while universities have well developed research ethics policies and guidelines, and research is monitored by research ethics committees, training in ethics is less consistently in evidence”. That research also suggests that where research ethics teaching occurs, it tends to be in the context of modules teaching research methodology, or in health care and similar professional courses. This means that significant numbers of undergraduates will not experience any formal discussion of ethical issues as part of their education. The QAA Framework for Higher Education in England, Wales and Northern Ireland has no requirement for students at undergraduate levels to gain some understanding of ethical issues while its European equivalent has. Asking for consideration of ethical issues in relation to research to be included in the QAA when the framework is next revised would do much to raise awareness in graduates.

Public attitudes surveys suggest that universities could be more active in promoting their regulatory and quality assurance systems to the public. While there is lay member involvement in many university ethics committees this practice could be disseminated further. The UK Universities Research Ethics Committees Forum, although an informal body, has done much to disseminate good practice across universities. University involvement in the Association of Research Ethics Committees (AREC) is also to be encouraged.

In engineering, The Royal Academy of Engineering has also been especially active, through its Teaching Engineering Ethics Group (TEEG),⁵⁴ which has mapped gaps in university curricula and made a number of recommendations for improving the teaching of ethics in a university context. The ethics strand within that Academy’s work is shaped by its Statement of Ethical Principles⁵⁵, and work with the engineering community to embed good practice in both education and the engineering sector more broadly. TEEG’s curriculum map is the only such map to have been drawn to our attention during the course of this work; it may be worth considering whether a similar map is needed for individual subject areas, and who would be best placed to deliver and monitor this.

53 That report is available on our interactive site, and a short summary is attached as Annex 9.

54 www.raeng.org.uk/societygov/engineeringethics/teaching.htm

55 www.raeng.org.uk/societygov/engineeringethics/pdf/Statement_of_Ethical_Principles.pdf

In the research community, there is a welcome growing emphasis placed on ethical contexts. For example, in July 2008, RCUK published its *Statement of Expectation on Economic and Social Impact*⁵⁶, which describes the behaviour and attitudes they wish to foster. Researchers in receipt of funding are expected to demonstrate an awareness of the wider environment and context in which their research takes place, and to move beyond research conduct considerations, and take account of public attitudes towards those issues.

What about when things go wrong?

The UK Research Integrity Office (UKRIO – www.ukrio.org.uk) offers independent advice and guidance to organisations, researchers and the public about research conduct.

UKRIO was set up by government and the major regulators and funders of health and biomedical research. Its guidance is applicable to universities, NHS, business, and charities and covers all subject areas.

UKRIO publishes guidance on good research practice and operates a confidential helpline to offer advice to researchers and the public. Another of its core functions is to help address issues around misconduct. So, in 2008 UKRIO introduced its Procedure for the Investigation of Misconduct in Research.

Since its launch, the Procedure has been used by universities and NHS Trusts to investigate allegations of research misconduct and develop systems to help prevent misconduct.

UKRIO is not a statutory body so adherence to its guidance, which reflects best practice in research, is voluntary.

RCUK has also set out its own approach to the conduct of research in their *Policy and Code of Conduct on the Governance of Good Research Conduct*⁵⁷. This has been circulated to all universities. We would support their approach, calling as it does for the areas which universities should address in developing of systems to support good practice, including:

- training and development modules to ensure that all researchers are aware of best practice requirements;
- training needs analysis for all new employees, especially but not exclusively for those who have not received formal training (for example at PhD level) and those from non-research organisations or institutions outside the UK;
- mentoring and promotion of good research conduct roles for key research managers within the organisation.

Individual research councils have also developed discipline specific codes, and are working with universities and industry to ensure awareness of good practice. For example, ESPRC works with the Institution of Chemical Engineers (IChemE) to increase awareness of ethical concerns among engineers at all levels, and is also leading development of a new framework for those in Digital Economy Research areas.

⁵⁶ www.rcuk.ac.uk/innovation/rolerc/missionsei.htm

⁵⁷ <http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/reviews/grc/consultation.pdf>

Fiona Hill's report also includes some interesting examples of the ethics course options available to researchers, as well as highlighting useful cross university collaboration. Additionally, the pledges made by Vitae and RCUK in relation to including an appreciation of ethics in the forthcoming Researcher Development Framework and Concordat for Public Engagement should make a real difference and enhance capacity for ethical decision making in the wider research community.

Recommendation and Actions:

Strengthen ethical skills and raise profile of ethical training In Universities at all levels

- QAA should consider following the European model and place a requirement on all science and technology subject areas to include ethical training at undergraduate level.
- Universities UK and Association of Research Ethics Committees should increase visibility and profile of Research Ethics Committees.
- Learned societies and others should consider mapping and developing a plan to improve, ethics course provision in individual subject areas.
- Universities should increase the visibility of their approaches to research conduct.
- The Association for Research Ethics Committees will continue to hold regular events, open to all staff from subscribing universities, to raise awareness of ethical issues in the university context.
- UKRIO should assess the availability of ethics courses in their regular survey of universities on research conduct issues and will continue to work with universities to address training provision in ethics, and monitoring of training needs.
- The Royal Academy of Engineering will continue to embed ethics into engineering degrees through its Ethics Engineering Group.

Enhance ethical skills and decision making capabilities of researchers

- RCUK will develop a Public Engagement Concordat for funders of research (to clarify expectations and improve coherence and impact of engagement as detailed in the *Science for All* report). The Working Group developing that Concordat will ensure an awareness of social and ethical issues is reflected within the final Concordat.
- ESRC and its Research Synthesis steering group are developing a potential synthesis on *The Ethics of Engagement* on the ethics of user and community engagement, including impacts on the research process.
- Vitae and NCCPE will embed the development of social and ethical awareness and relevant professional competencies in engagement and dialogue into the Researcher Development Framework.
- NCCPE in conjunction with Vitae, Sciencewise; the Science Media Centre and others will develop practical guidance and resources to support researchers to develop their skills in this area, and work closely with other support networks to improve coordination and signposting to relevant resources.

Ethical Practice of Science in the Workplace

Many science-based companies have at the heart of their corporate responsibility activities transparent ethical codes. In AstraZeneca for example a global Code of Conduct was published in 2008 bringing together the standards of behaviour expected across the company in every function. In 2009 this was supported by eleven global policies covering the most sensitive areas of business and science and continues to be supported by further levels of transparency describing internal codes of practice⁵⁸.

The Bioethics policy is one of the eleven global policies which describes the practice of ethically sensitive science within AstraZeneca. The topics covered range from the conduct of clinical trials through to the use of human tissue, stem cells and animals in research. In many cases more detailed standards of practice are also available. The use of animals in research continues to be a controversial area; however, the AZ policy is a good example of a company describing not only the standards of behaviour expected from its own scientists, collaborators and suppliers, but also describing challenging goals which will drive improvements for the future on a global scale. The company's performance in achieving these targets is evaluated internally through compliance and internal audit functions and every year through the responsible business reporting system, verified by external reviewers.

Many scientists working outside the university setting will have codes of practice available to them, including those developed by the Institute of Physics, the Royal Society of Chemistry and elsewhere. While the survey conducted by the Science & Trust Expert Group does have its limitations it does show that, where they have been available, scientists and engineers have taken advantage of opportunities to learn more about ethics.

Royal Academy of Engineering: Engineering Ethics Group

The engineering ethics work at The Royal Academy of Engineering has been carried out under two headings, "engineering ethics" and "teaching engineering ethics". The former is the main concern of this group, and the latter is focussed on by the TEEG group. Engineering Ethics is focused on professional engineers. A focus in 2009/2010 has been a survey of engineering corporations to assess the extent of their engagement in ethical issues. A significant number of respondents had been in situations at work which concerned ethical problems and noted how they would like more support/training from their companies to deal with ethics in their professional work. In partnership with the professional bodies, the Academy is looking at ways to meet the support and training needs of companies through existing and new provision.

The Engineering Ethics Group is also producing an "Engineering Ethics in Practice" guide for engineers in industry, research and teaching throughout the UK. That guide aims to consider a range of ethical challenges that an engineer is likely to face in their working life. Through case studies, vignettes and interviews from the experiences of practising engineers, the guide aims to bring to life the Academy and ECUK Statement of Ethical Principles and provide practical ways for critically approaching ethical issues in engineering.

Recommendation and Actions:

- The Royal Academy of Engineering and IDEA CETL will publish and widely distribute their “Engineering Ethics in Practice” guide to exemplify the value of ethical judgement & decision making in professional engineering and provide practical ways to help engineers.
- The Royal Academy of Engineering, IDEA CETL and Engineering Institutions will respond to the results of the ethics survey of engineering companies to provide tailored resources, training and support (and signpost those offered by the professional bodies).

The NHS and Commitment to Public Involvement in Ethical Issues

In autumn 2008, the NHS INVOLVE carried out a survey designed to gain a better understanding of the perspectives, experience and knowledge that lay members bring to the work of NHS Research Ethic Committees and the diversity of perspectives amongst the membership. In particular, it sought to establish the range of backgrounds of lay members, the range of contributions that they make, and what helped or hindered these inputs being taken into account.

A summary report on the survey noted the diversity of membership, changes in appointment procedure and recruitment, education, lay members’ experiences as health or social care users, and whether lay members should be paid.

The survey will set a benchmark for future recruitment to RECs and to ensure that membership is representative of a cross-section of society where possible.

Ethics in Government

We were asked to assess the value of the Universal Ethical Code for Scientists, developed by the previous Government Chief Scientific Adviser Sir David King, working with a range of experts. The code, subtitled *Rigour, Respect and Responsibility*, was introduced as a potential educational tool that could voluntarily be adopted by scientists and their organisations. Conceived of as an accessible and useful distillation of existing codes, the word “universal” was intended to capture its relevance across the disciplines.

The Code was piloted within five Government agencies⁵⁹. In addition, a Council for Science and Technology (CST) consultation⁶⁰ in 2005 saw its wide dissemination in the scientific community – we didn’t feel that it was useful to replicate that at this stage, as our goal was primarily evaluation as opposed to promotion. Government followed a number of the CST recommendations, and took steps to promote the Code, with varying degrees of success and uptake⁶¹. This was achieved by inclusion in the 2007 Code of Practice for Scientific Advisory Committees; a leaflet; with GSE staff; and in articles, events and radio interviews with Sir David King⁶². Outside Government, it has influenced the shape of university codes of practice, been promoted on websites, used to help benchmark existing codes within industry and used to influence curriculum development.

59 The Environment Agency; the Veterinary Laboratories Agency; the Pesticides and Safety Directorate (now part of the Health & Safety Executive); DSTL; and the Forestry Commission.

60 www.cst.gov.uk/reports/#Ethics

61 The Universal Ethical Code is referenced within the Royal Academy of Engineering’s Statement of Ethical Principles, and is actively incorporated into a number of university ethical frameworks.

62 <http://news.bbc.co.uk/1/hi/sci/tech/6990868.stm>

We contend that the landscape has moved on since the CST's recommendations were made, and new codes have been integrated into individual structures and processes (for example by RCUK, individual research councils and the UKRIO). Its primary usefulness remains in Government. In that context, there is scope for BIS to promote a refreshed code as a benchmark for scientists, and equally for non-scientists who engage scientists and research evidence in the policy making process to enable them to understand more of the limitations under which science is produced. We would also support its use as a benchmarking tool for business and other sectors.

Rigour, Respect and Responsibility: The Universal Ethical Code for Scientists

Rigour

Rigour, honesty and integrity

- *Act with skill and care in all scientific work. Maintain up to date skills and assist their development in others;*
- *Take steps to prevent corrupt practices and professional misconduct. Declare conflicts of interest;*
- *Be alert to the ways in which research derives from and affects the work of other people, and respect the rights and reputations of others.*

Respect

Respect for life, the law and the public good

- *Ensure that your work is lawful and justified;*
- *Minimise and justify any adverse effect your work may have on people, animals and the natural environment.*

Responsibility

Responsible communication: listening and informing

- *Seek to discuss the issues that science raises for society. Listen to the aspirations and concerns of others;*
- *Do not knowingly mislead, or allow others to be misled, about scientific matters.*

In addition to helping frame the Group's views on trust, Tim Lewens' and Stephen John's report has assessed the usefulness of the Code in terms of addressing issues around trust in both individual scientists and in publics' views of institutionally produced science.

The Science and Trust Expert Group's survey of Government scientists and engineers cannot, as already indicated, be considered representative, but it does show a reasonable degree of awareness of the code both in and out of Government (42% inside, compared to 34% outside Government), with some non-Government respondents indicating that their organisation is actively using it. We also asked PSP to examine the impact of the Universal Ethical Code within pilot organisations, as well as with Chairs of Scientific Advisory Committees to test their awareness of the code as placed within the 2007 Code of Practice for Scientific Advisory Committees. Again, a summary of their report is reproduced at the end of this document, and a longer version has been made available online at our interactive website.

That research established that there was low awareness of the Code among the interviewed Chairs of Scientific Advisory Committees, although some had implemented it as part of their Committee process. More significantly, there did seem to be an appetite for the Code's profile to be raised, and an acknowledgement of its usefulness, as well as fresh views on its potential advantages and disadvantages. Among the advantages reported was the ability to use the seven points as "*a concise summary of what it means to be a good scientist*".

PSP were also able to assess the impact within four⁶³ of the Government agencies that had piloted the code, and those results suggest that "adoption" had not been as overt as had previously been thought. Despite this finding, efforts had been made to raise awareness among staff, including through intranet sites, seminars and induction packs. One issue is that the wording of the Code may have been integrated into existing guidance, and thus this could explain why GSE staff responding to the Science and Trust Group's survey were unaware of its distinct identity. There was an interesting suggestion that the Code would help scientific researchers to appreciate that science is just one of the many factors upon which policy-makers base their recommendations and decisions.

Recommendation and Actions:

Refresh and update the Universal Ethical Code and embed awareness within Government

- BIS and GO-Science should develop a refreshed Universal Ethical Code for use in Government and promote awareness to science and engineering staff through GSE;
- BIS and GO-Science should draw the attention of non-scientific staff to that refreshed Code through the STEM assurance scheme and other means.

Develop ethical training opportunities within Government

- BIS and GO-Science should explore with other Departments whether there is potential to develop a suite of questions pertinent to the ethical behaviour of Government scientists, engineers and technologists, to enable a more robust and widespread picture of behaviour to be drawn;
- BIS and GO-Science should explore with the National School of Government potential for the development of a specific ethics module for practising scientists and also to develop a training package to raise the scientific literacy of non-scientists within Government.

Wider Conversations on Ethics

There are no shortage of organisations involved in facilitating and holding this type of discussion, from the Women's Institute, to the Church of Scotland (whose Society, Religion and Technology Project has now finished), to the Nuffield Council on Bioethics, who accompany their projects with public debates and deliberative engagement with members of the public. Again research councils are also active. Science centres, museums and other venues, as part of their wider science communication activities, will almost inevitably cover social and ethical issues in their interactions. The actions below focus expanding those conversations beyond "the usual suspect" locations, and enabling the widest possible audience to be involved.

63 DSTL were unable to participate in this research.

Recommendation and Actions:

Enabling Wider Conversations about ethics

- The Nuffield Council on Bioethics is establishing a Working Party on the social and ethical implications raised by emerging technologies in biology and medicine in autumn 2010, with a view to publishing a report in winter 2011/12. The Working Party is likely to explore issues of public perception, risk and precaution, uncertainty and intellectual property related to emerging technologies, in light of the historical context.
- BIS will encourage science centres, national museums, the Wellcome Collection, the Dana Centre and other public venues (including those not necessarily connected with science) to look for all opportunities to promote ethical awareness, and the ethical decisions which scientists and engineers are faced with daily.
- The British Library will continue their commitment to discussion on implications of science, feeding into raising awareness of scientific issues among audiences that may not traditionally be associated with interests in science.
- The Research Information Network will instigate a short project to assess the feasibility of other National Libraries, non-HE research libraries and others in providing "Talk-Science" type events for a non-specialist audience.
- BIS will work with DCMS and the MLA to encourage libraries to use their community meeting spaces and extensive collections to encourage understanding of scientific and ethical issues as part of a wider drive to support informal adult learning.
- The Sciencewise process will enable members of the public to voice their ethical concerns about science, and ensure that those considerations are fed into the policy making process on new science and technology.

6. Building Partnerships

Aim: Government, Business, and Academia will work together more closely to maximise the benefits of science and society activities.

Rationale:

The Science and Society strategy has, at its heart, the relationship between science (be that in industry, academia or elsewhere), policy, and the publics in which they operate, exist and with which they seek to interact. There is much good work in this area already, some of it co-ordinated by Government, for example under the auspices of the STEM programme, and many activities being carried forward by individuals and organisations.

We recognise the contribution that social sciences, humanities and the broader range of disciplines have to play in deepening our understandings of the social and ethical contexts in which science and technology develops, in driving forward methodological innovation in public dialogue, and in evaluating "science and society" initiatives. In some respects this Group has lived this tale, through its interactions between social sciences, the humanities, science and engineering in government, academia and industry. The full range of disciplines have much to offer the policy making process.

Actions proposed here will also go some way to addressing the recommendations made in 2008 by the Council for Science and Technology report, *How academia and government can work together*⁶⁴ and in the British Academy publication, *Punching our weight: the humanities and social sciences in public policy making*⁶⁵. The Government Office for Science has already developed a ten point plan⁶⁶ for acting on the CST report, and many of those actions are also relevant to this plan.

There are many bodies contributing to strengthening partnership in the science and society area. For example, there are many learned societies whose policy functions are active in this area, and who organise regular events and opportunities to build the kind of partnerships outlined in the Action Plan.

The Low Carbon Communities Challenge

Working together to find common solutions

Sciencewise are just one of the contributors of an innovative approach to policy development being taken forward by the Department of Energy and Climate Change (DECC). The Low Carbon Communities Challenge (LCCC) recognises that Government doesn't have all the answers to helping facilitate the drive to low carbon sustainable lifestyles that is needed if the UK is to meet its renewable energy and carbon reduction targets in an efficient and affordable way.

This is a two-year research programme designed to test delivery options for achieving ambitious cuts in carbon emissions at community level, which will provide finance and advice to 22 test communities in England, Wales and Northern Ireland. Its aim is to support both technical innovation and understand the social changes that are needed to help meet carbon reduction targets. So it's about understanding the science and the context.

Communities will be supported through dialogue, but also through practical help from a range of third sector partners (including the Carbon Trust, National Energy Action and others). Partnerships with EPSRC and ESRC have also been developed to support a range of research, with academics linked to local communities.

*The LCCC represents a new approach to policy making and this is recognised by the Cabinet Office, who have chosen the project as one of three demonstration areas for their "**Listening to the front line**" initiative – along with work by the Department for Health on obesity and Lewisham Council's work on customer redress. The work, aims to reconnect policy making with front line professionals and ensure that those who develop policy do so in close partnership with the people who are responsible for its implementation.*

64 www.cst.gov.uk/reports/files/academia-government.pdf

65 www.britac.ac.uk/reports/wilson/

66 www.dius.gov.uk/go-science/strengthening_engagement

Similarly, many industries, from SME's through to multinational companies are involved in excellent work to engage their local communities, and in dedicated work to raise awareness of careers and enhance the curriculum e.g. through STEM ambassadors. Such outreach and enrichment activities not only have the potential to build relationships with the communities in which scientists operate but also provide an enriching experience for employees themselves, development opportunities to improve communication skills, and contribute to organisations' corporate responsibility goals.

The Research Councils' cross council programmes, with their interdisciplinary approach to addressing key strategic issues also build relationships in this way.

Recommendations and Actions:

Bring Scientists and Researchers closer to the Policy Making Process

- GO-Science, in partnership with the British Academy will develop a Science and Society Academic partnership scheme to build relationships between academia and policy making and greater interchange between the two.
- The British Academy will take this work forward through their recently instituted policy centre. A key role will be the facilitation of policy discussions, and hosting the UK Strategic Forum for the Social Sciences.
- The Royal Society has this year, expanded their MP/scientist pairing scheme to include building relationships between scientists and civil servants. The programme is currently being evaluated, and will continue in its expanded form next year.
- The Royal Academy of Engineering will introduce a scheme to develop closer relationships with civil servants through Government Science & Engineering.
- The Academy of Medical Sciences & Wellcome Trust will build on a pilot policy internship scheme to provide future scientific leaders with a deeper understanding of science policy and help form bridges between the scientific community and policymakers.
- BIS will also explore with the Research Information Network and Newton's Apple to assess how their work to increase individual researcher exposure to the policy making process can feed into this plan.
- GO-Science and RCUK should work to develop people exchange schemes between academia and Government.
- GO-Science should work with the National School of Government to ensure that training provided on the analysis and use of evidence includes awareness of the research process and practical steps for engaging with academic research.
- GO-Science should promote the placement of civil servants to those Higher Education Institutions, National Academies and other learned societies that are seeking to improve their engagement with Government policy making.
- GO-Science should work with the Higher Education Funding Council for England (HEFCE) and other stakeholders to ensure that policy engagement is explicitly valued in the Research Excellence Framework.
- GO-Science should support Heads of Analysis, Scientific Advisory Councils, Departmental Chief Scientific Advisors in their role as promoters of engagement between academia and Government.

Scientists, Engineers and Technologists from Business, Academia and Government will strengthen links with their local communities

- BIS & STEMNET will encourage a selection of key organisations that have not yet been involved, to take industry leadership roles in STEM enrichment and outreach within their local community, with STEMNET and others through participation in programmes including STEM Ambassadors and STEM Clubs;
- Government Science & Engineering should support science-based volunteering and encourage a commitment to volunteering in their local communities (through the STEMNET ambassador programme, through the UKRC's mentoring scheme, via their British Science Association local branch or other suitable mechanism);
- STEMNET will work with the Local Government Association to increase existing awareness of the STEM ambassador programme, and other ways in which public servants at local level can get more involved in building relationships with their local community.

Develop relationships between science communication and dialogue professionals, and facilitate linkages with the policy making process

- Sciencewise, NCCPE, Beacons for Public Engagement, and others will facilitate and support the development of partnerships between the science community, dialogue experts, science related venues, the public and others through creating practical guidance and case studies and by sharing expertise across networks.

7. Evaluating Science and Society Initiatives

Aim: Evaluation is recognised as a key part of the science and society landscape, and scientists, technologists and engineers work closely with social scientists and other research professionals to build on and lead good practice in evaluation methods. Resources, methods and learning are shared.

Rationale:

Those involved in the type of activity detailed in this, and the other Science and Society Action Plans will be called on to evaluate the impacts of their interventions to assess effectiveness, inform further funding decisions, and to lead and shape best practice. Funders, and never more so than in the current climate of economic uncertainty, have to be sure that they are getting the most for their investment.

We know that for many of those involved in being evaluated, the evaluation process can be viewed with a degree of scepticism, and motivations behind it questioned. That scepticism and concern is, of course, not peculiar to the science and society landscape. Evaluation should not be seen as a potential trap or something to use against the evaluatee – rather, as a way of improving learning, skills and the overall quality of interventions, and helping to ensure that scarce resources are invested as effectively as possible.

We read with interest the proposal made by the *Science for All* group, that a qualification for those involved in this landscape could be on the agenda. In some respects, the work outlined in this section represents a potentially valuable first step in thinking how that might be approached, although our focus is on the development of a shared approach to learning in the first instance.

There is already a broad framework for evaluation of science and society interventions, and it was piloted on two BIS-sponsored delivery bodies. Developed by the Tavistock Institute⁶⁷ and funded by DIUS (now BIS) and ESRC, it highlights the need for triangulated multi-method approaches to assess the impact of activities of organisations whose impact can be difficult to measure, as well as highlighting the value of the insight that well-constructed qualitative methods can offer. This is bread and butter to the social scientist, but perhaps less familiar territory for the natural or physical scientists who have chosen to undertake public engagement or outreach activity. As the emphasis on public engagement activity increases, more scientists and researchers may find themselves in this particular situation.

That framework points to the lack of a systematic approach within the sector: and suggests that this has been a concern since at least the beginning of the last decade. It also highlights the “unique” features of science and society which have an impact on the evaluation approach chosen. Indeed, Joe Cullen, from the Tavistock Institute, took part in a workshop that we held as part of this strand, and categorised the many different factors influencing science and society evaluations:

- Social construction of science
- Its evolutionary nature
- New forms of knowledge production
- Different evaluation purposes
- Problems of causality and attribution
- The range and complexity of Science and Society programmes and actions.

Our workshop was held in February 2010, with the aim of bringing together representatives from a number of different bodies – including those who are evaluated, evaluators and funding bodies – to see if a common approach and language around evaluation was even a possibility.

The full report of that workshop is included in Annex 3. Attendees considered a range of tools and techniques, and helped us develop a set of principles which should help guide evaluation processes. *These are very much the work of the workshop attendees*, as opposed to our view as an Expert Group. We present these principles below, and invite the wider science and society community to comment on, and help shape them further.

Indeed, there was a clearly articulated wish for a community wide approach to be taken and for both learning and resources to be shared more effectively. That extends to tools, techniques, and actual evaluation reports. As in other areas of this report, there would seem to be no shortage of resources, but a relative lack of visibility.

We avoid advocating any particular methodology – there is not, and should not be, a “one size fits all” approach – scientists, science communicators, and other practitioners should, instead, be free to take advantage of good practice in social science evaluation and research, and also to adopt, develop, and help shape new and innovative approaches to suit circumstances. The box shows the range of tools and techniques available, some of which were presented at the workshop, and others which were suggested by participants. Of particular relevance to policy makers, for example, was an *Involve* toolkit for evaluation of public participation, while specific resources have been provided for the academic, engineering, and STEM enrichment audiences.

67 <http://www.dius.gov.uk/~media/publications/F/file40324>

Two of the approaches are based on the theory of change⁶⁸, designed to enable logical analysis around initiative building, and a five step process comprising:

- Identifying long-term goals and the assumptions behind them;
- Backwards mapping and connect the preconditions or requirements necessary to achieve that goal;
- Identifying the interventions that your initiative will perform to create your desired change;
- Developing indicators to measure your outcomes to assess the performance of your initiative;
- Writing a narrative to explain the logic of your initiative.

Table 1: Frameworks for Science and Society Evaluation

Royal Academy of Engineering – Ingenious Evaluation Toolkit ⁶⁹	For use by RAEng public engagement grant holders; Process encompasses workshop at grant inception; Step by step process with standard forms; Evaluation bookshelf.
RCUK – Practical Guidelines: Evaluation ⁷⁰	Targeted at academics needing to evaluate interventions.
National STEM Centre – STEM Partnership Toolkit ⁷¹	For enrichment & enhancement partners in STEM cohesion programme.
Tavistock Institute "Science and Society framework"	Highlights range of methodologies available; Tries to match method to initiative type.
New Economics Foundation – Social Return on Investment ⁷²	UKRC piloting; HM Treasury backing; Enables measure of proxy economic value.
MLA – Generic Learning Outcomes ⁷³	Assesses learning achieved in five key areas; Used by science and discovery centre community.
Involve/Ministry of Justice – Making a Difference ⁷⁴	Focused on policy makers wishing to evaluate public participation projects.
Sciencewise-ERC	For assessing good practice in public dialogue; impacts, costs and benefits.

68 www.theoryofchange.org/index.html

69 www.raeng.org.uk/societygov/public_engagement/ingenious/evaluation.htm

70 www.rcuk.ac.uk/aboutrcuk/publications/corporate/evaluationguide.htm

71 www.nationalstemcentre.org.uk/stem-programme/evaluation

72 www.neweconomics.org/projects/social-return-investment

73 www.inspiringlearningforall.gov.uk/toolstemplates/genericlearning/

74 www.involve.org.uk/making_a_difference/

The workshop also highlighted some of the most common concerns around evaluation processes, and some of the differences around funder and evaluatee perceptions of the process. So, while funders can view the exercise as a learning/improving process, and a necessary way of establishing value for money and their own accountability, there are concerns on behalf of evaluatees that the methods and techniques are not necessarily suitable; that the funder or evaluator does not fully understand what they do; and that the funding body will not necessarily allow scope for capturing the value of risky projects or those with longer-term impacts.

Indeed, measuring long-term impact, as well as disentangling the various range of influences on policy, attitudes and behaviour, represents one of the key challenges to evaluation in this sector. To date, there have been few longitudinal tracking studies, and that approach would certainly add value.

Recommendations and Actions:

Ensure appropriate evaluation skills are developed by commissioners

- Sciencewise-ERC will hold Departmental drop in sessions on evaluation of public dialogue projects.
- Policy makers involved in evaluation of science and society initiatives should be "intelligent customers". Training should be developed as part of the "Analysis and Use of Evidence" Skills set.
- Involve's *Making A Difference* guidelines for evaluation of public participation should be publicised by Sciencewise.
- RCUK should re-publish and disseminate its *Science in Society Evaluation Guide for project/programme managers*.
- Individuals and organisations likely to be evaluated should take advantage of training opportunities to build in-house capability in evaluation methods or to develop "intelligent customer" base.

Share resources and learning from evaluation more effectively

- A Web 2.0 resource (Ning) should be established to share resources, accessible and usable by all with interest in evaluation of science and society interventions.
- There should be regular opportunities for informal workshops and sharing of approaches between evaluators, evaluatees and funders.
- Funders should collaborate more closely to ensure consistent messaging and producers of resources should ensure that resources are visible and appropriately targeted.
- *Evaluation* journal should be asked to publish a special edition of their journal on science and society evaluation.

Capture and recognise long-term impacts in science and society evaluation

- Work should be done to investigate piggybacking on existing longitudinal studies and/or initiate a new study to assess the long-term impact of science and society initiatives.

8. Monitoring public attitudes and our progress

Aim: Public Confidence is measured on an ongoing basis, as part of wider work to understand public attitudes to science. There should be an attempt to understand the attitudes of those involved in science and policy making, and an attempt made to bridge any gaps which may stand in the way of mutual understanding and relationship building.

Rationale:

Government and others are committed to measuring attitudes on an ongoing basis. The *Public Attitudes to Science* series is the Government's main vehicle for measuring progress towards the goals set out in the full set of Science and Society action plans.

While evaluation can attempt to show the impact or outcome of a particular programme, it is and will remain difficult to assess what specific individual interactions or influences have had an effect on behaviour or attitudes. Similarly, the Science and Trust Group were in agreement that it would be naive to assume that any of the recommendations above would, in isolation, have an easily measurable impact on future Public Attitudes.

Undoubtedly, future iterations of the *Public Attitudes to Science* Survey will be the Government's key mechanism for measuring progress towards its goal of achieving closer integration between science and society, increasing numbers studying science, increasing exposure to science, and development of more positive attitudes toward science and scientists. We would also expect to see positive trends in surveys conducted by other actors including the Wellcome Trust, the ABPI and EngineeringUK.

The development of future surveys will also be informed by the analysis conducted by PSP (who have seen the survey's evolution since their involvement in the first OST/Wellcome Trust survey). Their report on how the questionnaire should go forward is included as Annex 10. That work suggests that BIS should seek to focus questions on many of the issues raised within this report, including assessing the understanding of the knowledge production process, "confidence" and views on the regulatory system. The survey will also be used to monitor progress towards the goals set out in the four Expert Group action plans.

Recommendations and Actions:

Public Attitudes surveys will build on the work of the Science and Trust and other Science and Society Expert Groups

- BIS will commission Public Attitudes to Science 2011 in early 2010, taking into consideration PSP recommendations on future development of the survey;
- BIS and other funders should explore the possibility of measuring the attitudes of scientists and decision makers to better understand their needs, beliefs and any potential gaps or areas of concern uncovered by the *Public attitudes to Science* survey;
- BIS should collaborate with other funders of attitudinal surveys, including the Wellcome Trust, the ABPI, and EngineeringUK, to share learning, best practice, and methodological approaches.

Given that the Group has had a remit to look at evaluation, it was felt that it would be incongruous not to suggest a way forward in terms of reviewing progress on its recommendations. It goes without saying that all the Science and Society Expert Groups should annually review how their actions have been implemented – this should be a mixture of quantitative data and qualitative case studies to demonstrate the impact of new and existing action. As new actions and actors are identified, we would hope that they could be integrated into the existing plan. We very much hope that the community will see this as a dynamic document, and let us know about activities, learning and resources which can help shape this plan and its aspirations going forward. We positively welcome fresh thinking and approaches, and want to hear from you if you can play a role in helping meet our overall goals.

Conclusion

The Group's main aim was to make recommendations and propose actions that will enhance society's capabilities to make better-informed judgements about the sciences and their uses in order to ensure that the "licence to operate" is socially robust.

We also said that we wanted to see people enabled – be they schoolchildren, researchers, engineers, or members of the public – to have a well-informed conversation about good science, to be able to discuss the good practice and ethical frameworks which surround the government, industry, and academic use of science, and to be sufficiently knowledgeable to be constructively critical when they see organisations or individuals stepping away from those norms or expected standards of behaviour.

The recommendations and actions presented in this report show the broad range of activities that many organisations across the board are involved in. We are confident will help us work towards our aspirations, and meet our ultimate goal of enabling all our publics to make better informed judgements about the ways in which science is produced, used and applied.

However, we feel that it would be wrong to stop there and so we make a further recommendation, and call on scientists and engineers in Government, business, academia, and all those involved in this landscape to think carefully about how they communicate their activities, and work together to ensure that the lessons learned from interactions are shared and built upon.

Finally, looking to the future, we believe that a follow-on Group – or Groups – need to be established to drive forward the recommendations and action plans from all five of the Science and Society Expert Groups. We recommend that this is done in a way that delivers a coherent and interlocking programme which secures maximum benefit from complementary actions.

Glossary

ABPI	– Association of the British Pharmaceutical Industry
ACMD	– Advisory Council on the Misuse of Drugs
AHRC	– Arts and Humanities Research Council
AREC	– Association of Research Ethics Committees
ASDC	– Association for Science and Discovery Centres
BBSRC	– Biotechnology and Biological Sciences Research Council
BEEP	– Bioethics Education Project
BIS	– Department for Business, Innovation and Skills
CBI	– Confederation of British Industry
CHEEP	– Chemistry Ethics Education Project
CIHE	– Council for Industry and Higher Education
CEO	– Chief Executive Officer
CSAC	– Chief Scientific Advisers Committee
CST	– Council for Science and Technology
DECC	– Department for Energy and Climate Change
DCMS	– Department for Culture, Media and Sport
DCSF	– Department for Children, Schools and Families
DECC	– Department of Energy and Climate Change
DfID	– Department for International Development
DIUS	– Department for Innovation, Universities and Skills (now BIS)
DSTL	– Defence Science and Technology Laboratory
EAG	– Expert Advisory Group
ECUK	– Engineering Council
EPSRC	– Engineering and Physical Sciences Research Council
ESRC	– Economic and Social Research Council
EU	– European Union
FHEQ	– Framework for Higher Education Qualifications
FOI	– Freedom of Information
FQ-EHEA	– Framework for Qualifications of the European Higher Education Area
FSB	– Federation of Small Businesses
GCSA	– Government Chief Scientific Adviser
GLO	– Generic Learning Outcomes
GO-Science	– Government Office for Science (situated within BIS)

GSE	– Government Science & Engineering; a network for scientists and engineers working with Government, and others working on science and engineering related policy
HE	– Higher Education
HEFCE	– Higher Education Funding Council for England
HEIs	– Higher Education Institutes
HSE	– Health & Safety Executive
IChemE	– Institution of Chemical Engineers
IDEA CETL	– Inter-Disciplinary Ethics Applied, a Centre for Excellence in Teaching and Learning.
IOP	– Institute of Physics
KPI	– Key Performance Indicator
LA	– Licensing authority
LCCC	– Low Carbon Communities Challenge
LSIS	– Learning and Skills Improvement Service
MHRA	– Medicines and Healthcare Regulatory Agency
MLA	– Museums, Libraries and Archives Council
MoJ	– Ministry of Justice
MRC	– Medical Research Council
NC3Rs	– The National Centre for the Replacement, Refinement and Reduction of Animals in Research
NCCPE	– National Co-ordinating Centre for Public Engagement
NDA	– Nuclear Decommissioning Authority
NERC	– Natural Environment Research Council
NICE	– National Institute for Health and Clinical Excellence
NIHR	– National Institute for Health Research
OCPA	– Office for the Commissioner of Public Appointments
OECD	– Organisation for Economic Co-operation and Development
Ofqual	– Office of the Qualifications and Examinations Regulator
OST	– Office for Science and Technology
PEEP	– Physics Ethics Education Project
PSP	– People, Science and Policy
QCDA	– The Qualifications and Curriculum Development Agency
QAA	– Quality Assurance Agency for Higher Education
RAEng	– Royal Academy of Engineering
RCEP	– Royal Commission on Environmental Pollution

RCUK	–	Research Councils UK
RRAC	–	Risk and Regulation Advisory Council
SACs	–	Scientific Advisory Committees
SET	–	Science, Engineering and Technology
Sciencewise-ERC	–	Sciencewise Expert Resource Centre for Public Dialogue in Science and Innovation
SCORE	–	Science Community Partnership Supporting Education
SME	–	Small and Medium Enterprise
SROI	–	Social Return on Investment
STEM	–	Science, Technology, Engineering and Maths
STEMNET	–	Science, Technology, Engineering and Maths Network
STFC	–	Science & Technology Facilities Council
TDA	–	Training & Development Agency for Schools
TEEG	–	Teaching Engineering Ethics Group
UAR	–	Understanding Animal Research
UECS	–	Universal Ethical Code for Scientists
UKES	–	UK Evaluation Society
UKRC	–	UK Resource Centre for Women in SET
UKRIO	–	UK Research Integrity Office
WIST	–	Wider Implications of Science and Technology

Annexes:

Annex 1: List of Organisations Consulted or Involved in the Work of the Group

ABPI

Academy of Medical Sciences

AHRC

Association for Science & Discovery Centres

Association of Research Ethics Committees

AstraZeneca

BBSRC

Beacons for Public Engagement

BIS

BP

British Academy

British Library

British Science Association & Science for All Expert Group

Cambridge Science Festival

DCMS

DCSF

DECC

Department of Health

Edinethics

EngineeringUK

Environment Agency

EPSRC

ESRC

Forestry Commission

Gallomanor

GO-Science

Government Science & Engineering

Health & Safety Executive

IDEA CETL, University of Leeds

Institute of Education, University of London

Institute of Physics

King's College London, King's Centre for Risk Management

Laura Grant Associates

National Co-ordinating Centre for Public Engagement

National STEM Centre

NC3Rs

NERC

Nuclear Decommissioning Authority (NDA)

Nuffield Council on Bioethics

RCUK Public Engagement with Research Group

Research Information Network

Residual Risk & Regulation Advisory Council

Rolls-Royce

Royal Academy of Engineering

Royal Society

Royal Society of Chemistry

Science and Society Champions' Network

Science Council & Science for Careers Expert Group

Science Media Centre & Science & The Media Expert Group

Sciencewise-ERC

SCORE

Scottish Government

Sheffield Hallam University

Society of Biology

STEMNET

STFC

Sussex Science and Technology Research Unit

The Tavistock Institute

Universities UK

UK Research Integrity Office

UK Resource Centre for Women in SET

UK Universities Research Ethics Committees Forum

University of Bristol, Graduate School of Education

University of Cambridge Faculty of Education

University of Manchester, Manchester Business School

University of Manchester, Neuroscience

University of Oxford, Said Business School

University of Ulster Science in Society Unit

Veterinary Laboratories Agency

Vitae

Wellcome Trust

Annex 2: Report of Science Advice Workshop

The Science & Trust Group held a workshop on 30th of November to examine the strengths and weaknesses of how different organizations obtain and utilize expert scientific opinion. The scope of the top-line review included governments (UK, US and EU), learned societies (Royal Society, Academy of Medical Sciences, Society of Biology), and private sector companies (AstraZeneca, British Petroleum, Rolls-Royce).

The main points are captured in the table below:

<i>Strengths</i>	<i>Weaknesses</i>
Private Sector	
<p>Collaboration with the public sectors builds understanding and trust;</p> <p>Growing transparency;</p> <p>Resourcing work which is then published in peer review journals;</p> <p>Patient groups provide sustained views to pharma</p> <p>Fantastic vehicle for accessing innovation and the current opinion leaders;</p> <p>Very effective in challenging corporate thinking;</p> <p>Sustainable panels or chief scientists are highly valued;</p> <p>Panels or advisory boards will develop a balanced view;</p> <p>Builds an environment of sharing and openness;</p> <p>Links private sector strategy with leading science.</p>	<p>Public suspicious in pharma sector;</p> <p>Transparency can embarrass “independent” advisors;</p> <p>Patient groups can be too focused;</p> <p>Environment advise not always based on science or evidence;</p> <p>The 3 companies represented probably represent the best in UK industry.</p>
Governments	
UK	
<p>Considered in Europe to be the model;</p> <p>Works well in most cases;</p> <p>Improved in the past 8 years;</p> <p>Calls for evidence provide a wider view;</p> <p>Code of practice well respected;</p> <p>Flexible process capable of responding to very different issues and levels of public interest.</p>	<p>Not transparent and over complex processes;</p> <p>Standing appointments can lead to advise becoming associated with an individual – system personalized;</p> <p>No apparent checks and balances;</p> <p>No impact assessment;</p> <p>Poor continuity across departments;</p> <p>Very UK focused;</p> <p>Selection of advisers relies too much on the same institutions;</p> <p>Best scientists often don’t understand policy process;</p> <p>Few examples of multidisciplinary advice (e.g. including social science);</p> <p>Not all advisers perceived as independent.</p>

<i>Strengths</i>	<i>Weaknesses</i>
US	
<p>National academies highly respected; Opinion produced is comprehensive and thoroughly investigated; Deliberately inclusive in researching views; De-personalized since collective advise; Perceived as independent.</p>	<p>Slow to respond; US-centric; No public face; Expensive; Can be adversarial; Consensus views can be anodyne.</p>
EU	
<p>In many aspects of science EU overrides member states.</p>	<p>Not transparent; Not trusted by national experts; Perceived as based on views from a small group of individuals and not independent; Fragmented; No clear who the advice serves; Extreme views use EU as a vehicle to shape legislation (weak link with overriding powers).</p>
Learned Societies and National Academies	
<p>Senior group of fellows who are scientific leaders can be called upon; Views broadened by consultations; External review before publication.</p>	<p>Fellows can be a "self interest" group.</p>

Emerging Themes

- Private industry has a variety of mechanisms for bringing external advice, innovative approaches and scientific challenge – these are all highly valued. Transparency of engagement and "expenses only" payments help to legitimize the public's view in controversial areas. Also if data is generated publication in peer reviewed journals is important;
- UK Government system has improved and may be the best in the EU. However it should be streamlined, more transparent and managed across departments. There are concerns that appointments of statutory advisers can lead to a personalization of the system, with obvious consequences. Concerns also that since the system is not proactively managed or evaluated across government that no one is evaluation performance;
- The UK should be calling for reforms of the EU process, one solution would be an EU Academy of Science.

Annex 3 : Report of Evaluation Workshop

February 2010

Objective

What are the best ways to evaluate Science and Society initiatives, and how should we develop and support the sector over the next 5 years?

Agenda

- Welcome from Tony Whitehead;
- Perspective on evaluation from the funder and evaluatee;
- What methods and principles should underpin good evaluation;
- Existing evaluation frameworks – 5 presentations;
- Actions for developing and building good practice in the sector over the next 5 years.

Introduction

The workshop brought together representatives from initiative funders (RCUK, BIS, Scottish Government, Wellcome Trust, Royal Academy of Engineering), with professional evaluators, academic interest, and evaluatees representing some of the variety of initiatives available in the Science and Society Landscape. We refer to people/organisations in receipt of funding as "funderes".

The text below shows the broad content of discussions. Attendees were asked to put themselves in the "shoes" of funders and evaluatees to assess common concerns, and to assess understanding of the funders' perspective.

A set of principles were put forward, which could be used to guide further evaluation in science and society, and attendees agreed that these would be usefully discussed with a broader community. There were a number of small presentations on a selection of tools which have been developed for use in the science and society landscape, and other potentially useful sources of information were identified.

There was some interest in carrying discussion forward, and in developing concerted efforts to share resources and meet regularly to share learning.

The outputs of discussion are presented after the boxed Principles which are put forward by the workshop group for community discussion.

Science and Society Evaluation

Funder/Evaluator/Evaluated Workshop Principles

- *Build evaluation in at all stages of your project or programme;*
- *Don't set arbitrary limits on costs, and build in costs of evaluation to your planning;*
- *Recognise the value of formative and summative evaluation (ie shaping and monitoring);*
- *Make sure that your programme or project objectives can be evaluated;*
- *Those objectives should have a clearly defined and **realistic** scope and focus;*
- *Evaluators should give credit to those taking risks, and evaluators should not see "failure" as wholly negative, but take into account the learning gained. Funders should recognise that some projects will be risky;*
- *Evaluation doesn't always have to be externally commissioned. Depending on the type of project, self evaluation can be appropriate when the aims are self-learning and self-development, or if there are fewer resources;*
- *Internal evaluations can be independent too, but an external perspective can be useful to bring new perspectives and insights;*
- *External evaluation establishes credibility and accountability;*
- *Manage expectations of funders/commissioners, about what evaluation can achieve;*
- *Commissioners equally need to consider their skills sets;*
- *Aim for evaluation that can stand rigorous appraisal (in some cases, peer review may be appropriate);*
- *Commit to sharing learning across communities.*

Perspectives on evaluation

What do fundees fear about evaluations?

Fear of failure

"Failure" – even when funding risky projects

Look stupid, poor practise, exposed, mistakes

Shows their scheme doesn't have any affect

That project hasn't had impact + nothing learnt

"Negative" evaluation outcomes

Failure to show impact

Identities poor practise

Their intervention had no impact that they could prove

Shows up failure

Forced to justify

Negative impacts identified

Inability to capture outcomes and impacts

Getting it wrong

No demonstrable impacts – not working

Fear of criticism

Too much information coming out into the public domain

Unfair criticism

Exposure

Hearing criticism from the horse's mouth

Funder understanding and methodology

Evaluators do not understand the programme

Jumping through hoops

Poorly done (e.g. white wash or lack of detail)

Lack of rigour in evaluation methods (compared to scientific processes)

Fear of having evaluation "done to you"

That qualitative evaluation is purely anecdotal

Lack of technical know-how/specialist knowledge

The good work of a programme will not be taken into account

Loss of money

Not enough funds allocated for proper evaluation

That if project hasn't worked you won't get future funding

Removal of funds

Losing out to competition

Not meeting expectations, loss of funding

Budget cuts, cuts in funding

Expense

Evaluators who don't understand what the fundees are doing

Extra work

Lots of extra work

The extra work

Perceive it is difficult

What do funders look for in evaluations?

Improve and learn

To improve science and society work

Tweak future activity and identify gaps/shortcomings

Identify gaps and overlaps

Sign that organisation recognises evaluation can help them improve

To understand whose learning what! Society, sub-sections, science included

Lesson to improve practice

To educate: evaluation as a learning opportunity

To inform future decisions

To find out what works and what doesn't

To help grant holders improve

Capture learning

Building a body of knowledge "what works"

Accountability

Accountability for public funding

Accountability, accountability, show accountability

Justify public money

Reporting

Because it is their mission

To justify decisions to ministers and public

To report back to their own funder / board

To cover their backs

Demonstrate success

Proof of success

Evidence through proper evaluation

To prove value

Demonstrate success

To inform their government areas (all government areas have science + society element)

Value for money

To protect budgets

To show VFM

To make best use of finite resources

Was it VFM?

To make it sure they are VFM

To assess VFM

To report their board to show their great works / ideas passions

Demonstrate VFM

Session Two – What methods and principles should underpin good evaluation?

Principles

- You need careful planning: Start early and continue after: pre, during and post project. Clarity of scope, boundaries, focus;
- Sufficient resources (time and money);
- We should see evaluation as a process, including both formative and summative elements. Think about it early and plan for it. // Time for self-reflection should be embedded through a Science and Society programme. // Evaluation can be of processes (staff, management, systems etc) as well as of project outcomes;
- Failure is not necessarily a bad thing. Evaluators should give credit to those taking risks, and evaluators should not be frightened of failure, as this is where learning is, and successes could be different from those we expected;
- Independent evaluation is important when assessing accountability is a key aim and possible when there are resources to fund it. Self evaluation is appropriate when the aim is around self-learning and self-development, or if there are less resources. Internal evaluations can be independent too, but an external perspective can be useful to bring new perspectives and insights;
- Manage expectations of funders/commissioners, about what evaluation can achieve. // Build skillsets of commissioners so they can commission effective, realistic evaluations // Commissioner needs to understand skill-sets needed for a rigorous study (a study that reaches a publishable standard);
- Ensure objectives of the project are evaluable;
- Commit to making finding and methodologies available and sharing learning across communities (e.g. *the DCSF database of research, Practitioner journals, The Evaluation Society, possible shared community database of findings hosted by ASDC, BSA, Sciencewise etc Join international practise networks*).

Methods

- Evaluation must be Evidence Based;
- There's not one method – the methods should be chosen to meet the objectives of the evaluation;
- Build an appreciation of qualitative research methods, among evaluators and commissioners;
- There can be difficulties of attributing cause, therefore use qualitative methods, in-depth methods or a mixture of methods;

- The Theory of Change approach provides insights on outcomes and processes;
- Impacts often occur at a much later date, therefore chose objectives that are measurable at the time of evaluation;
- Consider longitudinal studies for a few projects, but avoid a retrospective approach. NB a progressive, forward looking design requires a hypothesis, and theory of change. Establish a baseline to measure change against. (*NB 1990 cohort studies might be useful to piggy bank on*) // Longitudinal studies can be very useful. Do more longitudinal –
- Don't set arbitrary target figures for evaluation – build in appropriate costs to scale of evaluation you need;
- Research and employ "early indicators" that give an early view of findings;
- Consider whether a retrospective approach is really the right one, or whether prospective studies are more appropriate;
- We need to rigour and consistency in who (stakeholders) we chose to speak to in evaluations (i.e. sampling frame);
- Quantitative measures are easier to know at the end of a project than at the beginning;
- In come cases, important to ensure that methodologies rigorous enough as to (potentially, not actually) provide publishable quality results (this could be a quality criterion for methodologies, even we don't intent to publish). Should there be peer review, of methodologies as well as reports? // Build peer review into the evaluation process (*e.g. peer review panel, including both evaluators and social research academics, e.g. use practitioner journals*).

Evaluation Frameworks

Evaluation frameworks presented included:

Tavistock
 RCUK
 SROI
 STEM
 Ingenious
 GLO

Comments on Evaluation Frameworks

- There is good information and advice available but there is a view that awareness of what is out there is low.
- Different approaches may be relevant to different types of project.
- Many charities would value being able to demonstrate or show their social impacts.
- There is a need for advice on what evaluation approach to use when.

Organisations and evaluation frameworks

- The Evaluation Society provides a resource in terms of evaluators with a range of experiences.
- The National Co-ordination Centre has a resource centre with a number of toolkits around public engagement e.g. STEM booklet.
- Sciencewise has a framework for evaluating public dialogue and also enables evaluators to experiment and share experiences. It also has a workstream on Costs and Benefits of Public Dialogues.
- The London Benchmarking Group has an evaluation framework re corporate citizenship.
- The New Economics Foundation may have a framework for evaluation social investments.
- DfID has a Knowledge Management for Development framework.

- DCMS has a framework for National Museums with KPIs and a few qualitative measures.
- MoJ has Making a Difference which is available through the Involve Website.

Potential Actions

- Task: What Actions do you recommend for the Evaluation Sector to move it forward over the next 5 years. Consider:
 - Thought
 - Approach
 - Stakeholders
 - Resources
 - Best Practice
- Map and market the map of the landscape of evaluation options, initially nationally and ultimately internationally;
- Develop a community of practice around a resource like Ning or Delicious;
- Approach the editorial board of *Evaluation* re a Science & Society edition;
- Undertake a project on converting evaluation to learning and subsequent behaviour change which encourages networking and promotion of best practice etc;
- Promote existing resources like NCE, Ingenious, Isotope & W20 & provide examples of evaluation toolkits and consider which organisation can provide sectoral “glue” such as Science 4 All/BSA. Avoid setting up something new;
- Take account of why Delicious is so useful – it provides access to other resources and it is possible to see the popularity of the various links it contains;
- Evaluators should decide as a group which portal to use;
- Bear in mind that Science & Trust and Science 4 All have useful elements to the future of the evaluation sector;
- Existing funding and initiatives such as Sciencewise could be used to initiate any central resource. For instance, Sciencewise has plans to promote best practice though note there will be a need for a long term funding source of funding sources;
- Sciencewise could help build capacity for funders regarding evaluation;
- Different organisations could pick up different aspects of the evaluation sector development like evaluation best practice and funder skills;
- Consider whether to think wider than Science in Society and relate to the wider evaluation community e.g. Theory of Change.org, Bloggers, UKES;
- The Magenta Book from the Treasury looks at how to measure impact of initiatives.
- Consider whether to develop a case study to illustrate application of the existing Science in Society evaluation principles;
- Funders such as RCUK, Wellcome & DCSF need to share their experiences of evaluations especially around techniques and consider common goals. They must also promote effective evaluation;
- Science & Society must provide links to help share experiences e.g. Web2.0 and widen the Sciencewise model beyond public dialogue;
- Informal networking and workshops are valuable e.g. from NCCPE and ASDC;
- Consider courses for developing the “Intelligent Buyer”

Annex 4: Note of Risk Workshop

The starting point for discussion was how to ensure that lessons are learned from past studies of public deliberation and analysis of risks associated with emerging technologies. In particular the workshop was concerned with how to include public deliberation as part of the risk analysis and communication process. The role of science underpinning the innovation and regulation of emerging technologies is a central element in the wider context of science and society relations.

Discussion of the Risk & Regulatory Advisory Council

1. The **Risk & Regulatory Advisory Council** made a series of recommendations to government on **Public Risks** in its final report (May 2009)⁷⁵. These included setting up an independent *Public Risk Commission* as a **"resource to Government in helping to understand and manage the risk landscape"** (page 39).
2. Government responded by stating that recommendations for public deliberation of the risk landscape would be met by existing institutions, including the Better Regulation Executive and the Regulatory Policy Committee. In addition BIS with the HSE will commission a research programme **"to develop practical guidance that will help Government consider the appropriate response and responsibility for public risks"** (page 15)⁷⁶.

Discussion of other approaches to risks and emerging technologies

3. The question of risk is often an important element in the judgements that society makes about sciences and their uses. It has been well known for several decades that the identification and management of risks involves both analysis of the best available science and deliberation of public perceptions and values (see for example US National Research Council 1996⁷⁷ and RCEP 1998⁷⁸).
4. There have been recommendations coming from studies into potential risks from nanotechnologies for setting up bodies to consider the public risks of these technologies in broader context:
 - In 2004 the Royal Society and Royal Academy of Engineering recommended that a group be formed "that brings together representatives of a wide range of stakeholders to look at new and emerging technologies and identify at the earliest possible stage areas where potential health, safety, environmental, social, ethical and regulatory issues may arise and advise on how these might be addressed" (Page 84)⁷⁹.
 - Similarly in 2008 the RCEP recommended: "Government should move beyond one-off public engagement "projects" to recognise the importance of continual "social intelligence" gathering and the provision of ongoing opportunities for public and expert reflection and debate. We see these functions as crucial if, as a society, we are to proceed to develop new technologies in the face of many unknowns" (RCEP 2008)⁸⁰.

75 <http://www.berr.gov.uk/files/file51459.pdf>

76 <http://www.berr.gov.uk/files/file54045.pdf>

77 Stern, P and H Fineberg eds (1996) *Understanding Risk: Informing Decisions in a Democratic Society*, US National Research Council/NA Press: Washington, DC.

78 http://www.rcep.org.uk/reports/index.htm#21_stand

79 <http://www.nanotec.org.uk/finalReport.htm>

80 <http://www.rcep.org.uk/reports/27-novel%20materials/27-novelmaterals.htm>

5. Cases where risks have been mishandled by governments have led to a loss of public trust in government's capacity to use science wisely, as illustrated in the BSE crisis of the 1990s (Phillips 2000). This led the House of Lords in its report on Science and Society to state:

Much public policy debate is confused by an assumption that the issues reverberating around science in the public domain, especially a whole variety of risk issues, can be reduced to a set of questions capable of objective and incontrovertible answer by scientific research. Most often, in truth, the issues are complex. Scientific understanding can contribute to a resolution of these issues, but only in partnership with judgements based on people's attitudes, values and ethics⁸¹.

Note of discussion

- Members of the group met with the Secretariat of the Risk and Regulation Advisory Council to discuss how the actions and outputs of that particular group were relevant to the work of the Science and Trust Expert Group.
- There were a number of outputs from the group, including a number of research reports, and a public leaflet, "A Worrier's Guide to Risk". Documentation had also been prepared with GO-Science to explore how policy makers could communicate risk effectively with the public.
- The Secretariat (RRAC) agreed to talk to residual RRAC members to discuss whether they would be happy for their work to be signposted by Science and Trust.
- The group also considered how "risk" was dealt with by Government, and how the regulatory system is designed to deal with risk. There are conflicting views on evidence to support the view of public risk aversion.
- The concept of public risk – ie risk where Government might be expected to have a role in managing – was discussed.
- It was agreed that actions would be developed around:
 - Clarifying and streamlining the governance landscape;
 - Greater consideration of risk within the curriculum;
 - Publicising RRAC documentation.

Annex 5: Summary of The Universal Ethical Code for Scientists and the “Crisis of Trust in Science”

Dr Stephen John, Hughes Hall, University of Cambridge

Dr Tim Lewens, Department of History and Philosophy of Science, University of Cambridge

1. General findings

- This paper examines the effectiveness of the Universal Ethical Code for Scientists (UECS) as a response to the alleged crisis of trust in science. It concludes that there is no single phenomenon of the public crisis of trust in science. Rather, there are many different trust-related problems which arise in relations between science and the public.
- Resolution of these problems will probably need a general rethinking of the role of public involvement in science and the relationship between the institutions of science, of industry and of the State. A limited focus on changing scientists’ professional ethics is unlikely to be sufficient.

2. The meaning of mistrust

- When we say there is mistrust in science we might mean that scientists are not trusted to tell the truth, either because of incompetence or bias, or we might mean that scientists are not trusted to perform research that is beneficial, rather than obscure, whimsical, and self-indulgent. We might mean that scientists are not trusted to make good social policies. We might mean that individual scientists are not trusted. We might mean that scientific institutions are not trusted. We might mean that corporate or government-based institutions which make use of scientific evidence are not trusted.
- Clearly, a focus on an ethical code for individual scientists will fix only some of these problems at best.

3. Why care?

- We need to clarify why one might care about trust in science. There are three broad sets of reasons.
- First, research scientists require enough trust from society as a whole to enable their work to continue, and to be funded at adequate levels.
- Second, trust in the testimony of scientists is important for public health reasons.
- Third, trust in scientific research may be important for generating broader economic benefits.
- These rationales require not only that scientists are trusted, but that they are also trustworthy. Hence efforts to ensure trustworthiness of scientists and scientific institutions are just as important as efforts to ensure trust in these individuals and institutions.

4. "Crisis of trust"

- We argue that evidence of a genuine and generic "crisis of trust in science" is lacking. What appears at first sight to be a crisis of trust in "science" *per se* might be better analysed as a crisis of trust in science sponsored by industry or government, or in the ways in which government and industry institutions make use of scientific advice.
- There are, for example, considerable difficulties in interpreting empirical data on trust and science. What appears to be mistrust may, in fact, be miscommunication. Scientists may make statements about questions of fact, which the public would be reasonable to trust. But scientists' statements may also unwittingly stray into questions of value, which the public would be reasonable to distrust.
- There are also cases where people in fact trust, and yet claim they do not. Conversely, what might appear to be trusting relationships can, in fact, be relationships where one party feels they have no choice but to rely on a second party, even though they lack any trust in that party.

5. Sincerity and competence

- When trust is a genuine issue, concerns sometimes focus on scientists' sincerity. Concerns about sincerity can stem from scientists' involvement in industry and politics. These worries give rise to quite legitimate concerns over the ability of scientists to act and speak sincerely.
- At other times, concerns can focus on competence ("They were wrong about BSE, so why believe them on GM?"). We do not trust those who are unlikely to be able to do what we rely on them to do. Concerns about competence sometimes draw on cases where scientists ignore, or misinterpret, important elements of lay knowledge in producing policy recommendations. Neither, either or both concerns may be present in non-scientists' attitudes towards science, and neither, either or both might be justified.
- Public engagement, and the involvement of diverse constituencies of scientists, may work to allay concerns in all of these areas.

6. Scientists and policy making

- Where scientists are also involved in the formation of policy, there can sometimes be a tension between the desire for the scientist to communicate sincerely, and the desire for the scientist to act as a competent policy-maker.
- Sincere communication about the limits of knowledge, uncertainty, and ambiguity surrounding technical scientific findings may be at odds with the production of decisive, reassuring policy measures. Scientists will sometimes find themselves drawn in both directions at once, with the result that maintaining trust in general will be difficult.

7. Universal Ethical Code for Scientists

- The Universal Ethical Code for Scientists itself (UECS), may aim to reassure the public, or it may aim to re-shape the scientific professional ethos. Only the second role seems likely to have much impact on public attitudes towards science.
- There are reasons to think that re-shaping the ethos of a body of workers may be more effective than traditional methods of ensuring trustworthiness based on audit and accountability. The problem with these more traditional methods is that competent auditors or accountants will typically fall into the very profession they aim to oversee. The result is that concerns over trust are simply shifted to the auditors or accountants themselves.
- Altering professional ethos cannot plausibly be achieved by a code alone. Forms of training, comprehension, sympathy and enculturation are also essential. And even here, concerns about trustworthiness are bound up with broader institutional issues about incentives.
- The UECS does not resolve one of the most pressing concerns for trust in science, namely the tension between sincerity and competence outlined above (section 5).
- The Code might do some good in allaying concerns about competence, but it could be reformulated to pay greater attention to the ways in which scientific and social concerns often interrelate. As such, it may suggest too limited a model of engagement between scientists and the public to respond to some concerns about competence.
- The Code does not adequately respond to the problems which give rise to concerns over the sincerity of scientists: that their allegiance to non-scientific institutions makes them untrustworthy. These are not criticisms of the Code as such, but they are criticisms of the thought that ethical codes are the primary ways to respond to alleged crises of trust in science.

Annex 6: Summary: Psychological Review of Trust

Ann Macaskill, Professor of Health Psychology, Sheffield Hallam University
Kyle Brown, Department of Health Psychology, Sheffield Hallam University

1. Defining trust

1. This paper considers trust in the context of increasing citizens' trust in Government on scientific questions.
2. Defining trust is important. It involves the person trusting, the one being trusted and the relationship between them. Understanding what factors are involved here will reveal where intervention could increase trust.
3. Most definitions of trust have certain things in common. For example, they acknowledge the vulnerability of the person who trusts. One strategy for increasing trust in science would be to find out what it is that enables this vulnerability, and what it is about the relationship between the two parties that allows it.
4. When it comes to people trusting persuasive messages from the Government, the most important relationship is the one between the two parties. As far as this goes, common characteristics are commitment, coordination, good communication, participation, and joint problem solving through techniques of conflict resolution.

2. Institutional trust

1. Trust in an institution is different from trust between people.
2. It is the impersonal nature of institutions that makes institutional trust so difficult. It is more problematic to trust some abstract principles or anonymous others who do not express any emotions.
3. Trust in institutions as impersonal entities depends on their perceived legitimacy, technical competence and ability to perform assigned duties efficiently.
4. Another strategy to increase trust in institutions would be to find a way of making it seem as though there were a relationship between the institution and the people. Then the aim would be to increase the factors listed in section 1-4 as being important to that relationship.
5. High levels of trust in society can facilitate faster and wider diffusion of information, which in turn may promote healthier behaviour. It also helps control unhealthy behaviour such as smoking and alcohol abuse.

3. Repairing trust

1. Studies have investigated an assortment of tactics that can be used following a violation of trust. These include apologies, denials, promises, excuses, reparations, legalistic remedies, hostage posting (pledging a bond) and even no response at all.
2. Since trustworthiness is in the eye of the beholder, there may be times when trust has been violated, but the trustee (the person trusting the one who has violated) does not know a violation has occurred. In such cases, the violation need not necessarily be followed by an attempt to repair trust. The trustee may simply need to be informed of the violation.

4. Maximising the legitimacy of messages

1. The important part of designing a trustworthy communication is to examine the motivation and ability of the intended recipients and tailor the message accordingly.
2. An expert source would be appropriate if recipients are motivated and able to process the message, but only if the source is relevant to the persuasive message. In that case, factors such as the quality of the argument and its credibility will be influential.
3. Finding inventive ways to increase the recipients' attention and comprehension may be an effective way to enhance the effectiveness of the message.
4. If there is no motivation or ability to process the message, then a different strategy will be more effective. This will depend on factors the recipients of the message associate with learning. These include bodily movements such as head nodding which increase persuasion, the number of arguments in the message and the overall length of the argument.
5. However, as most people are subjected to persuasive messages on a daily basis, they generally know when someone is trying to persuade them about something.
6. There are several strategies which might be use to overcome this. One is to make the message seem less like a persuasive one (for example, by using a "front group"). Another is to increase the recipients' motivation and ability to process the message despite their knowledge of persuasion. A third is to increase trust in the message (possibly through increasing the perception that the sender of the message genuinely cares about the recipient).

Annex 7: Summary: Ethical Dimensions in Sciencewise

A review of public perceptions of ethics issues from the sciencewise dialogues

Daniel Start

Sciencewise Dialogue and Engagement Specialist

1. Summary

1. Sciencewise-ERC has completed thirteen public dialogues⁸² on science and technology since 2005. This review examines the public attitudes to ethical and trust issues emerging from these dialogues.
2. Broadly, people were likely to be positive about developments in science and technology that promised gains in choice, quality of life, health, longevity, convenience, time-saving and reduced environmental impact. However, potential impacts on freedom, privacy, social equity, vulnerable groups such as the mentally ill or very young, or on “natural and human values” were regarded with varying degrees of suspicion or hostility.

2. Common themes

1. Three common lessons about the public participants’ attitudes to the science and its governance can be identified. The public is concerned about:
 - First, the social distribution of impacts. The calls for science to serve a “social good” suggest that public participants see the Government as playing an important part in shaping the social purposes of science and technology.
 - Second, the Government’s ability to manage risk, uncertainty, and regulation. The public also has little trust and confidence in the resilience of Government to stand firm against perceived vested interest in industry. It is also concerned about the role of private ownership in research and development.
 - Third, there is consistent demand for more open discussion and public involvement in policymaking relating to science and technology. The challenge for Government is to trust the public’s ability to understand and contribute meaningfully to upstream policy discussions. It also needs to find ways to incorporate members of the public directly in these discussions and open up decision making processes to wider public scrutiny.

3. Differences across topics

1. Differences of ethical opinion tended to be most pronounced *within* dialogues, rather than between them.
2. The most common dichotomy was between libertarian and communitarian values systems: between upholding free choice and personal well-being, and the protection of wider societal outcomes and social goods. Mirroring this were competing desires for “modernising” information technology (IT) and labour-saving technology, as against concerns to preserve “traditional” values and qualities in the way we work, care and manage the land.

⁸² Risky business, Trustguide, Nanodialogues, Nanodialogue engagement group, Democs, Community exchange, Drug futures, Science horizons, Hybrid and chimera, Stem cell, Forensic use of DNA, Industrial biotechnology and Big energy shift.

3. Different science topics did tend to create their own areas of debate.
4. Medical research was always deemed to be very important, but it raised issues about what illnesses (and age groups) were most deserving, how the safety of a donor should be protected, and the moral rights of embryos and human genes.
5. IT science tended to raise issues around consent and privacy, and the misuse and governance of data.
6. Food and environmental science stirred debates on the containment of risks, and impacts on wider social and natural systems.
7. For downstream technology products, the public were keen to be empowered through information, particularly labelling on risks, so they could make choices for themselves, rather than have their behaviour regulated. They were also keen on the provision of restitutions and guarantees.
8. The public were most supportive of research that had the potential to offer clear benefits (e.g. clear medical/clinical benefits), and wanted to see more invested in understanding side-effects of potential applications. They understood that risk and uncertainty were unavoidable in emerging technologies, and encouraged all players to be much more open about the uncertainties and unknowns they face. They wanted government and businesses to take responsibility for unintended consequences, and explain how they would deal with worst case scenarios. There were calls for more research and tighter regulation until more is known about the long-term side effects of some science-based innovation on humans and the environment.

4. Regulation, technology, engagement

1. Some form of regulation was seen as key in all upstream science research. However, some areas were deemed to be over-regulated, and others under-regulated.
2. Most importantly, the Government was asked to clarify the governance map, to be open about who does what and to ensure different parts of Government co-ordinate better. This will build public confidence in a strong and resilient Government that can stand up to commercial lobbies and vested interests (see section 2 – 3 above).
3. Although Government and other public bodies have a powerful role in steering and regulating scientific research and development, technological trajectories emerge from a complex combination of forces that include private investment, market forces, public interest, and individual enthusiasm, not to mention chance. Although Government alone cannot be held responsible for them, the public wanted it to play a more or less dominant part in seeking to influence them.
4. Across all dialogues the public called for more public engagement and oversight, to shore up trust in Government processes, as well as to inform a longer term vision of science and society strategy. However, this was not just about holding events, but about engendering a long-term cultural change that would increase transparency and openness in science and Government, across all processes and decisions.

Annex 8: Summary of The Universal Ethical Code for Scientists and Assessment by Chairs of Scientific Advisory Councils and Pilot Institutions

Richard Greenberg, People Science & Policy Ltd

1. Introduction

1. Sir David King's Universal Ethical Code for Scientists (the Code) was introduced in 2005. The Code is directed to all fields of science and the pursuit of knowledge in general and is intended for everyone who would use scientific methods as part of their work. It is meant as a "public statement of the values and responsibilities of scientists"⁸³. The code has been piloted at five Government organisations that are responsible for scientific research or regulatory decisions based on scientific research. The Code is also appended into the entry packs for all members of Government Scientific Advisory Committees (SACs)
2. This paper summarises the findings of an assessment of its impact in three areas. First, whether it has been useful to the pilot organisations and to SACs. Second, how far it has been implemented by these bodies. Third, whether its introduction has made an impact in the practices of the organisations which have adopted it.
3. The findings are based on interviews with 12 Chairs of Scientific Advisory Committees (SACs) providing advice to Government departments in a range of fields, including environmental, medical and veterinary sciences. A separate element involved site visits and interviews with key personnel at four of the institutions that piloted the implementation of the Code: The Environment Agency, The Pesticides Safety Directorate, The Forestry Commission and The Veterinary Laboratories Agency.

2. Usefulness of the Code

1. Both Chairs and those interviewed in the pilot institutions felt that, as a standalone document, the Code did not offer much in terms of specific guidance on the ethical issues that a researcher might encounter. However, this was not necessarily a point of criticism. While some Chairs felt that the Code was too vague to be of any practical use, others viewed it as "commendably short". They felt that its primary value was not in offering specific guidance or protocols, but rather as a means of cementing the idea of ethics as a principle that permeates all aspects of scientific enquiry.
2. The Code was, for example, regarded as particularly useful for multi-disciplinary research to ensure consistency of practice.
3. Many welcomed the primary purpose of the document as a unifying code for scientists in the same way that other learned professions have their own codes of practice. The Code was felt to be particularly useful for the areas of research that do not currently have prescriptive codes of practice and where ethical issues may be less overt.
4. Those interviewed felt that the Code could give confidence to those who might be in a position to speak out about corrupt practices and professional misconduct, and that this may help compliance.
5. Many felt that the value of the Code was in starting the conversation on ethics, and keeping ethics at the forefront of researchers' minds.

6. They saw the Code as a helpful basis for clarifying the relationship between scientists and policy makers. They felt it upheld the principle of an open organisation and aided management in general.
7. Both Chairs of SACs and those interviewed in pilot organisations saw the Code as valuable because it raised the issue of communication with the public, which other codes of ethics and practice do not cover well. They felt that this emphasis might help to stem future controversies and thus maintain and improve public trust in science.
8. The Code also highlighted the need for Chairs to be competent communicators, as they are spokespeople for a particular area within science.

3. Implementation

1. The Code does not enjoy a high profile. Few of the 12 Chairs interviewed were aware of it, and even fewer had implemented it as part of their committee's procedures. However, it was viewed in a largely favourable light by those who participated in this exercise.
2. Some Chairs had adopted the Code as part of their committees' practices. They felt it served as a reminder of what being a good scientist means. It also reinforced the need to declare conflicts of interest, which is very important in ensuring public trust in science and scientists.
3. Once the Chairs were given information about the Code, there was some enthusiasm for using it to raise all scientists' awareness of ethical issues. Some would like to see its profile raised. They felt it should be introduced early in scientists' training.

4. Impact

1. None of the institutions that had piloted the Code had experienced major upheavals as a result of adopting it. They saw it as helpful in shifting the perception of ethics from an abstract concept to a central principle of scientific research.
2. Many of those who participated in this exercise felt that the Code was in effect a summary of what it means to be a good scientist, and those who had been involved in its implementation in pilot institutions felt that it was a reflection of way in which they currently operate. However, this did not lead to outright dismissal of the Code, as some felt that the principles of "being a good scientist" cannot necessarily be taken for granted. The Code ensured that these principles were cemented, particularly amongst scientists who are at the earlier stages of their research careers.

5. Problems

1. Chairs perceived that implementation of the Code would raise some problems.
2. They felt that preventing people from being misled about scientific issues placed undue onus on scientists. Furthermore, for many areas of science there are no clear guidelines and it was not clear how the Code would relate to the working life of these researchers.
3. Another perceived problem was that the Code contains little guidance on how compliance is enforced.
4. Some felt that there was little guidance about what should be done if a policy contradicted scientific research, or if public opinion contradicted scientific research.

Annex 9: Summary: Ethics Training in Universities

Fiona Hill

Introduction

1. As part of its brief the Science and Trust Expert Group is looking at what training scientists can expect to receive in ethics.

Methodology

1. This research aimed to explore what ethics training is given in universities to students and researchers. The focus was on a sample of publicly accessible information including frameworks and codes of practice; framework for Higher Education Qualifications; QAA Subject Benchmarks; University ethics policies and Ethics training courses.
2. Research Council statements on ethics training have been examined, and a number of representative bodies have been consulted for their position on and attitude to ethics training.

General frameworks and codes of practice

1. The QAA Framework for Higher Education Qualifications (FHEQ) in England, Wales and Northern Ireland outlines expected skills and qualities for students at five levels but these do not make specific reference to understanding and application of ethics.
2. However, the so-called Dublin Descriptors in the Framework for Qualifications of the European Higher Education Area (FQ-EHEA) do include the expectation that students will have gained some understanding of ethical issues.
3. At doctoral level ethical judgements are not mentioned but perhaps this is implicit within the requirement to "have demonstrated a systematic understanding of a field of study and mastery of the skills and methods of research associated with that field".
4. QAA subject benchmarks for honours and masters degrees indicates what students can expect to receive in the way of ethics training. This is not set out for all subject areas at this level.
5. RCUK's Research Careers and Diversity strategy lays out three main aims, which include "help universities to improve the quality of their research training". Its Research and Development group has responsibility for giving a lead on strategies relating to research, training and development, including research ethics.
6. In addition the Research Councils have ethical guidance statements. This all leads to requirements of researchers and students in receipt of grants to abide by the ethical principles laid out.
7. All HEIs have a research ethics committee, and some of these are faculty-based. These oversee that research carried out meets the ethical standards laid down.

Training

1. The Royal Academy of Engineering has developed an engineering ethics curriculum map as a guide for academics interested in teaching ethics to engineering students. This research has not found a similar curriculum map in other disciplines.

Undergraduate Courses

2. It is not always possible to obtain the details of undergraduate programmes of study and many institutions do not give full programme specifications on their public websites. It is therefore difficult to see how the QAA benchmarking statements are implemented across the sector.
3. Degrees such as medicine, dentistry and veterinary sciences have both an expectation in the QAA subject benchmarking statements and a requirement from the professional bodies to include ethics training. For health sciences the QAA benchmarking statements suggest that ethics should be covered as a related subject rather than part of the course.
4. In other undergraduate programmes ethics training is generally offered in the context of research projects and dissertations. Where the nature of the subject demands it, for example in medicine, or where there is a research project (for example in psychology) training is included. Other modules are designed to cover ethics relating to the subject, or may be offered as an option.

Postgraduate and researcher training

1. The expectations for postgraduates are laid out in the QAA Code of Practice for the Assurance of Academic Quality and Standards in Higher Education and include access to appropriate skills training. This includes an awareness of ethical issues arising from their research. Accordingly, postgraduates can expect to access a skills development programme suited to their needs. Alongside, and developed from this is the Concordat to support the career development of researchers,
2. Postgraduate researcher training can be delivered in a variety of ways. Programmes may be laid on within the university. There are also various training packages and schemes for postgraduates and researchers such as Skills Forge based in the University of York. Vitae provides training workshops and courses in ethics for both doctoral researchers and their supervisors at different university venues.
3. The research councils do not appear to offer specific training in ethics, although understanding of ethics is a requirement of their grants, apart from the Medical Research Council which has guidelines and offers some distance or face-to-face training aimed at practitioners.

Attitudes towards ethics

1. There is a large body of stated frameworks, policies and codes of ethics for scientists which show the expectations both in terms of behaviour and training.
2. HEFCE has no particular policy on ethics training, but funded the project carried out by the CIHE, the Institute of Business Ethics and Brunel University to draw up the "how to" guide, "Ethics Matters: Managing ethical issues in higher education".

3. In its Code of Practice for Researchers, the UK Research Integrity Office offers a useful checklist for researchers. It also states that: "Organisations should provide training for researchers to enable them to carry out their duties and develop their knowledge and skills throughout their career".
4. Generally research ethics is well covered within HEIs and institutions have a policy and guidance on this.

Conclusion

1. This brief survey illustrates that although universities have well developed research ethics policies and guidelines, and research is monitored by research ethics committees, training in ethics is less consistently in evidence. There are benchmarks and frameworks which outline what students and researchers can expect to receive, but it is difficult to triangulate these with the course outcomes and how these are implemented is not so clear.
2. At postgraduate level there is entitlement to programmes in skills and personal development, sometimes provided by the institution and sometimes externally, and there are other opportunities from organisations such as Vitae to receive training in ethics.

Annex 10: Public Attitudes to Science Survey Review (PSP)

Background

There have been three public attitudes to science surveys conducted between 2000 and 2008. After analysis of the most recent (2008) survey, it was felt that the questionnaire would benefit from review without the pressure of fieldwork timetables. In October 2009 PSP with TNS was commissioned by the Department for Business, Innovation and Skills (BIS) to undertake that review.

Methodology

The review comprised:

- a review of the previous research, both qualitative and quantitative undertaken as part of the three surveys, with a particular focus on the qualitative work; including the six focus groups conducted as part of the 2008 study on awareness and understanding of social science;
- re-analysis of the attitude statements and the factor analysis from the 2008 survey;
- cognitive interviews with 16 individuals focusing on specific elements of the 2008 questionnaire and new questions felt to be necessary based on the analysis of the 2008 survey data; and
- interviews with the Chairs of the five Expert Groups set-up by BIS to help develop the Science and Society strategy.

Outcomes

The review resulted in suggestions for a revised questionnaire, which took into account the priorities of the five Science and Society Strategy Expert Groups, as well as the findings from the cognitive interviews and re-analysis of previous research. The draft revised questionnaire is supported by a report of the rationale behind the suggested changes. Some of the key conclusions are outlined below.

- The attitude statements were tested to determine their value to the analysis and as a result two statements were recommended for removal;
- Many of the questions that provide indicators for the Expert Group Action Plans are already included in the survey, although a few have been added to provide additional insight;
- There are a number of tracking questions in the survey that should remain unchanged to allow for consistency, however the removal of two tracking questions was recommended.
- The review also considered, and made recommendations on, specific aspects of the questionnaire. These were: understanding of the system for the production of scientific knowledge; views on specific scientific research topics; understanding of, and confidence in, the regulatory system; attitudes to careers in science; and engagement with science. It was also recommended that the survey focus on science as understood by the lay public and not include engineering, technology or social science.

The report also suggests that for maximum benefit to be derived from the survey, the analysis must be driven more by policy questions. This means that more time is required between the completion of fieldwork and publication of the report.

Sampling method

As part of this review we considered the most appropriate sampling method for the survey. The three surveys to date have been undertaken using random location sampling, although slightly differently applied by the two different survey research firms that have conducted the surveys. If the survey is to move from being a general, occasional, public attitudes survey to a measure of progress against departmental strategy, we suggest that the sampling moves to a random probability method. This method is more appropriate for tracking change, although the resulting discontinuity with previous surveys and a significant additional cost are factors to be considered by BIS.

Annex 11: Ethics Training for Scientists and Engineers

Michael J. Reiss, Institute of Education, University of London, 20 Bedford Way, London WC1H 0AL, UK

Introduction

There was a time when in most countries those learning to become scientists or engineers would not formally have been taught anything about ethics. But that is changing. It is not just medical students who learn about ethics, engineers learn about environmental ethics, agricultural and veterinary students learn about issues to do with animal ethics and so on. This broadening of educational aims and content reflects a growing societal expectation that graduates in applied science disciplines, in particular, should know something of ethics in their field rather than merely being expected to “pick it up” during the course of their professional lives (Reiss, 2006).

Why should scientists and engineers study ethics?

But what precisely might be the aims of teaching ethics to scientists or engineers? Based on Davis (1999), at least four can be suggested (Reiss, 1999).

First, such teaching might heighten the ethical *sensitivity* of participants. For example, scientists and engineers (and those training to be scientists or engineers) who have never thought about whether laboratory rats deserve the same standard of care as laboratory dogs or whether a financial value can be placed on human life when calculating safety margins in design might be encouraged to think about such issues. Such thinking can result in scientists and engineers becoming more aware and thus more sensitive. It is not unusual, as a result, to find students saying “I hadn’t thought of that before”.

Secondly, such teaching might increase the ethical *knowledge* of scientists and engineers. The arguments in favour of this aim are much the same as the arguments in favour of teaching any knowledge – in part that such knowledge is worth possessing in itself, in part that possession of such knowledge has useful consequences. For example, appropriate teaching about the issue of rights might help scientists to distinguish between legal and moral rights, to understand something of the connections between rights and duties and to be able to identify fallacies in arguments for or against the notion of animal rights.

Thirdly, such teaching might improve the ethical *judgement* of scientists. As Davis, writing about students at university, puts it:

The course might, that is, try to increase the likelihood that students who apply what they know about ethics to a decision they recognize as ethical will get the right answer. All university courses teach judgment of one sort or another. Most find that discussing how to apply general principles helps students to apply those principles better; many also find that giving students practice in applying them helps too. Cases are an opportunity to exercise judgement. The student who has had to decide how to resolve an ethics case is better equipped to decide a case of that kind than one who has never thought about the subject.

(Davis, 1999, pp164-5)

Fourthly, and perhaps most ambitiously, such teaching of ethics might make scientists and engineers *better people* in the sense of making them more virtuous or otherwise more likely to implement morally right choices. For example, a unit on ethics for student veterinarians might lead the students to reflect more on the possibilities open to them when people bring puppies to have their tails docked, leading them to be less pressured (consciously or otherwise) by the views of others and so resulting in improved animal welfare. There is, within the field of moral education, a substantial literature both on ways of teaching people to “be good” and on evaluating how effective such attempts are (e.g. Wilson, 1990; Noddings, 1992). Here it is enough to note that while care needs to be taken to distinguish between moral education and moral indoctrination, there is considerable evidence that moral education programmes can achieve intended and appropriate results (e.g. Straughan, 1988; Bebeau, Rest and Narvaez, 1999).

How might ethics be taught to scientists or engineers?

In discussing strategies for how ethics might be taught to scientists or engineers, considering some of the advantages and disadvantages of each, a useful distinction can be made between learning that occurs while someone is a student learning to become a scientist or engineer and learning that occurs subsequently, “on the job”, when one is a scientist or engineer.

Teaching fundamental ethical approaches

Teaching ethics by going through such fundamental ethical approaches as consequentialism, deontology, virtue ethics, feminist ethics and so forth provides a rigorous and valid grounding. But the approach can appear abstract and may give too optimistic a view of the ease of making ethical decisions in reality. If it is used – and this approach can be used as part of a course of applied ethics – it is particularly important for the approach to be even-handed. There are some consequentialists who, both in their writing and in their talks, seem more evangelical about their position than are many religious people about their faith. Similarly, in some quarters the principlist approach has reached the level of a mantra. Equally, virtues are culturally laden.

Studying case studies

Case studies can be highly motivating for learners. They are seen to be “relevant” (the highest accolade for some students) and allow learners to contribute their own views and to discuss the views of others, whether of their peers, their lecturer(s) or academics in the field. They have considerable flexibility, taking as little as 20 minutes or occupying months of study.

However, some care is needed. Too much background information or too complicated a dilemma may be overwhelming; too superficial an introduction to a case study and learners may not engage; too many case studies and learners may fail to see connections between cases or get bored. Teachers (e.g. higher education lecturers) may need to help students “debrief” at the end of a case study, so that more general lessons can be drawn out and learnt – even if the lesson is only that sometimes general lessons can’t be learnt!

Role plays

Role plays, though rarely used in teaching about ethics in higher education, can be memorable and allow for a lived experience rather than students just engaging in talk. They can also increase empathy so that students see more deeply how others may perceive a situation. Indeed, it can be worth encouraging (but not forcing) students to take on a role different from that which they would anticipate occupying themselves (e.g. that of an eco protester or CEO). However, role plays do make particular demands on both lecturers and students. Role plays can polarise attitudes and it is always a good idea to “de-role” at the end of one, so that participants come out of role and get the chance to say anything they want to now that they are again “themselves”.

Imitation of lecturers

In a higher education course, students inevitably get to know something of the views of their lecturers and the degree to which their lecturers’ actions are consonant with these views. The extent to which students gain such knowledge depends on the structure of the course. If you are a lecturer and all your teaching is delivered in 50 minute lectures to groups of over one hundred students they will learn far less about you than if you take them on a residential field trip or visit to an industrial site.

Imitation of lecturers is an apprenticeship model in which lecturers are seen as role models. It is a form of embodied learning and is likely to happen to a certain extent in any event. However, awareness of it can make especial demands on lecturers. Equally, students learn from the whole ethos and structure of an institution as well as from individual lecturers.

Students act authentically by changing their own actions during the course

Do students get the chance to learn authentically by changing their own actions during their course? This is a type of enacted learning which involves getting into the habit of being good through the manifestation of agency. Of course, it requires courses to provide opportunities for students to make such authentic decisions, and so makes demands on course administrators, lecturers and technicians – as well as on the students. What opportunities do students get to choose the subject matter of their project work and other assignments?

Scientists and engineers reflect in the course of their work on ethical issues

Finally, ethics can be and is learnt by scientists and engineers in the course of their professional activities. In many ways this can be one of the most powerful sources of learning. Of course, education at an earlier educational stage (e.g. school or university) can help all of us as adults subsequently to reflect on the ethical acceptability of various practices. Given the number of new ethical issues that scientists and engineers are facing, and are likely in the future to face, it is particularly important that formal education provides learners with the tools to enable them to make their own, valid ethical analyses subsequently in new situations. After all, ten years ago few prospective scientists and engineers were taught about the ethics of genetic engineering or carbon usage. Ten years hence there will be new, presently unexpected ethical issues.

References

Bebeau, M J, Rest, J R and Narvaez, D (1999) "Beyond the promise: a perspective on research in moral education", *Educational Researcher*, vol 28(4), pp18-26.

Davis, M (1999) *Ethics and the University*, Routledge, London.

Noddings, N (1992) *The Challenge to Schools: An alternative approach to education*, Teachers College Press, New York.

Reiss, M J (1999) "Teaching ethics in science", *Studies in Science Education*, vol 34, pp115-140.

Reiss, M J (2006) "Educating scientists about ethics" in Turner, J & D'Silva, J (eds) *Animals, Ethics and Trade: The Challenge of Animal Sentience*, Earthscan, London, pp55-67.

Straughan, R (1988) *Can We Teach Children to be Good? Basic issues in moral, personal and social education, 2nd edn*, Open University Press, Milton Keynes.

Wilson, J (1990) *A New Introduction to Moral Education*, Cassell, London.

